COMPOSITE AND COMPREHENSIVE MULTIMEDIA ELECTRONIC HEALTH CARE RECORDS

by

NICHOLA JANE SALMONS
MSc.

A thesis submitted to the University of Plymouth in partial
fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Computing
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In collaboration with
Plymouth Hospitals NHS Trust

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ABSTRACT

Composite and Comprehensive Multimedia Electronic Health Care Records

Nichola Jane Salmons

The thesis considers the issue of multimedia data utilisation within modern health care delivery and the consequent need for an appropriate patient records system. The discussions centre upon the deployment and utilisation of IT systems, and paper-based patient records within health care establishments (HCEs), and the resultant problems, such as data duplication, inconsistency, unavailability and loss. Electronic Health Care Records (EHCRs) are put forward as a means of obviating the problems defined, and effectively supporting the future development of care provision in a coherent manner.

The thesis identifies the barriers to further development of EHCRs with respect to clinical data entry, clinical terminiologies, record security and the integration of other information sources. Equally, a number of EHCR developments are reviewed. This shows that, although elements of EHCRs (such as electronic prescribing) have been achieved, significant further developments are required to produce composite and comprehensive EHCRs, capable of capturing and maintaining all patient data (especially multimedia data, which is being increasingly utilised within care provision).

The thesis defines a new comprehensive and composite Multimedia Electronic Health Care Record (MEHCR) system to facilitate the following:

- delivery and management of all patient care;
- creation/recording/support and maintenance of patient data (including multimedia data) to give composite and comprehensive multimedia patient records.

The assistance of a local HCE was utilised throughout the project, enabling a suitable reference environment to be established and utilised, so that the process of care provision could be defined. The thesis describes how the requirements of the new MEHCR were identified (via examination of the care provision process defined), and thus how an appropriate conceptual design was formulated. This describes the form and capabilities of the required system. The resulting MEHCR is effectively a comprehensive care provision tool, which aids both process of care delivery and that of data generation and recording. Thus, the MEHCR concept facilitates patient care provision whilst aiding the seamless creation and maintenance of multimedia patient records.

To achieve the conceptual design, a design environment was defined to give an intermediate means of enabling the MEHCR's implementation and further development. Thus, the MEHCR can be achieved, or implemented, using either a revolutionary or evolutionary approach. Equally, it is a means for enabling the MEHCR's continued evolution (e.g. the incorporation of new clinical systems etc.), so that it remains composite and comprehensive over time as care provision changes.

The thesis also describes an evaluation of the ideas defined, based upon the development of a prototype system simulating the form and operations of the MEHCR conceptual design. The prototype system was demonstrated to a number of parties and an evaluation conducted. The results obtained were very positive as to the nature, structure and capabilities of the system as given by the conceptual design. The design environment was also commended as both a practical means of achieving the MEHCR (especially as it enables retaining of existing system where appropriate), and for its future development as care provision advances.

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Acknowledgements

AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other university award.

Relevant scientific seminars and conferences were regularly attended at which work was often presented. Equally, external institutions were visited for consultation and demonstration purposes, and several papers prepared for publication.

The work presented in this thesis is solely that of the author.

Signed ...*N. Sala*...........

Date ....*25/9/2000*.........

Glossary of Abbreviations

AEHDS	Additional Encounter History Data Set
A&E	Accident and Emergency
AI	Artificial Intelligence
ARTIMIS	Advanced Research Testbed for Medical Informatics
CERC	Concurrent Engineering Research Center
CORBA	Common Object Request Broker Architecture
CPR	Computerised Patient Record
CPRI	Computerised Patient Record Institute
CT	Computer Tomography
ECG	Electrocardiograph
EHCR	Electronic Health Care Record
EHDS	Encounter History Data Set
EHR	Electronic Health Record
EIS	Executive Information System
EMR	Electronic Medical Record
ENT	Ear, Nose and Throat
EPR	Electronic Patient Record
GDP	Gross Domestic Product
GIOP	Generic Inter-ORB Protocol
GP	General Practitioner

HCE	Health Care Establishments
HcM	Healthcare Model
HD	Hospital Departments
HIPACS	Hospital Integrated Picture Archive and Communication System
HISS	Hospital Information Support System
HL-7	Health Level Seven
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
ICD9	International Classification of Disease ninth revision
ICD10	International Classification of Disease tenth revision
ICWS	Integrated Clinical Workstation
IDL	Interface Definition Language
IfH	Information for Health
IHIS	Integrated Hospital Information System
IOM	Institute of Medicine
IMACS	Image Management and Communication Systems
IS	Information Systems
IT	Information Technology
IV	Institutional View
LONIC	Logical Observation, Names, Identifiers and Codes
MEHCR	Multimedia Electronic Health Care Record
MH	Medical History
MCI	Multimedia Control Interface

MICU	Multidisciplinary Intensive Care Unit
MIT	Massachusetts Institute of Technology
MRI	Magnetic Resonance Imaging
NHS	National Health Service
NMI	Nuclear Medicine Imagery
OPCS4	Office of Population and Census Studies four
ORB	Object Request Broker
ORSOS	Operating Room Scheduling Office System
PACS	Picture Archiving and Communication System
PAS	Patient Administration System
PCIS	Patient Care Information System
PCM	Patient Centric Model
PI	Patient Information
PHC	Private Heath Care
POSEIDON	Prototype Composite Hospital Multimedia Records for Patients
PPR	Permanent Patient Record
RAD	RADiology department system
RJAH	Robert Jones and Agnus Hunt
SGML	Standard Generalised Markup Language
SNOMED	Systematic Nomenclature of Human and Veterinary Medicine
SV	Structural View
TCP/IP	Transport Control Protocol/Internet Protocol
UMDA	Ubiquitous Multimedia Data Availability

VB	Visual Basic
VEMR	Virtual Electronic Medical Record
VNI	Virginia Neurological Institute
VR	Virtual Reality
W3-EMRS	World Wide Web Electronic Medical Record System

Chapter 1

Introduction

Introduction

This chapter gives an overview of the current utilisation of systems and paper-based patient records in secondary care provision. The chapter defines the associated problems and how these obstruct moves within health care to improve both the efficiency and quality of care provision. One solution to the current situation is offered, in the form of Electronic Health Care Records. The aim of the research project, to design a composite and comprehensive Multimedia Electronic Health Care Record (MEHCR), is then defined. The chapter concludes by outlining the structure of the thesis.

1.1 IT in health care: An overview

Since the 1960s, computerised systems have gradually been developed and implemented within health care provision. The first systems deployed tended to be mainframes, having administrative roles. However, as technology has progressed, other types of systems have been deployed, so that today within health care there are a wide range of systems present (e.g. imaging systems, Patient Administration Systems (PAS), departmental administration systems, visualisation systems, theatre management systems etc.).

As a whole, these disparate systems perform a diverse range of operations, clinical and administrative, and produce considerable quantities of data surrounding certain aspects of care provision. However, the general lack of integration between systems means that islands of information exist, and that data is only available at certain locations and to particular individuals.

Despite numerous types of systems being deployed over the last forty years, to aid particular care activities, patient records have remained largely untouched, resulting in the vast majority of them consisting of paper folders. The paper-based nature of patient records hampers care provision as they can only be in one location at any point in time, are difficult to search for information and do not permit the recording or viewing of certain types of data (e.g. video and audio). Thus, the nature of the current paper-based patient records means that, within care provision, data may be unavailable.

The problems of data unavailability, given by both disparate systems and paper-based records, can adversely affect the quality and efficiency of care provision as follows:

- clinical decisions may be made in ignorance of relevant information;

- clinical tests / examinations may be repeated (data detailing previous requests / results is unavailable).

At present health care is under immense pressure to increase its efficiency and quality, so that more care (often of greater complexity) can be provided to more patients (having greater care expectations), in a climate of financial restraint. Thus, its disparate systems and paper-based records stand in the way of improving both the efficiency and quality of care provision. One solution to this situation is the development and deployment of Electronic Health Care Records (EHCRs).

1.2   Research project aims

For a number of years research towards EHCRs has been conducted, although it has accelerated considerably in the last decade. However, at present, only some elements of EHCRs exist, there being no EHCRs enabling all patient data (including multimedia) to be recorded as care provision occurs. Thus, this research project was undertaken with the aim of determining a composite and comprehensive multimedia electronic health care record (MEHCR) framework, capable of the following:

- generation / recording / presentation of all patient data (including multimedia data) as care is provided;

- support of patient care provision (and its constituent activities), care management and care administration;

- accommodation of future care provision advances whilst remaining composite and comprehensive.

Although the capabilities of the desired MEHCR can be summarised in a few lines (as above), the goal defined is an ambitious one due to the demands and complexity of the care provision environment and process. The work undertaken to achieve the aim of the research project is described in the thesis, as detailed in the next section.

1.3 Thesis structure

The thesis is separated into nine chapters, including this one which sets the scene for the research project and defines its aims. The contents of the remaining eight chapters are described in the following paragraphs to give an overview of the thesis structure.

Chapter two gives an overview of the utilisation of IT in secondary health care over the past forty years. It discusses the development and implementation over time of different types of systems, and their capabilities. The problems associated with the deployment of health care's numerous disparate systems are commented on, as are moves towards their integration. The chapter also discusses the shortcomings of the current paper-based

records utilised, and how in conjunction with the presence of the numerous systems present (which are rarely integrated), health care's efforts to increase both its quality and efficiency are thwarted. The chapter offers one solution to the problems defined in the form of EHCRs and concludes by discussing their requirements and potential benefits.

Chapter three progresses the discussion of EHCRs by looking at the current barriers to their further development. The need for advances with respect to physician data entry, clinical terminologies, record security and the integration of other information sources (i.e. existing systems) are commented on, along with a brief review of current developments. A number of EHCR projects drawing together data from various systems to give virtual patient records are discussed. These projects achieve important elements of EHCRs (as defined in chapter two) but none are complete systems and the chapter concludes with the need for the research project.

The fourth chapter defines the health care resources, and information collection and analysis methods used to enable the process of care provision to be defined, and thus, the requirements of a MEHCR to be established. The chapter comments on the numerous findings yielded by the research as the process of care provision was defined (e.g. health care resource roles, care provision processes and activities, types of records present and the ways in which the records are used) and the MEHCR requirements identified.

Chapter five discusses the designs developed to give the desired MEHCR. Initially, an overview of the MEHCR's "conceptual design" is given, to explain its purposes (i.e. the

definition of the MEHCR's basic structural form). After this, there are more detailed discussions of the conceptual design with respect to the MEHCR's precise composition, interfaces and utilisation, functional capabilities and its ability to embrace and accommodate change. The "design environment", which contains two types of views (Institutional and Structural) is subsequently defined. Its purpose is to provide a means of enabling both the MEHCR's implementation and its continued development, so that over time it remains comprehensive and composite. The chapter concludes with an example of how the MEHCR (as defined by the conceptual design) could be realised using the design environment.

Chapter six discusses the benefits which the MEHCR brings to care provision. An example patient care scenario is defined as a vehicle for demonstrating the MEHCR's utilisation in, and benefits to, care provision. The scenario follows the care of a patient through the following:

- initial GP referral;

- consultation appointment given;

- consultation encounter examination;

- consultation encounter departmental clinical tests;

- consultation encounter inter-departmental clinical test;

- consultation encounter outcome.

The scenario described occurs within an environment where the MEHCR has been implemented using the evolutionary approach, to illustrate how existing systems can be retained and utilised. The chapter moves on to discuss the benefits given by the MEHCR due to its support of electronic communications, existing systems and the modes of use and working practices identified. The chapter concludes with a discussion of how the MEHCR can accommodate future health care developments whilst remaining composite and comprehensive.

The seventh chapter details the development of a prototype system called POSEIDON. The key features of the MEHCR shown by POSEIDON, and its role as an aid to the evaluation of the ideas defined by the conceptual design are discussed. Equally, the details of the system's use during the care of the hypothetical patient is defined. Finally, the chapter concludes with a discussion of limitations of prototype system.

Chapter eight describes the two evaluations undertaken. For the first evaluation, involving end users and IT staff, the chapter details the evaluation question set utilised and the results obtained. Equally, the second evaluation, involving health informatics professionals, is commented on and the results gained are defined, and appropriate conclusions drawn. Finally, there is a review of the evaluations performed.

The final chapter briefly reviews the work undertaken and its worth as a research project. The chapter concludes by looking ahead to what developments are likely within the

health care arena, the benefits they will bring and how the ideas defined could support

them.

Chapter 2

IT utilisation in health care

Introduction

This chapter discusses the current pressures on health care systems and the typical deployment of systems within UK Health Care Establishments (HCEs). The evolution of information systems (IS) within the National Health Service (NHS) is commented on with respect to the systems present, their capabilities and moves towards their integration. The problems associated with the current IS situation are discussed, as is the way that these are compounded by the use of paper-based patient records. Finally, the chapter offers one solution to the current problems of care provision, in the form of Electronic Health Care Records (EHCRs).

2.1 IT in health care: a requirement

Within the world's developed economies (such as those in North America and Western Europe) health care has evolved in different ways, supported by (in various proportions) private and government funding. The discussions in this chapter, although centred upon UK, define problems and pressures which are typical of those experienced by established health care systems globally.

Health care provision has developed tremendously in this century, enabling a greater range of treatments (some of enormous complexity) to be received by an ever increasing number of patients. A consequence of this development in health care is the increase in its costs. For example, at present the UK spends 6.8% of gross domestic product (GDP) on health care, which equates to £45 billion (Ferriman, 2000).

Currently, care provision is under immense pressure to meet increasing consumer demands as more patients seek a greater number of available treatments. This increase in demand can be illustrated by, for example, looking at admission rates. These have increased by 40% in the period 1987-8 to 1997-8, so that now 20% of the population are admitted annually (Edwards & Harrison, 1999). These increases can be explained partly by demographic changes. For example, there was a 25% increase in the number of people aged 85 and over in a seven year period (Ebrahim, 1999), and an ageing population has greater care needs.

In addition to demographic changes, technological advances and greater patient expectations have also added to increased demands on care provision. Technological advances have enabled the development of new treatments, and help to raise patient expectations by facilitating much greater access to health information (e.g. on the Internet) (Ferriman, 1999).

As health care has grown in scale, complexity and cost so has the need to manage its effective provision. For secondary care (i.e. HCE based care provision), this requires the improvement of both HCE management and care delivery. The improvement of HCE management requires the intelligent and effective collection and utilisation of information concerning the operation of the HCE. The benefits of IT implementation for this purpose have been acknowledged, and exploited, for some time (this is demonstrated by the development and use of numerous administrative systems within the management of HCEs). For example, over five years the NHS spent £125,000,000 per year on managerial information systems at 260 sites (Wyatt, 1995). However, it is now becoming apparent that the use of IT within health care needs to be greatly extended and developed beyond HCE management and administration in the terms of patient based systems to increase the actual efficiency and quality of care delivery, if care provision is to match society's expectations.

2.1.1 The development of IT in health care

During the past forty years, computerised systems have gradually been developed and utilised within health care. At first, in the 1960s to 1970s, HCEs deployed computer systems (in the form of mainframes) for the automation of administrative or repetitive

operations (Mon et al, 1998). These systems tended to be developed on an application by application basis, gradually automating a variety of administrative tasks. For example, once the hospital payroll had been computerised, accounts and inventory control systems could then follow (Charles, 1979).

During the 1970s, developments led to the further automation of administrative functions within HCEs and the development of various non-integrated departmental systems. An example of the type of departmental systems developed would be the computerisation of a laboratory to enable the production of test data and reports. However, to view the test / report data generated outside the laboratory / department required the printing out of information on paper (Ricci, 1997).

The 1980s and 1990s witnessed the most dramatic increase in the use of IT in health care. Decreasing costs and increasing technological capabilities resulted in the deployment of numerous systems of various clinical and administrative / managerial types. Thus, within care provision, a wide range of activities are now aided or performed by computerised systems.

Health care has benefited from the utilisation of IT, but its deployment has not been a co-ordinated process. This has resulted in the presence of a non-integrated IT care provision environment where there are islands of automation and information.

2.2 Health care IT: current deployment and use

To give a brief overview and understanding of the current utilisation and development

of IT in secondary care provision it is possible to define three basic types of systems

and discuss their roles, capabilities and deployment. Table 2.1 shows the types of

systems defined and examples of each type.

System type / category	Examples of type
Hospital-wide administrative systems - co-ordinate and manage the administration of the HCE. They hold administrative data and some patient data (e.g. patient details)	Patient Administration System (PAS)
Departmental Administration and Clinical systems - aid the administration of departments or specific activities. They hold administrative data, some patient details and clinical information	Theatre Management Nursing Radiology Administration
Isolated / Stand alone systems - generate, process and present specialist clinical data	Magnetic Resonance Imaging (MRI) Computer Tomography (CT)

Table 2.1 – HCE systems and their classification

The system types defined are broad classifications and some systems cross the bounds

of one or more of them. For example, a variety of medical retrieval, clinical research,

decision support, medical education, medical training and medical records systems

could be viewed as fulfilling the criteria for inclusion in more than one category. This

is because their deployment, capabilities and utilisation within and between HCEs is

extremely varied. For example, some HCEs may not utilise a particular system type

widely, while another may use the system throughout the HCE. Equally, some

systems, such as clinical research and decision support, may utilise existing systems

to generate data, and thus they could be viewed as modular extensions of existing systems rather than separate ones. However, the three basic categories given do provide a means through which IT in health care can be discussed.

In addition to looking at the types of systems deployed it must be remembered that there are wide differences between HCEs with respect to the number of systems deployed and the extent of their integration. For example, some HCEs contain systems whereby those responsible for appointments and admissions, speciality results, drug treatments, procedures, care plans and clinical correspondence are integrated (Denley & Weston Smith, 1999), whilst others have considerably less integration.

Figure 2.1 gives an example of how HCEs currently utilise IT in secondary care provision. It illustrates a small number of the various types of systems present and summarises their purpose and the extent to which they are integrated.

HCE-wide systems	Departmental systems	Isolated clinical systems

PAS

PAS, a HCE-wide administration system responsible for managing a number of patient administration functions (e.g. admissions)

RAD

Pathology

Departmental systems responsible for departmental management and the generation of limited patient data (reports). Systems are integrated with PAS

MRI

CT

X-ray

ECG

Isolated systems perform specific clinical tasks, such as the production of ECG data. They are not integrated with other systems

Accounts payable

Staff payments

Debtors billing

General ledger

Additional specific activity systems (usually administration based) integrated with PAS. They can be viewed as PAS modules

Ward Nursing

Pharmacy

Theatre

Departmental systems responsible for managing departmental activities for a number of departments (e.g. ward management). Systems generate limited patient data and are not integrated with PAS

Figure 2.1 - Example of systems deployment within a HCE

2.2.1 Hospital-wide administration systems

The 1980s witnessed many HCEs implementing hospital-wide Patient Administration Systems (PAS). These co-ordinate much of the administration of the HCE, generate HCE performance data and hold certain patient administration information (e.g. patient's name and GP details). They tend to be mainframe systems, and their operation is enabled by the selection of options, or the entry of data to fields, within different system screens.

Since their initial implementation (when their primary function was the recording of Admissions and Out Patients appointments (Lee & Millman, 1995)), many of the

systems have been upgraded so that now their capabilities tend to include the following:

- creation of new patients records;

- booking of HCE appointments, generation of letters and clinic lists;

- tracing of the patient records;

- amendment of patient details;

- patient admissions and discharge;

- recording of diagnosis using ICD9 (International Classification of Diseases - Ninth Revision) codes;

- generation of theatre lists;

- the recording of operations using OPCS4 (Office of Population and Census Studies - Four) codes;

- bed occupancy;

- printing of patient details on labels.

In addition to the capabilities listed, the systems also provide managerial information concerning HCE activity. This information concerns the operation, and thus the performance, of the HCE (e.g. the number of patients undergoing a particular treatment, patients seen by a particular department and on a particular waiting list etc.).

Within HCEs there are also systems (e.g. audit systems and systems to provide information concerning patient episodes / encounters), which act like additional PAS

modules. They are usually developed locally to aid clinicians in their day to day patient management, medical audit operations, workload management, contract management and resource allocation and utilisation. They are often tailored to individual department needs, and may gather data from both PAS and departmental administration and clinical system types, and / or have data entered directly.

Over the years, the majority of PASs have been upgraded with new functional modules added. However, the basic age of these systems (in 1995, 166 PAS gave a modal age of 9 years), means that they are costly to operate and inflexible (Wyatt, 1995). This means that the ability to substantially progress PAS operations is limited, hence, the introduction of additional support, administration and audit systems. This situation does not mean that the PASs are redundant, as they still perform a vital role in HCEs at present. It merely suggests that PASs alone will not be capable of satisfying the expanding information requirements of HCEs in the future.

2.2.2 Departmental administration and clinical systems

There are two groups of systems in this category:

- departmental administration and clinical systems;
- activity-specific administration and clinical systems.

The department administration and clinical systems are utilised within both specialist and laboratory-based HCE departments (e.g. Radiology and Intensive Care) (Kalra et al, 1998). The systems aid administration (e.g. the planning of departmental

workloads), and ensure that specialised clinical resources are effectively managed and used. In addition to this, the systems generate clinical data, such as numerical analysis values, or clinical investigation reports. This information can be made available to other HCE departments, either electronically (if the systems are integrated with the HCE's PAS) or by means of a hard copy.

The activity-specific administrative and clinical systems are those responsible for the administration of tasks and the recording of certain items of clinical data associated with a specific activity or range of activities within the HCE or a department. For example, theatre management systems hold all the administrative information concerning the procedures performed within the HCE, and some clinical data relating to the procedure (e.g. the type of drain and anaesthetic used).

As the deployment of these systems is on a smaller scale than those previously discussed, they tend to be of a more modern nature because they have either been upgraded or replaced from the original deployment, or the system is of a more modern nature due to its more recent development. However, it is still the case that these systems are generally unable to supply information concerning clinical outcomes and patient encounters. Thus, in many cases, they are unable to meet the increasing demands for information, especially with respect to the measurements of performance, on the basis of patient encounters. Again, it must be stressed that, at present, these systems perform an essential function in the successful operation modern HCEs.

2.2.3 Isolated clinical systems

The 1980s and 1990s witnessed the most dramatic advances in the use of computers within medicine. The development of a variety of computerised systems enabled the use of modern clinical techniques, and the generation of specialised clinical data. These computerised systems are defined as stand alone or isolated systems.

Many of the first isolated clinical systems involved the processing of images, their transmission and archiving, and were focused upon departments such as Radiology and Nuclear Medicine. Now, however, applications are being developed and implemented within a variety of disciplines, such as Cardiology and Neurology (McGarty et al, 1992) for the monitoring of patients, when perhaps as in Cardiology two related state indicators such as heart rate and EGC values can be shown (Padmanabhan et al, 1996). Thus, within most HCEs, a number of advanced medical techniques are commonly available including Computer Tomography (CT), Magnetic Resonance Image (MRI), Nuclear Medicine Imagery (NMI), Ultrasound and Electrocardiography (ECG).

More recent advances in computer technologies have also enabled systems to be developed which, using visualisation techniques (e.g. volume and surface rendering (Udupa & Odhner, 1993)), give 3D computer generated images of internal patient structures, enabling clinicians to more accurately assess patient problems. Equally, there have been further clinical developments utilising the visualisation of patient data for the planning of appropriate patient therapy and surgery. These developments can be used to simulate a number of possible technical approaches to a particular surgical

or therapeutic problem, and determine the most applicable one (Caponetti & Fanelli, 1993). In addition to this, simulation techniques can also be used to determine the probable outcome of the procedure and the likely extent of its success (Patel et al, 1996).

The clinical systems utilising the visualisation of patient data and simulation tend to be less common within HCEs than MRI and CT type systems, as they are more recent innovations, but their presence and use will increase as the technologies involved fall in cost.

2.2.4 Moves towards systems integration

It can be seen from the previous sections that the factors common to the deployment of the systems discussed is that they do the tasks they are designed to do and that they tend to do them in isolation. However, if the ever-increasing pressures exerted on health care are to be met, care provision and its disparate, non-integrated utilisation of IT systems must change. Systems must be developed and deployed to support improvements in the efficiency and quality of care provision and the availability and use of more and better information (both clinical and administrative). To this end, a number of different advances have been made with respect to the integration of existing HCE systems.

2.2.4.1 Integration of isolated clinical systems

One of the first areas to tackle the problems of systems integration and data availability was Radiology and associated imaging specialities. These departments

have utilised computer aided imaging techniques and the multimedia data produced for some time. The growth in modalities has given rise to clinicians wanting to both contrast modality results and discuss cases with other specialities. Equally, there have been growing demands from referring clinicians and other care teams to have speedy access to images and reports (Treves et al, 1992). Thus, within this area of care provision there have been moves towards the integration of systems.

The Picture Archiving and Communication Systems (PACS) concept has been under development for some years. This aims to network all the isolated imaging systems of an HCE, although systems known as miniPACS aim to perform the same functions within individual departments. A PACS will thus link a number of imaging modalities (e.g. CT, MRI, DSA etc.), storing the data in suitable databases (Cox et al, 1992; Huang et al, 1992).

Developments are also being made towards the "Digital Radiology Environment", which aims to integrate PACS with the Image Management and Communication System (IMACS). The IMACS concept aims to effectively manage the storage and communication of the images. The departmental administrative and clinical systems and the PAS could then be integrated to produce a Hospital Integrated Picture Archive and Communication System (HIPACS) (Mattheus et al, 1992). This type of development, when a PACS is integrated with an older PAS and / or department administration type system, must overcome software development and workstation installation problems. However, these types of developments have been achieved

(especially in Japan) when PACS are integrated with later PAS developments (Inamura et al, 1996).

2.2.4.2 Administrative and clinical systems integration

Alongside the work towards developing integrated networks for isolated imaging systems have been moves towards the integration of HCE-wide administration, departmental administration and clinical systems and isolated clinical systems. For some time it has been possible to integrate systems (such as the PAS and departmental administration and clinical systems) developed in the same languages and by the same vendors. For example, the Radiology system may be integrated with the PAS in a limited way, so that the systems exchange certain items of text and numerical data such as X-ray reports.

In the UK, the need for systems integration was addressed on one level by the Hospital Information Support Systems (HISS) initiative, launched in 1988. Its aim was to increase the quality of information available to managers and clinicians by creating integrated HCE computer networks which would enable data to be entered once and be available as required throughout a HCE (Anthony, 1998). The HISS aimed to link PAS, departmental systems, research and clinical audit systems and, where appropriate, order communications systems (e.g. for the ordering of clinical services and medication) (NAO, 1996). The results of the initiative defined the benefits of the HISS as being "qualitative rather than quantitative" as pilot sites failed to achieve the financial benefits predicted. However, they did report greater

efficiency, and in some cases improvements as the following decreased; admissions, none attendance and waiting times and lists (IMG news, 1998).

As health care has developed and more systems (of greater complexity) from various vendors have been implemented, integration has become more complex. To overcome the problem of integrating inflexible legacy systems, a number of "middleware solutions" have been developed. Middleware can be thought of as a systems component that provides real-time access, or data transfer, between non-native heterogeneous systems, so that a user can (without a knowledge of the systems or networks involved) locate, access and manoeuvre data throughout an organisation / enterprise (Brown, 1996). These middleware solutions enable various HCE systems of different types to be linked via a single piece of software. They generally enable message translation from different applications (regardless of communication protocols or messaging formats) and permit the exchange of data throughout the network.

A number of these middleware solutions are commercially available and are utilised by a large number of HCEs world-wide. One example of this type of software is "DataGate" which resolves differences in format, protocols and data between different systems (Siemens, 2000). This software is currently used by a number of NHS Trusts (STC, 1998), as follows:

- Ipswich Hospital - integrated the HISS and Pathology laboratory information management system;

- Glan Hafren - integrated departmental systems and PAS over a number of sites;

- Hammersmith - integrated systems as part of its community IT strategy to enable X-ray image interchange;

- Nottingham - integrated GP clinical systems to enable GPs to receive test results.

Web-based technologies have been used by HCEs in the form of Intranets as alternatives to middleware solutions as a way of migrating towards the integration of all HCE systems. For example, the Oxford Radcliffe Hospitals NHS Trust has a web browser to access a number of legacy systems (Black, 1998), enabling clinicians to have greater access to clinical information. The ability to access the intranet through the HCE has encouraged its use to become a normal part of clinician's work, helping to reduce paperwork and the interruption of other clinicians with requests for information (Kay, 1998).

These developments illustrate how HCEs are implementing solutions to enable the integration of systems. It can be seen that they offer a way to effectively integrate legacy systems and permit the accommodation of advances in health care such as GP links and the use of further web applications. However, an examination of these developments also shows that, thus far, the potential of middleware solutions to enable the integration of all HCEs systems (permitting multimedia data exchange), and the integration of other health care advances (e.g. telemedine) within HCEs has not been commonly realised. This is because these types of integration developments

tend to address the basic or common problems associated with data availability and exchange (e.g. by increasing speed and amount of data exchanged between GPs and Trusts, and decreasing time taken to obtain results), rather than more limited or specialised problems such as the availability of visualisation images between clinicians.

2.3 Paper-based patient records

So far, from this chapter, it can be seen that over the past forty years care provision has deployed systems to aid the performance of administrative and clinical tasks and latterly moved towards the integration of these systems to improve the availability of information. However, whilst this work has aided care provision to date there will, in the future, be more systems (clinical and administrative) deployed as technological advances inexorably become utilised in routine care provision. Advances in the fields of communications, robotics, artificial intelligence (AI) and virtual reality (VR), can all have benefits for health care. For example, communications advances can be exploited in the form of telemedicine applications which make more efficient use of clinical resources. Equally, VR and robotics can enable better and more effective surgery as they permit the planning and simulation and the utilisation of robots where appropriate, such as in heart bypass surgery (Highfield, 1997).

Although, these future systems (many of which will produce multimedia data) could be integrated with existing systems (subject to networking improvements), health care will still ultimately be held back by one fundamental element of today's care provision, i.e. the paper-based patient records, as these are unable to hold much of the

data generated by advanced systems. Hence, the availability of patient data is inhibited, and thus, care provision is adversely affected with respect to its quality and efficiency.

2.3.1 Form of paper-based records

Today's paper-based patient records have developed from the personalised "lab notebooks" of the nineteenth century, in which observations and plans were recorded by clinicians (Shortliffe, 1998). Over time the patient records have developed to accommodate changes in care provision, such as the need to record more test data and legal requirements, so that they are currently the primary repository for patient data. However, they are, due to their paper-based nature, acknowledged as a major factor in holding back the increased efficiency of care provision (Dick & Steen, 1991).

2.3.2 Problems of paper-based records

Although, the current paper-based patient records have the established advantages of being familiar to users in the health care environment, and being relatively easy to scan and examine, there are numerous problems associated with their use:

- records only permit singular access at the same physical location - (i.e. their availability is limited unless multiple copies are made and this can lead to integrity and security problems);

- records require requesting, locating and transporting to where they are needed;

- records may be mislaid;

- data can be lost or removed from the record without trace;

- records contain redundant data (as data is re-recorded);

- records may contain inconsistencies;

- information may be unavailable to clinicians due to poor legibility and structure, or ambiguities (different styles, vocabularies and approaches used when entering data);

- records are not comprehensive (i.e. data is unrecorded) or composite (i.e. all data recorded is not present in a consolidated form, only within various separate records);

- records do not permit the retention or viewing of multimedia data (such as video or audio) which form part of the patient record (Carpenter, 1998).

These problems have led to the situation where clinicians spend time communicating with others in an effort to acquire information, duplicating data in the records, repeatedly completing requests for clinical services (due to the requests being lost or mislaid), struggling to decipher illegible record entries and coping with the unavailability of records (Wyatt & Keen, 1998). This situation means that clinicians spend up to 40% of their time generating or acquiring information (Christie, 1994), 30% of staff perform administrative tasks only, and in the USA 25% of all health care costs are due to the administration and information management requirements (Wallace, 1994).

The problems associated with the use of paper-based records can only grow as health care develops and more advances are deployed. For example, the record's inability to hold and present multimedia data alone will mean that more and more patient data (e.g. endoscopy videos, audio and 3D graphics data) is held separately (and thus made unavailable to clinicians). It will also mean that inefficient practices within health care, such as the seeking of information (e.g. specific patient details / data) from colleagues rather from the patient notes or laboratory results, will increase as greater amounts of patient information becomes more disparate and inaccessible (Coiera & Tombs, 1998).

In 1991, the Institute of Medicine (IOM) task force published a report which formed the basis of "The computerised patient record: an essential technology for healthcare" (Dick & Steen, 1991), and triggered the formation of the Computerised Patient Record Institute (CPRI). This landmark publication stated that *"the current paper medical record is insufficient in content, format, accuracy and accessibility to allow determination of care effectiveness and outcomes"*, and that *"computer based patient records can remedy the inherent flows of the conventional paper system through improvements in accessibility, cost savings, quality and marketability"* (Traugott, 1998).

The CPRI went on to define the computer based patient records (CPR) as follows: *"electronically maintained information about an individuals lifetime health status and health care, replacing the paper medical record as the primary source of information for health, meeting all clinical, legal and administrative requirements. It is seen as a*

virtual compilation of non-redundant data about a person across a lifetime, including facts, observations, plans, actions and outcomes. The CPR is supported by a system that captures, stores, processes, communicates, secures and presents information from multiple disparate locations as required" (AMA, 2000).

Before and since this definition, numerous terms have been defined (e.g. Automated patient records, electronic medical records and scalable patient records), and inconsistently applied to various developments (CPR Description Working Group, 1996). Equally, this definition can be interpreted as meaning different things depending on the context it is placed in. For example, the CPR could exist at an institutional level (i.e. a HCE), the record given being of the patient's life long treatment and health status as far as the institution is concerned, and the multiple disparate locations being those within the institution. Equally, the CPR could exist at an organisational level, where data from a group of HCEs forms the record, or at a national level when information from all HCEs in the country is contained within the record.

To clarify the discussions in this thesis, the term Electronic Health Care Record (EHCR) is used to mean a record of periodic care provided mainly by one institution, and corresponds to an EPR as defined by "Information for Health" (IfH) (Dobson, 1998). It is used as it represents the context within which most computerised or electronic record implementations occur (i.e. mainly within one HCE) and the context within which most developments are occurring or being planned.

2.4 EHCRs

The development of electronic health care records is seen as the way to overcome a number of the disadvantages associated with the use of paper-based records, and increase the efficiency and quality of care provision. To achieve the goal of the EHCR a number of basic requirements are defined (Dick & Steen, 1991) for the support of the following:

- simultaneous access;

- direct clinician entry;

- access to information sources;

- security (user access continuously authorised / audit trails / confidentiality etc.);

- health research;

- problem lists;

- measurement of health status and functional levels;

- documentation of clinical reasoning;

- longitudinal linkages with other patient records;

- support for all health care advances now and in the future;

- measurement of costs and outcomes.

The above merely outline what an EHCR should support, they do not detail requirements with respect to the data content, decision support, functionality, interface or technical requirements of EHCRs.

2.4.1 EHCR benefits

If and when the requirements defined for EHCRs are met, their embodiment is projected to have a variety of benefits for patients, clinicians and providers. The benefits predicted for patients include the following:

- clinical decision making improved (more appropriate care should be received by patients);

- decrease / elimination of duplicate testing, imaging, and history taking (as data duplication is reduced);

- more efficient administration (records always being available for consultations and results being available immediately);

- effective implementation of preventative health measures and screening programs (via the enabling of the improved targeting of information and screening).

For clinicians the benefits should include the following:

- improved support for clinical decision making (all appropriate and up-to-date patient data (including, for example, physiological data captured automatically from bedside monitors) is immediately available as are medical information sources);

- reduced data entry burden (data is not duplicated by its re-recording in patient encounters because it is buried elsewhere in the record);

- improved prescribing (availability of adverse drug reaction alerts);

- improved record review (all data is present and can be more easily comprehended) - data is not held in the form of illegible hand writing, or presented as incomprehensible notations. Equally, data can be presented in the most appropriate media (e.g. video). Information can be structured in such a way as to permit its easy use and enable a variety of search options.

Finally, the EHCR can benefit care providers, such as HCEs and Health Authorities, as it is envisaged that they will enable the following;

- cost savings with respect to administration care support, transcription costs. Physical record storage and transport and supplies (Narcisi, 1998);

- improved resource allocation and management;

- improved outcome and cost benefit analysis of treatments;

- the ability to mine data to aid the identification of risk factors, the monitoring of adverse drug reactions, demographic data and the informed development of policies (Mount et al, 2000).

These are not exhaustive lists of the benefits that are expected for EHCRs, but they do indicate what could be achieved. The benefits expected are such that work towards the development and implementation of EHCRs in various forms has been ongoing for sometime since the EHCR concept was first promoted in the 1960s (MRI(a),

1999). However, due to technological advances in the recent past (i.e. the last ten years) work in this area has accelerated considerably.

2.4.2 Existing EHCR developments

Moves towards EHCRs originally began in the late 1960s and early 1970s, as universities in the USA, such as Harvard and Duke, developed systems which illustrated the advantages that computerised systems could give health care with respect to data access, legibility and the abstraction of statistical information (Amatayakul, 1998). However, it was not until the publication of "The computerised patient record: an essential technology for health care" in 1991, which defined the goal of the EHCR, that developments accelerated.

Numerous systems and applications have been developed, but most centre on improving systems integration and data access to improve administration / business processes. In fact, less than 10% of systems developers / providers have funded developments to provide integrated clinical information systems to aid care provision (Dalander et al, 1997).

At present, most HCEs maintain paper records whilst providing some automation of health care processes. Many systems have been deployed and called CPRs, EMRs and EHCRs, but are in fact only developments towards the goal of an EHCR as defined by the IOM report, being found on inspection to be in early / pilot stages of implementation with limited capabilities. Equally, it has been stated that the future of

care provision is somewhat negative when considering that even the most pioneering systems are little more than visions (Marietti, 1999).

Generally, these systems are difficult to use. For example, a number of screens are required to request services, which often results in paper requests being made and the electronic version created later by another person. Equally, the entry of notes via either the keyboard or pull down menus is problematic for many clinicians, resulting again in paper notes being generated during care provision and added to systems later. Whilst these systems do enhance the availability of data to clinicians, the "work arounds" used in their operation defeat many of the envisaged benefits especially for patient care. For example, when requesting medication for patients the requests are made on paper first, thus the systems adverse drug reaction alerts are bypassed until the data is entered onto the system later, when it is often too late (Amatayakul, 1998).

Having stated that the EHCR is still an unrealised goal and that only limited moves towards its realisation have been made, the reasons for this apparent lack of progress should be examined. The main issues holding back progress are as follows:

- standardised clinical terminology;

- data security, confidentiality and privacy;

- direct physician data entry;

- problems concerning the integration of information sources with records systems (Shortliffe, 1999).

The next chapter examines why these issues are hampering EHCR developments.

Equally, the chapter reviews the latest moves towards EHCRs, and concludes with the

need for the research presented in this thesis.

Chapter 3

EHCR barriers and developments

Introduction

This chapter reviews the need for EHCRs, and examines the four main areas of development (i.e. security, clinical terminologies, data entry and the integration of information sources) restraining their further advancement. Each of the areas defined is briefly discussed, as is some of the associated work. The chapter also reviews a number of EHCR projects which represent some of the most complete embodiments of elements of EHCRs. Finally, the chapter concludes with a discussion of the shortcomings of current developments and the need for this further research.

3.1 Care provision and EHCRs

The previous chapter gave a brief description of IT utilisation in health care, and the problems of the existing paper records. Equally, it defined how a lack of integration between systems, coupled with the inherent shortcomings of paper-based records, gives a situation as follows:

- data unavailability – paper records are only available in one location, hence simultaneously in all other localities data is unavailable (unless duplicated). Equally, access to systems, and thus data, may limited (e.g. access is physically restricted to a laboratory or office);

- data duplication – data (e.g. patient address) may be duplicated between both various systems and paper records, and between different types of paper records (e.g. main HCE records and Radiology department records);

- data inconsistency – certain data (e.g. patient address), may change over time. However, if it is duplicated, any changes over time may not be reflected in all the systems / records where the data resides;

- data unrecorded – the inability of paper-based records and many existing systems to hold and present multimedia data in an appropriate form results in data (e.g. endoscopy examination video) not being recorded.

The above means that the efficiency of care provision is adversely affected as clinicians spend time trying to obtain information. Equally, its unavailability can diminish care quality as the following occurs:

- clinical decisions are made in ignorance of some information (e.g. one study found that during return visits to an ambulatory care clinic, the inaccessibility of relevant patient information resulted in decisions being postponed or made on the basis of incomplete data in 81% of cases (Tang et al, 1999));

- care processes such as blood and urine tests are repeated as information detailing requests / results is unavailable, or has been mislaid.

This situation will worsen as medicine advances and more sophisticated systems producing multimedia data become routinely used in care provision. One solution to this problem is the introduction and use of EHCRs.

3.2 Barriers to EHCR developments

The previous chapter discussed the requirements and benefits of EHCRs, the limited moves towards their implementation, and identified the four main issues currently restraining their development. These issues are now examined in more detail.

3.2.1 EHCR data entry

Currently, the use of paper-based records means that care provision information forming

the patient records is generally entered as follows:

- narrative notes – hand written on paper then added to the record (e.g. the

  taking of patient histories during consultations);

- forms recording specific data – generally completed by hand on paper

  which is then added to the record;

- typed reports – transcribed from audio tapes (e.g. X-ray examination

  report).

The extensive use of pen and paper in the above is understandable as data entry is easy,

portable and quick. However, these methods of capturing information have shortcomings

in that:

- hand written entries may be difficult to read (Cabral, 1997);

- transcribed entries may contain errors, take time to produce (thus, they

  are not immediately available), and have additional costs associated with

  their production ($6 billion annually in the USA (Colbum, 1997));

- unstructured entries (i.e. narrative notes / reports) are difficult to code

  (Poon & Fagen, 1994).

It can be seen that paper record data entry (especially direct point of care data entry) is less than ideal. However, the difficulties of recording patient information when computers are used increases, as integrating computers within the process of care provision is inherently challenging (Shortliffe, 1998), and the lack of suitable interfaces for the entry of data has been seen as the largest obstacle to the clinical use of computers (Poon & Fagen, 1994).

For over twenty five years work has progressed towards enabling the capture of clinician generated data (Zafar et al, 1999), but this has been problematic with clinicians resisting keyboard-based data entry (Shiffman et al, circa 1997). Thus, a variety of alternative methods such as pen based entry, menus, pick boxes and speech recognition have been examined. Speech recognition, for example, is now a viable technology for dictation and transcription applications (Clark, 1998), having developed substantially since the late 1980s when specialists, such as Radiologists, used discrete speaking styles to generate data via expensive systems having specialised vocabularies (Essex, 1999). Equally, pen-based data entry methods have progressed. For example, projects such as PEN-Ivory have developed interfaces which enable clinicians to create progress notes (from a controlled vocabulary) using simple pen-based gestures, such as the circling and scratching out of words on screen, within a structured interface (Poon, 1995).

Although developments have occurred, further advances are required as no technology has adequately dealt with EHCR data input problems (Dalander et al, 1997). Thus, the

need for physicians themselves to enter data remains a barrier to the use of EHCRs (Strasberg & Tudiver, 1999).

3.2.2 Standardised clinical terminologies for EHCRs

Over a century ago developments began to enable the systematic collection of medical data in such a way that statistics regarding morbidity (i.e. the state of being diseased) and mortality could be generated and compared on a national and international basis (Rector et al, 1994). The process of systematically collecting and recording this information is based upon various combinations of the following:

- classifications – a structure framework arrangement of similar groups;

- nomenclatures – also known as vocabularies which are predetermined sets of words available for the naming or describing of phenomena within a knowledge base / language;

- coding schemes – hierarchically structured alphanumeric terms defined to represent a clinical term (e.g. T-20000 represents the respiratory system, T-28000 the lungs and T-28010 the alveoli, hence the derivation of T-28014 to represent the term "Alveolar duct of lung" can be seen) (McCormick & Jones, 1998).

Numerous schemes have been developed so that, currently, there are in excess of 150 known (Blair, 1998), including the following:

- Read codes – developed in the UK, version 3 aims to be a common clinical terminology and coding scheme for use within the NHS for describing the care and treatment of patients;

- ICD-10 (International Classification of Diseases version 10) - utilised for the classification of morbidity and mortality information for statistical purposes;

- SNOMED (Systematic Nomenclature of Human and Veterinary Medicine) – has a multiaxial code structure which allows it to give improved clinical specificity over other codes being designed to permit the indexing of the entire medical record (Kudla & Rallins, 1998);

- LONIC (Logical Observation, Names, Identifiers and Codes) – which gives names and codes for the unique identification of laboratory and clinical observations.

Traditionally, schemes have been developed for a specific purpose. However, the goal orientated nature of many developments means that schemes are often unsuitable for use in spheres for which they were not designed. For example, a scheme designed for the definition of nursing intensity might describe a patient's characteristics in a way which enables the care resources required to be determined. Equally, a scheme designed to enable the effective billing of care might only describe processes which can be charged for (Zielstorff, 1998). Hence, each is effectively limited to its application and utilisation within the intended deployment area.

Despite this goal oriented development background, schemes such as SNOMED have, more recently, been developed / expanded to try and accommodate the encoding of the patient record. However, a recent study found that when existing schemes (i.e. the most commonly used, including SNOMED, ICD-10 and Read), where applied to the current paper-based patient records, most lost over 50% of the underlying information (Cohn & Chute, 1997).

This situation has major implications for EHCRs, which offer the opportunity to hold far more patient data (especially multimedia data) than existing paper records. So, without more comprehensive, or comparable, schemes being available the proportion of information in EHCRs not captured and encoded would rise. This would result in only a small proportion of the data available being encoded. Thus, only a small proportion of care provision could be improved by the analysis of the encoded data available. This would seriously limit the benefits which EHCRs could bring to care provision as the progression of knowledge concerning both the distribution and causes of diseases which schemes facilitate would be held back. Hence, the development of standardised clinical terminologies is necessary to further EHCR development and deployment.

3.2.3 EHCR security

The third issue discussed is that of security. Medical records contain a variety of information, some sensitive (e.g. details of sexual behaviour, psychiatric care, substance abuse and HIV status), and some generally regarded as non sensitive (e.g. patient height) (Rindfleish, 1997). It is important that patients have confidence in the security of their

records, if not, they may feel unable to reveal sensitive information to clinicians which may ultimately result in them not receiving the most appropriate care (Fuller, 1997). Equally, breaches in security of medical records may have far reaching consequences. Patients may be embarrassed by the disclosure of certain information (Pangalos, 1998), or limited in their ability to obtain insurance or employment, whilst HCEs may face litigation and financial penalties.

Although technical and procedural measures are generally deployed within health care systems to improve security, at present the vast majority of breaches associated with computer data occur when individuals fail to adhere to procedural measures designed to protect patient privacy (Picard, 1998). For example, users may have ids and passwords taped to monitors, or workstations logged in and unattended (enabling information to be accessed by unauthorised persons) (La Rochelle, 1999). Equally, users may misuse their privileges to "browse" information relating to friends / family or other individuals of interest (Kibbe & Bard, 1997).

To aid the security of health information work has been / is being conducted in both the technical and procedural arenas. Technical measures exist to deter and thwart security breaches in the form of security deterrents and obstacles. Deterrents to aid security may include system alerts and reminders, and audit trails (recording user activities such as data access, addition, deleting and alteration) (Murphy, 1996). Alternatively, obstacles include the following:

- authentication (passwords etc.);

- authorisation (access rights etc.);

- data encryption (to prevent the unauthorised viewing of data);

- digital signatures (validating data entry);

- data integrity management (such as the use of cryptographic checksums to ensure data has not been altered).

Equally, technological advances mean that in the future biometric measures (such as finger print and signature verification) and smart card technologies may be utilised. A plethora of other advances are also being developed such as label based access. This involves the operating system assigning access to data according to the security level of the data rather than the user. Thus, data cannot be sent by a legitimate user to one not authorised to view it. However, having stated that technical measures can be deployed to aid security, this must occur in the context of a security program where both procedural and technical measures are combined to collectively achieve a greater degree of security.

The development and implementation of EHCRs will result in systems holding more data which may be available to a greater number of people (ACHE, 1997). This means that potentially more people have the opportunity to not only access but also copy, alter or delete more patient information. Thus, adequate security is a requirement of the EHCR, and until both clinicians and patient have confidence in the security of EHCRs their development and deployment will be arrested.

3.2.4 EHCR and the integration of information sources

Clinicians tend to utilise a variety of information sources (e.g. data from departmental and clinical systems, journals etc.) while providing care. So, if EHCRs are to become an integral part of care provision, their utilisation must be within an environment where information sources are easily accessed (Shortliffe, 1999).

The need for clinicians to access information sources, and the existing situation where numerous disparate systems (information sources) are deployed within HCEs, has produced the "enterprise network" or "intranet" model of EHCRs. This model links systems via an Intranet so that a data repository, or clinical database, acts as a means of collating and integrating information from various systems (Shortliffe, 1998). This gives singular access to existing electronic patient data, thereby increasing the availability of information to clinicians. Hence, this model can be viewed as being a progression towards EHCRs, especially as the amount of information centralised can increase as further systems are deployed. Developments of this type, which can be thought of as virtual patient records generated from existing data, form some of the most comprehensive and advanced developments towards EHCRs. So, to give an appreciation of progress to date a small number of implementations are reviewed in the next section.

3.3 Examples of EHCR projects

The Integrated Clinical Work Station (ICWS) is a paediatric EHCR based at the Children's Hospital (Boston). It utilises a client / server architecture to enable the

retrieval and display of patient data (including demographics, pharmacy orders, lab results etc), added to the Integrated Hospital Information System (IHIS), via departmental applications (EMRS, 1994).

Further data (such as problem lists, bedside measures, family history etc.) can also be added to the IHIS, via the ICWS. This is achieved by using electronic forms to enter data, either via direct clinician data entry or by transcribing data recorded by clinicians on paper versions of the ICWS forms (Kohane, 1994). Initially, in 1991, the ICWS was implemented only in the Endocrinology department, but after three years its deployment was extended to Nephrology and Nuclear Medicine (data retrieval only) and planned for other departments (Kohane, 1995). Also, within the HCE a critical care data management system has been implemented within the Multidisciplinary Intensive Care Unit (MICU), enabling the units' bedside monitoring device data to be presented through the ICWS (Fackler & Kohane, 1997).

Following on from the ICWS, in 1994 MIT and the Children's Hospital Boston presented a proposal (EMRS, 1994), called the World Wide Web Electronic Medical Records System (W3-EMRS). This project aimed to develop an Internet based system to access multiple heterogeneous EHCRs (W3-EMRS Project, 2000). The project used an architecture comprising of the following:

- Common Medical Record – describing an information model, vocabularies and transactions common to multiple legacy EHCRs;

- visual presentation layer – describing the layout of elements of data in the CMR and user action responses;

- screen rendering layer – enabling the presentation of data when different interface technologies are used (e.g. W3, Visual Basic etc.) (van Wingerde et al, 1996).

The first achievement of the research was to use the database of a paediatric EHCRs at the Children's Hospital (i.e. the ICWS), so that "scrubbed" data (i.e. data with all patient identifiers removed) could be accessed over the web (Kohane et al, 1996). This work was then extended so that all the IHIS could be accessed via the web. However, to progress the work towards the accessing of multiple heterogeneous EHCRs, the Children's Hospital, MIT, Massachusetts General Hospital and the Beth Israel Hospital Boston formed the "Boston Electronic Medical Collaborative" in 1995 (W3-EMRS Project, 2000). The collaborative aimed to make available in A&E, patient data from multiple institutions (the three defined) so that evaluation and treatment of patients could be improved. Due to the lack of sufficient and appropriate security measures being in place, "scrubbed" data obtained from test databases outside the participating HCEs was utilised, thus, any threat to the confidentiality of patient information was avoided (Rind et al, 1997).

The system utilised the W3-EMRS architecture by implementing the following;

- web browser – acting as the screen rendering layer;

- Aggultinator – corresponds to the visual presentation layer by mediating between the users and the different EHCR sites. It gathers data from the various site, formats it and generates an appropriate HTML shown to the user;

- site servers – emulate the CMR by receiving requests from the Aggultinator (in the form of HL-7 messages), query the appropriate databases and return appropriate data (in the form of HL-7 messages) to the Aggultinator (van Wingerde et al, 1996).

Another version of the W3-EMRS, originally developed to link the Beth Israel and Deaconess HCEs in Boston, has also been developed (Fraser et al, 1997). CareWeb is an enterprise-wide clinical information network (based on the W3-EMRS architecture) which enables A&E clinicians at the Beth Israel HCE to access patient information (including patient histories, medications, allergies and images) from four HCEs and a number of associated clinics (Dakins, 1999). It enables users to obtain, in a singular form, patient information from a number of associated HCEs. A web browser is used as a means of entering a request for information (usually in the form of a patient identifier such as name, gender and DOB (Dakins, 1998)). The "Consolidator" then requests information (in the form of HL-7 messages) from the site servers of the associated HCEs. The site servers then translate requests into appropriate legacy system queries so that the required information is obtained (CareWeb Architecture, 1998). Finally, the patient information (in the form of HL-7 messages) is returned by the servers to the consolidator

which structures and presents it in the form of a virtual patient record comprised of the amalgamated data (Halamka et al, 2000).

Another example of a web technology based system is that of the VEMR (Virtual Electronic Medical Record), which consists of a web browser, HTTP information server, Medical Record Generator application, and data capture and integration technologies (Kazmer et al, 1998). The VEMR accesses the data held on the existing systems, collects it as objects, filters and organises it (using the Medical Record Generator), and permits its viewing by the use of a Web browser. To date the system is available throughout the Virginia Neurological Institute (VNI) and the University of Virginia's Health Sciences Centre's Department of Neurosurgery. Future planned developments include the display of complex data (such as graphs and ECG waveforms), the profiling of users to pre-fetch regularly accessed data types the extension of data entry applications, and the standardising of the record interface (the support of more transfer and presentation standards).

ARTEMIS (Advanced Research Testbed for Medical InformaticS) was a five year project started in 1993. The project aimed to aid collaboration between different types of clinicians in various distributed locations (Jagannathan et al, 1995). Its goal was to permit distributed multimedia patient information (such as medical histories, progress notes, images and laboratory reports), forming a virtual record, to be accessed via a web browser from patient record servers (CERC, circa 1997). Authorised clinicians view patient data (customised to their needs), and perform other operations such as the referral

of patients (achieved via multimedia mail), dictations and the scanning in of paper documents. Equally, consultations can be conducted through desktop video conferencing, which permits the shared viewing of the virtual multimedia medical patient records. The advances made are currently being commercialised by CareFlow / Net Inc., and utilised within the "Secure Collaboration Technology for Rural Clinical Telemedicine" project (Reddy & Jagannathan, circa 1997).

Although the USA, because of its greater deployment and utilisation of systems, has tended to lead the way in the integration of systems data giving virtual patient records, corresponding to elements of the EHCR, work is progressing in the UK. For example, over five years the Robert Jones and Agnes Hunt (RJAH) Orthopaedic and District NHS Trust, in association with Graphnet computer systems, has completed a three stage EHCR project. In 1994, the Trust produced electronic data via PAS and word processing applications, and communicated the data via a TCP / IP network. The first stage of the project consisted of a study commissioned by the Trust and performed by Graphnet. The study found that Standard Generalised Mark-up Language (SGML) could form an affordable framework for an EHCR, and involved the production of a mock-up system where SGML was used to present dummy data to emulate elements of an EHCR.

In 1996, a program jointly funded by Graphnet and the NHS EPR (Electronic Patient Record) program was established (stage two), to collect clinical data and examine the ways in which it could be both delivered / presented and analysed. Electronic data from 700 patients was collected from the existing systems. Subsequently 14 patients had

additional data in the form of X-rays, digital scans etc., added so that SGML records were given. Initially, these records could be examined and searched. However, additional functionality (e.g. the request and signing off test results and reports) was given by the development and utilisation of a new medical browser.

The final stage of the project (1998–1999), aimed to extend the work done to provide live textual data to the Children's and Professorial Units, so that the value of structured mark-up could be demonstrated. Approximately 300,000 documents were created from data obtained from various systems (e.g. PAS and the investigation results system at the Royal Shrewsbury Hospital). Users could examine patient data (including prescriptions, discharge summaries, procedure reports etc., from up to five years previous), using a specially developed "viewer" which obtained relevant patient documents from a server and presented them in a structure way (Leeming et al, 1999).

Other UK based work has taken the form of the NHS "Electronic Patient Record program" (EPR program), a three year strategic research and development project started in 1994. Ultimately, it aimed to advance the acute sector's development of shared electronic patient records to aid more effective care. Although the program was never designed to cover all elements constituting an EHCR (NHS Executive (a), 1998), it did aim to demonstrate how systems could be used to capture clinical information and improve the quality and efficiency of care provision. To do this, two demonstrator sites at the Burton and Wirral Hospitals NHS Trusts were defined.

At Wirral the EPR program (comprised of a number of sub-programs such as clinical terms, decision support / rules, electronic prescribing etc. (NHS Executive (b), 1998)), aimed to integrate a suite of systems to support the hospital's activities, and create elements of an EHCR (Spours & Marsh, 1996). The Patient Care Information System (PCIS) provides an interface between all the existing hospital systems, so that the following data is held by what is known as the PPR (Permanent Patient Record):

- patient demographics;

- admissions;

- admitting diagnosis;

- clinical requests, orders and prescriptions;

- history and physical examinations;

- nursing documentation;

- graphical representations of data (e.g. vital signs);

- allied health progressive notes (e.g. dieticians);

- discharge summaries.

The system enables data to be entered in a variety of ways (e.g. light pen, mouse, keyboard etc.), supports multiple user access, and has established links to the practices of six GPs so that they can inquire as to their patients clinical progress. Thus, the system effectively utilises its existing systems (extending them where appropriate) to give an online PPR (Spours, 1996).

Meanwhile, at Burton, elements of an EHCR were developed and included the following capabilities:

- problems lists - recording the presenting problem, working diagnosis and discharge diagnosis;

- prescribing and drug administration (digital signatures are implemented for the secure signing off of laboratory reports);

- the production of all discharge slips and letters;

- automatic flagging of completed results awaiting attention;

- speciality modules - enabling additional information to be collected for clinical audit purposes.

From the experiences of the EPR program, an incremental approach, called the "Six Level Model", for the development of EHCRs was defined. This model gradually adds functionality to a base IT level where departmental systems and a PAS are present (Decvlin et al, 1997). The model takes the approach that if clinicians are given the correct means (including IT) of improving the process of caring for patients, then an EHCR will be given as a result of care provision occurring (Leeming et at, 1999). The model is briefly defined as follows, with the paper based-patient records retained as the primary source of patient information in all levels except six:

- level 1- partial implementation of PAS, some casemix / Executive Information Systems (EIS) analysis, limited departmental systems (Pathology, Radiology and Pharmacy);

- level 2 – full PAS implementation, casemix and EIS systems, numerous departmental systems;

- level 3 – some order communications / result reporting in addition to level 2;

- level 4 – full order communications / results reporting, extensive departmental systems, some clinical care systems and care planning and multidisciplinary care in addition to level 3;

- level 5 – electronic prescribing, some decision support, some work flow and imaging, some integration of clinical systems in addition to level 4;

- level 6 – full EHCRs, clinical decision support / rules, extensive work flow, imaging, electronic availability of patient records and ability to analyse EHCR information.

This model, which provides an incremental pathway to an EHCR, has been utilised to enable targets, defined in Information for Health, to be set to progress EHCR in the UK.

3.4 Future development

Within this chapter it has only been possible to briefly outline the barriers to the further development of EHCRs, and some of the work done to surmount them. Equally, there

has only been time to review certain types of project developments and some of the work undertaken by the NHS.

A review of the projects commented on shows that they have demonstrated and progressed the capture, sharing and utilisation of electronic patient data, achieving a number of EHCR elements. Equally, the success of these developments, in conjunction with technological advances, has enabled some HCEs (especially in the USA) to implement systems, via differing technologies, and achieve some EHCR elements, such as the following:

- electronic prescribing;

- laboratory results;

- availability of digital images and traces (within and between HCEs);

- operation / procedure notes / reports;

- patient histories (Schoenfelt, 1999).

However, it is the case that despite the advances made, a review of the general level of progress towards electronic records shows that EHCRs are some way off. In fact in many cases it is felt that patient records are generally similar to those of thirty years ago, except that now they are thicker, and that; *"the majority of talk about the computerisation of patient records has been just that"* (Dorenfest, 1997). Equally, for example, even in the UK which is ahead of many European countries in its clinical use of IT (Cross, 1999),

systems hold 600 million records, ten for every person, and only 10% of HCEs have integrated clinical and management systems.

The lack of general progress towards EHCRs is also apparent when, for example, considering the latest UK health care strategy document "Information for Health". This defines targets which healthcare organisations should achieve. For example, by 2005 all acute Trusts should achieve level three of the six level model (described earlier). However, it can be seen that level three is still a long way from the EHCR goal as defined in chapter two.

By looking again at the projects discussed, and numerous others, it can be seen that no true EHCR has yet been achieved. Examination of the projects shows that, rather than the realisation of the EHCR goal, in the main the work has enabled coalescing and presentation of patient data, generally residing within and captured by existing systems, forming limited virtual patient records. This statement is not meant to degrade the work done, as the results obtained when compared to paper-based record are an immense advance, it is merely meant to re-enforce the fact that EHCRs as defined by Dick & Steen do not exist.

As there are no EHCRs which provide a comprehensive and composite framework through which all patient data (especially multimedia data) can be generated, recorded and presented as care is delivered, this research project was defined. The work done towards the creation of a composite and comprehensive multimedia EHCR which also

acts as a tool for all patient care provision is described in the next five chapters of the thesis.

Chapter 4

Research environment and findings

Introduction

This chapter examines the work conducted to define care provision and establish the requirements of a Multimedia Electronic Health Care Record (MEHCR). There is a discussion of the preliminary examination of a HCE and the subsequent definition and composition of the project's research base. In addition, the chapter describes the collection and modelling of the information gathered. Finally, the chapter defines the findings of the research which enable the nature of care provision to be comprehended and the MEHCR's requirements established.

4.1 Research context

The previous two chapters have reviewed the need for, barriers to and the current progress of EHCRs. Equally, the chapters have shown that despite numerous developments there are, at present, no EHCRs which possess the structures and capabilities necessary to facilitate all aspects of care provision in conjunction with the generation / creation, recording, organisation, manipulation, display and utilisation of all patient data, including multimedia patient data. Hence, this project was embarked upon to achieve an EHCR capable of the following:

- effective support of all care activities which collectively constitute patient care provision;

- seamless creation, during care provision, and maintenance of a comprehensive and composite multimedia patient record.

As the aim of this research project is focused upon both facilitating and recording all patient care, including all multimedia data, the desired system is referred to as a Multimedia Electronic Health Care Record (MEHCR). The term MEHCR is used to emphasise that the system being defined is different from others collectively known as EHCRs which may achieve aspects of what was envisaged by the IOM and some use of multimedia data.

To achieve the project goal a Health Care Establishment (HCE) was required to facilitate access to the care provision system, so that its nature could be defined and

the requirements of the desired MEHCR comprehensively established. Consequently, a local HCE, Derriford Hospital (part of the Plymouth Hospitals NHS Trust), was approached for assistance and agreed to help.

It should be noted at this point that the definition and integration of HCE organisation management functions (e.g. service planning, finance etc.) did not form a primary part of the project's goal (which focused upon facilitating care provision and recording) as it was felt that these functions could be integrated with and enhanced by the project's resultant developments.

4.2 Clinical investigations

Within HCEs there are a large number of specialised departments which collectively provide a range of patient care services. For each patient, the collective services within a HCE may or may not be sufficient for the provision of that patient's care. If not then the appropriate departmental services of other HCEs may be utilised.

The diverse and multidisciplinary nature of care provision within and between HCEs means that, to be truly comprehensive, research to define care provision and subsequently the requirements of a MEHCR would have to be conducted on a vast scale throughout and between numerous HCEs. The project, however, did not posses sufficient resources for this so an alternative means of facilitating the definition of the MEHCR's requirements was necessary. Thus, a preliminary review of HCE-based

care provision was conducted to find a way of enabling the required comprehensive research to occur on a reduced scale.

The preliminary review involved discussing with personnel (e.g. consultants, nurses and administrators) the workings of Derriford and other HCEs they had experience of. From these discussions it was possible to create a basic overview of care provision both within Derriford and between Derriford and other HCEs.

The overview clearly showed the complex and multidisciplinary nature of care provision. Equally, it showed that there are differences and similarities within and between HCE operations at a number of levels. For example, departments or individuals may operate in similar ways when patients are being given appointments, or in very different ways when direct patient care is being administered. Fortunately, due to the similarities identified it was felt that the comprehensive research required for the project could be conducted within a single HCE and within manageable, but representative, sub-set of departments. Derriford continued with its assistance and a number of its departments were selected to form the representative sub-set of departments, known as the project's "MEHCR research base".

4.2.1 MEHCR research base

The research base consisted of a number of departments, one of which was chosen as its centre or focal point. This department was known as the "base" department and selected as a means of illustrating how care provision is not only provided by a

department (i.e. its collective resources) but also managed and co-ordinated to enable the collective resources of other HCE departments to be utilised as required within patient care (the term resource was applied to any entity found within the HCE, e.g. individuals, accommodation, equipment and information).

A number of other HCE departments were selected to act as "associated" departments. These departments were chosen to demonstrate how a resource, or collection of resources within one department, may be utilised at the behest of another department so that as a whole the patient receives comprehensive care provision.

The ENT (Ear Nose and Throat) department was selected as the base department for the research as it:

- runs its own clinics;

- has a surgical and ward based roles;

- utilises the resources of other HCE and community departments during care provision (e.g. Radiology and community based Speech Therapy);

- is involved in a number of specialised clinic groups working closely with other HCE departments;

- contains a variety of staff types (e.g. Consultants, Receptionists, Nurses etc.);

- utilises multimedia clinical data (i.e. audio, video, text, images and graphics);

- utilises advanced medical techniques.

Thus, the complex and varied operations of the ENT department can be seen to be those which a composite and comprehensive MEHCR must enhance and support. Having selected ENT as the base department, a number of HCE departments became obvious choices for the associated departments as they provide resources / services to, and work closely with, ENT. The departments selected as associated departments are as follows:

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- Maxillo-Facial;

- Dental Specialities;

- Radiology;

- Radiotherapy;

- Medical Photography;

- General Surgery;

- Plastic Surgery;

- Microbiology;

- Information department;

- Medical Records;

- Speech Therapy.

Also included within the research base were two community-based departments; Paediatrics and Speech Therapy, to ensure that the research accounted for their needs.

An overview of the structure of the research base and the participating departments is shown in Figure 4.1 along with the ways in which the patient can enter the HCE based care provision system.
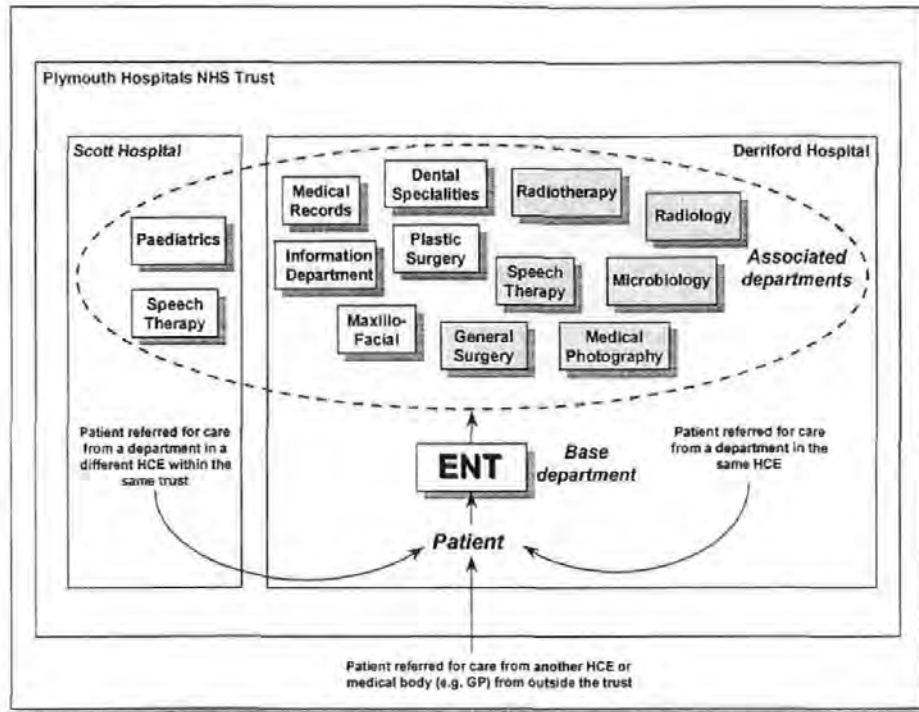
Figure 4.1 - Research base

4.3 Data collection

To define care provision fully, and thus the requirements of the MEHCR, it was determined that the process of care provision as a whole facilitating comprehensive patient care within and between departments (as witnessed within the research base) should be established and analysed. To do this meant that information concerning the operations and utilisation of all the resources present (e.g. staff, equipment, systems

etc.) needed to be gathered. To achieve this successfully, the data collection process had to utilise appropriate methods.

After some consideration, interviews were selected as an appropriate data collection method, as they are a valuable and established technique for the discovery of facts and the defining of processes. They were used in preference to questionnaires as these have a tendency to give low response rates throughout the sample in which they are distributed (Ackroyd & Hughes, 1992). A low response rate in this case may have resulted in numerous facts, and subsequently requirements, not being identified. It was also felt that the use of interviews, with their inherent ability to comprehensively solicit and explore the views of participants, would enable the real information needs of users to be established (Wilson, 1995), and any perceived problems associated with the development, implementation and future requirements of the MEHCR to be identified.

4.3.1 Interview techniques

There are two extreme types of interview techniques:

- standardised or structured;
- non-standard or unstructured.

Structured interviews are interviews in which an interview schedule is closely adhered to. Thus, any differences in responses are not due to variations in questioning. This

type of research technique is widely used in fields such as market research where a particular interviewee preference, view, or role with respect to a particular subject, is sought (Ackroyd & Hughes, 1992). Unstructured interviews, however, are interviews in which a very broad schedule is referenced by the interviewer. The interviewer is free to ask a range of questions about a subject area in a conversational manner, allowing the interviewee to fully express their views and findings about a subject (Fielding, 1993).

For this project, when deciding on the type of interview to be used, the purpose of the data collected was considered. Here, the data had to facilitate the comprehensive definition of health care provision establishing the roles, operations and utilisation of different resources. It was hoped that from this information both common and specialised (more individual) resource requirements could be identified.

To determine common requirements, a highly structured approach permitting the gathering and comparison of like data is required. However, to determine specialised, even unique, requirements some form of loose discussion is necessary. This being the case, a semi-structured interview methodology was adopted for the data collection process. This methodology combines structured and unstructured techniques and benefits (Fielding, 1993), and therefore enabled the interviews to achieve the desired results.

4.3.2 Interview schedule structure

A semi-structured interview schedule was carefully designed for the project. It was designed to be used with all participants (i.e. HCE staff), and cover all aspects of the care provision process so that all resources involved and their operations and utilisation could be determined.

The schedule itself was split into eleven sections, ten of which represented distinct areas of health care provision, while the other dealt with the future of IT systems in health care (a copy of the questionnaire used can be found in Appendix A). The interview schedule was sectioned so that if a member of staff played no part in a particular area of health care provision (such as the use of specialised clinical systems), then the relevant interview area could be omitted and the flow of the interview remained uninterrupted. The eleven subject areas were as follows:

- definition of job and duties;

- dealings with patients;

- patient referrals and appointments;

- patient records;

- patient data items;

- patient data generation, processing and interpretation;

- use of PAS;

- administrative departmental systems;

- specialised clinical departmental systems;

- IT systems (general);

- future systems development.

The first ten interview areas, comprised a number of questions which were designed to comprehensively determine the workplace role of the interviewee with respect to a particular aspect of their work (e.g. their utilisation of the patient records). The final section aimed to establish attitudes to IT, and future requirements for the proposed system. Within each interview area, a number of direct questions were asked, and then, if appropriate, the interviewee was asked to expand upon the answers. In this way the standardisation of certain responses (and thus requirements) was achieved. In conjunction with this, the discursive nature of other questions within each area enabled a range of more individual modes of workplace operations to be established, and thus the more individual and specialised resource requirements to be obtained and defined.

The interviews were conducted throughout the base and associated departments. There were just over ten interviews conducted in the base department, two interviews generally being conducted with each staff type found in the department. A number of interviews were also performed with the staff working on the base department wards, so that a complete picture of the care provision could be constructed.

In each of the associated departments between two and ten interviews were conducted. The exact number depended on the nature of the department and the number of staff types found therein. More interviews tended to be conducted in the departments

which had a multifaceted care provision role (e.g. Dental Specialities), which provide care directly and via the utilisation of other department's resources. Equally, these departments tended to have more resources present performing a greater variety of operations and being utilised in a greater number of ways.

The use of discursive interviews and the interview schedule proved to be very successful, with the staff interviewed talking freely and confidently about all facets of their workplace responsibilities and roles, and enabling sufficient information to be gathered to define the operations of individuals and their departments as a whole. It should be noted that, due to the nature of the project (which relied upon HCE staff giving up their own time), occasionally only one member of a specific staff type within a department could be interviewed. However, it was felt that this did not diminish the comprehensive nature of the research as interviewees:

- frequently referred to the work of others in relation to themselves:
- were very accommodating when asked to help sometime after the interview in filling in information gaps.

In addition to the interviews just discussed a small number of different interview sessions were also conducted with some of the more senior staff members, heads of departments and system managers. These interviews focused upon departmental, and IT system roles and development within the HCE as a whole, and enabled an overall picture of the department's operations within the HCE to be established. They also enabled the current pressures exerted upon the departments, their IT systems and other

resources, along with their plans for future developments, to be established and discussed.

Thus, the interviews conducted (around 53 in all) enabled the information required to determine the process of care provision to be comprehensively defined. As such, their utilisation within the data collection process was felt to be a complete success.

4.3.3 Other data collection techniques

A problem, which became obvious as the research progressed, was that of the MEHCR's practical use. This concerned how staff were to interact with the MEHCR without compromising clinical care in a variety of situations and how the MEHCR was to be physically integrated into the existing care provision environment. To examine this particular problem further, it was decided to perform a number of practical clinic analysis sessions.

Each clinic analysis session involved the careful observance of a departmental clinic. During the sessions, the flow of patients and HCE resources (such as staff, equipment, records and information), into, around and from the clinic was noted. Equally, the way resources were utilised (e.g. how, where and by whom patient records were transported, examined and added to) was recorded, along with the operations performed by different resources (e.g. the receptionist (being a resource within the department) accesses the PAS to check patient details on arrival, ticks the patient off on the clinic list, checks the patient's details in the their records and places the records

on the front of the reception desk for collection by the nurse). In this way it was possible to identify numerous problems associated with the practical use of the paper-based records (e.g. they can only be in one place at any one time, transport overheads are incurred to try to ensure their availability as required, the difficulty in searching the records for information etc.), which the MEHCR must overcome.

Further work was also performed to examine and determine the current structure, presentation, content, use and problems of the patient records. Here, the term patient records includes the main HCE records and separate departmental and media records (such as those in Radiology, Plastic Surgery and Speech Therapy, which were usually created because the main HCE records are unsuitable for the storage of the clinical data produced by, or used by, the department). This enabled what the users really wanted, and needed, from them to be determined. The work was accomplished by getting staff to demonstrate the circumstances in which they entered, searched and utilised the records. There were discussions as to the practical problems which the staff encountered with respect to the use of the records (as follows):

- physical state - records may be in poor condition (paper is ripped, soiled etc.) making their use problematic;

- non-uniformity - clinicians have very different styles of data recording and presentation and the lack of consistency can cause difficulties in the identification and comprehension of information;

- coding – after care is recorded it needs to be formally coded, this requires the records to be sent back to the Medical Records department whenever possible (further administrative overhead);

- unavailability of data – data may be missing from records having been removed or never added. Equally, records as a whole may be mislaid or lost. Also, because different types of records are utilised, clinicians may be unaware of the existence of particular records (e.g. departmental records) and therefore of any data therein. Thus, to them, it is unavailable. Finally, as records can only be in one place at a time they are frequently unavailable as required;

- paper nature – makes the records difficult to search for information (searches are manual and can be very time consuming);

- size - records may form two or more folders and be difficult to handle and obtain information from;

- time delay - delays in physically obtaining the records may occur;

- time spans - the fact that the records may cover several years means that recording / presentational / structural forms may have altered over time, complicating their use;

- media - the lack of image, video and audio data to define and record patient problems directly increases the difficulty of assessing a patient's relative progress as there is a reliance on textual accounts and sometimes score counts.

The problems identified are analogous to those found by other researchers. For example, lost or missing records and the unavailability of records have been cited as problems (Johnson & Pesek, 1998), resulting in access to relevant information being prevented between 22% and 38% of the time (MRI (b), 1999).

The work also defined other constraints placed upon the staff with respect to the use of the records, such as the need to maintain some degree of patient "eye contact" whilst taking details, and examining data without showing their contents to unauthorised personnel.

For each type of record there was also a thorough inspection of a number of anonymous records, with each record being examined with respect to both its data content and presentation. Examining the record data content involved looking at the exact items of information required and recorded in different care provision situations (e.g. data necessary for X-ray requests and reports). The examinations revealed wide inconsistencies in the information present within the different types of patient records.

Analysing the presentation of data necessitated looking at the diverse use of different colours, the use of pictures, illustrations, short hand symbols, and clinical annotations, the display of items of clinical test data in the patient records. The examinations revealed a huge diversity of styles and methods for the recording of data (due to differences in clinical practices) and highlighted the problems this gives rise to for those examining the records. Equally, during this body of work, the ways in which information is added to the record were examined (e.g. paper inserted and written on,

the use of typed notes and pre-printed drawings annotated inserted into the record once complete etc.). Finally, there were discussions as to the possibilities which exist for the utilisation, recording and presentation of information in different media from that currently found (e.g. use of video for recording certain patient data etc.).

4.4 Model construction and analysis

From all the data collected (via the interviews, clinic analysis sessions and examinations of patient records), it was possible to comprehensively define care provision within the research base and construct a set of Patient Centric Models (PCM). The purpose of the PCM (which were data flow diagrams), was to show what resources were utilised and which operations they performed and when, as care provision progresses in accordance with the various needs a patient may have. As such, the PCM enabled every aspect of care provision to be graphically demonstrated, and facilitate its effective analysis. The analysis of care provision then enabled the requirements of the MEHCR to be defined. Figures 4.2 and 4.3 show parts of the PCM defining the patient referral (Appendix B contains complete examples of the PCM defined).
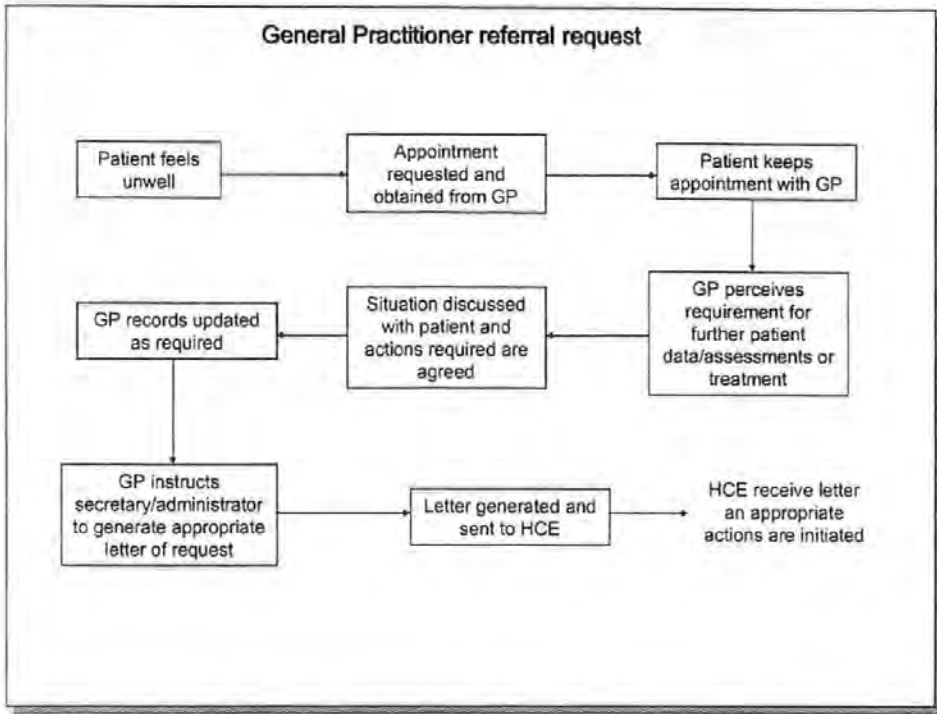
Figure 4.2 – PCM of GP referral request
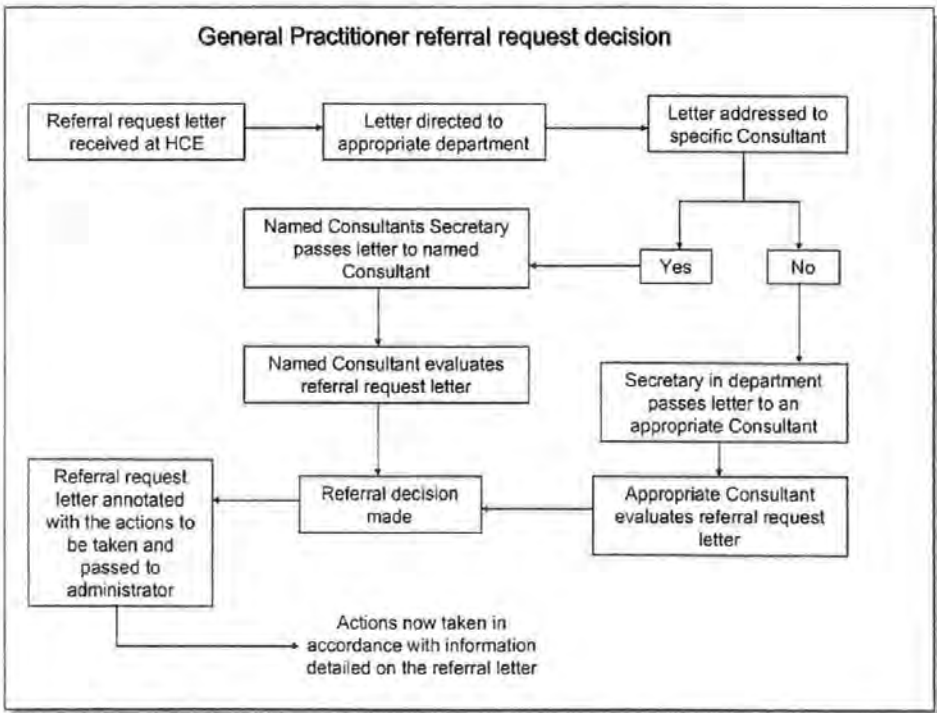
Figure 4.3 – PCM of GP referral request decision

The construction of the PCM also served as a checking mechanism as to the comprehensive nature of the research, as during their development any gaps or ambiguities in the information required to completely define all aspects of patient care provision were highlighted.

The models demonstrated the possible routes a patient might take (under the management of the base department, i.e. ENT), through the research base, as numerous care scenarios occur. Hence, almost every eventuality which might arise during the care of a patient within the ENT department was modelled. For example, one model showed the resources, their operations and utilisation during the referral of the patient from a GP to a department. Equally, other models defined the referral process from another HCE or HCE department, the various paths or routes the patient might take through the department (calling upon the resources of other departments / HCEs) etc., and the outcomes that patient care might have.

Thus, the models collectively enabled the presence and behaviour of HCE resources (such as staff, equipment, information etc.) involved in the facilitating of care provision, from the referral of the patient to their discharge, to be shown.

There are numerous other health care models (developed to either model aspects of care provision (such as business processes) or all elements of care activities), which tend be extremely detailed. These models are usually used as a means of checking or verifying findings before systems are developed to ensure requirements are not overlooked. By contrast the PCMs are simple and focused around patient care and the

use of the records during care provision. They were defined as a means of aiding the comprehension and analysis of the information gathered, so that the aim of the project (i.e. the defining of ideas to enable the development of a MEHCR) could be achieved. Thus, their primary purpose was not to act as an ultimate validating mechanism for the findings, but as an analysis tool.

However, the value of these sophisticated models would be seen if and when a full MEHCR system was developed (from the concepts defined). In such circumstances the designs would be validated against a sophisticated model (such as the NHS's Healthcare Model (HcM, 1998)), so that any omissions could be seen and rectified before full systems designs are completed and development occurs.

4.5 Care provision analysis findings

Collectively the models and all the information gathered enabled health care provision to be defined and analysed. This yielded a variety of findings, discussed in the following sections.

4.5.1 Care provision roles

The findings demonstrated clearly that care provision is comprised of a vast number of activities, only some of which will be necessary to constitute the care of a particular patient. By analysing care provision's constituent activities it was seen that at any one time the resources involved could be defined as assuming one of two care provision roles, as follows:

- consultative – resource(s) seen as responsible for enabling the accomplishment of the aspect of patient care under examination. This might involve the provision, management and planning of patient care and the utilisation of other resources to this end;

- service – resource(s) are seen as providing services at the behest / under the direction of a resource(s) acting in a consultative role to enable the aspect of patient care under examination to be accomplished.

For example, a nurse (nurse A) is made responsible for taking a patient's pulse and measuring their lung capacity. Nurse A performs one of the assessments and utilises another nurse (nurse B) to perform the other. Thus, the consulting role is given, as nurse A is seen to be both responsible for administering care (performing one assessment and for the utilisation and management of other resources to facilitate the other assessment). Equally, nurse B has a service role as she is providing a service to a patient (i.e. measuring of lung capacity) at the behest of another resource (nurse A).

The service role defined was further divided into three role sub-types as follows:

- clinical - a clinical service (such as an ECG examination) is done by one resource at the request of another;

- administrative - an administrative service (such as the booking of an appointment) is done by one resource at the request of another;

- consultative - a consulting role involving the co-ordination, planning and enacting of care provision is provided by one resource at the behest of another (e.g. clinical scans performed by a radiography for a neurosurgeon).

This information is depicted in Figure 4.4.
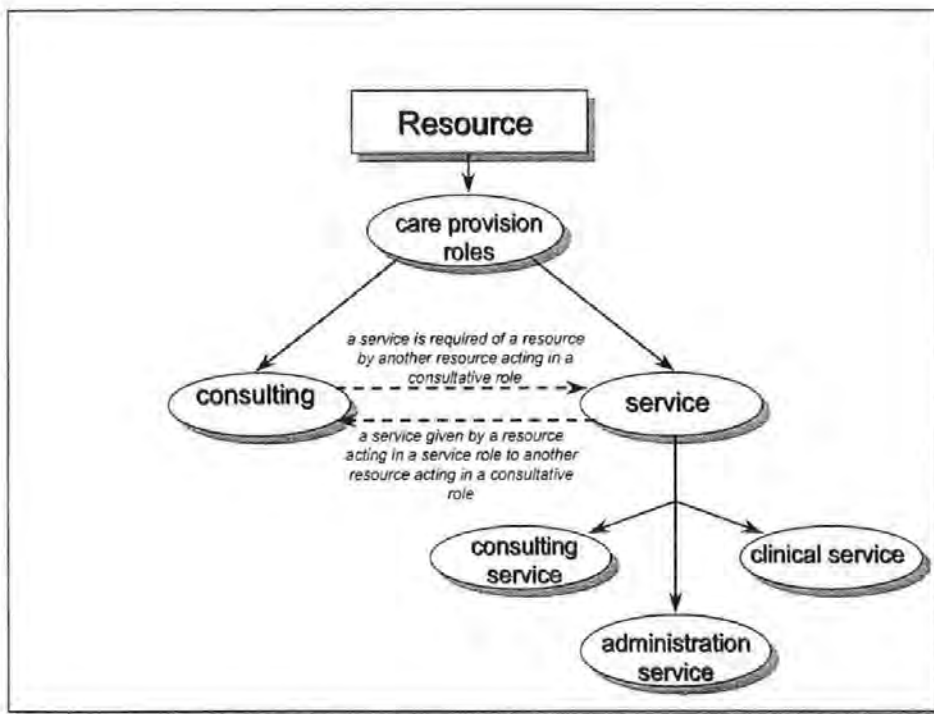
Figure 4.4 – Care provision roles

The definition of different care provision roles in accordance with the circumstance of a resource(s) operations (at any one time within a particular care provision activity) means that the real nature of care provision and its use of resources can be seen. Thus, by using care provision roles, it is possible to show how, for each care provision

activity they participate in, resource(s) may assume different roles depending on the aspect of care provision being examined at any one time. For example, an ENT consultant (consultant A) needs a patient to have a hearing test. Here consultant A is the resource responsible for the management and provision of patient care (when other resources may or may not be involved), thus, he has a consultative role. Equally, the Audiology clinician (clinician B) requested to perform the required hearing test is acting in a clinical service role to consultant A, as he provides consultant A with a clinical service. However, clinician B acts in or assumes a consultative service role within the auspices of Audiology as he may perform one part of the hearing test himself and direct another clinician (clinician C) in the performing of the other part of the test. Clinician C, whilst acting in a clinical service role to clinician B, also acts in a consultative service role when performing part of the hearing test, as he utilises and directs both Audiology equipment and a nurse. Figure 4.5 shows an overview of how the resources in the example assume different roles as time progresses and different aspects of care provision activities are examined.
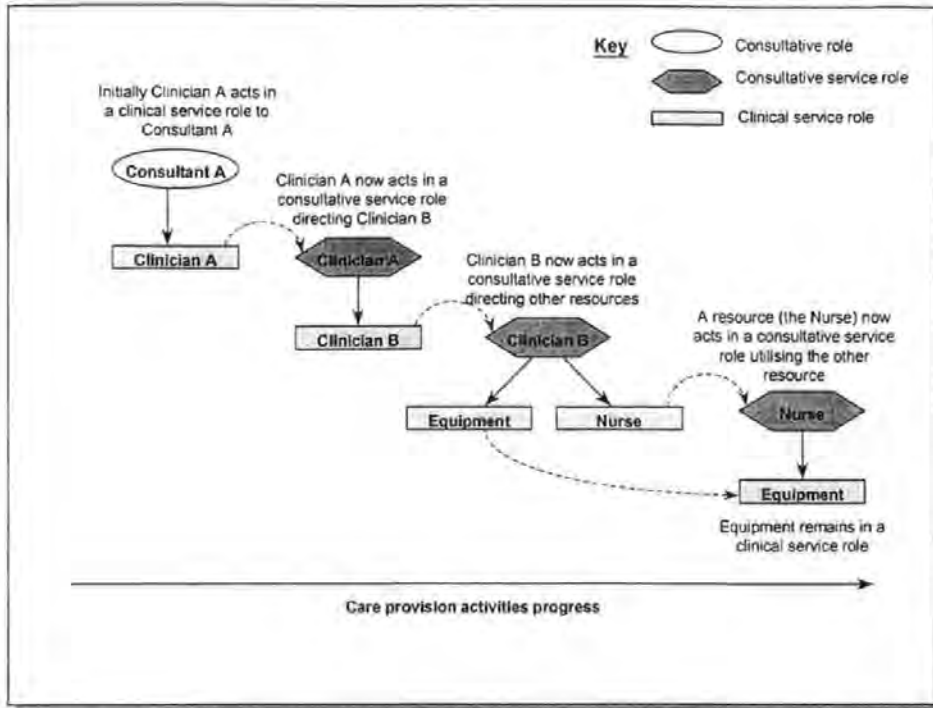
Figure 4.5 – Care provision role interchange

By defining different types of roles for resources, and how the roles assumed can change as care provision progresses and different care activities are completed, it can be seen that to aid care provision an MEHCR must support the resource roles defined and their dynamic nature during the care provision process.

4.5.2 Patient encounters

The previous section defined how HCE resources assume different roles depending on the aspect of the activity being accomplished at a particular time. However, the findings also revealed that the process of care provision (enabled by resources accomplishing various activities) tends to be structured on a departmental basis through encounters of various types. It was possible to classify or determine three

types of patient encounter which collectively enable all care provision activities to occur. The types of encounters determined were Consultations and Procedures (both primary types of encounters) and Departmental encounters (a secondary type of encounter).

In consultation encounters, patients are seen within a particular department (e.g. ENT). The clinician with whom the patient has the encounter is seen as responsible for overseeing all patient care arising from the encounter. During a consultation patients may be examined, assessed, consulted with, treated or have clinical tests all within one department, or be referred to one, or more, different HCE departments for clinical tests / examinations or assessments (each constitutes a departmental encounter within the departments used). For example, a patient might have a consultation encounter within ENT when he is actually examined. Then as part of the encounter the ENT consultant determines that an X-ray is required. The X-ray is associated with the encounter as it forms part of the care managed by ENT for that encounter. Equally, however, as the care provision associated with the X-ray occurs within the Radiology department, this part of the ENT encounter's care provision forms a departmental encounter within the Radiology department.

A procedure encounter, however, is one in which a patient broadly undergoes some kind of theatre-based surgical procedure under the direction of a particular department. As in the consultation encounter, the patient may utilise any resources within the department and, if necessary, the resources of other departments (this constitutes a departmental encounter within the appropriate departments). For

example, an ENT patient might undergo a biopsy procedure; this requires an ENT surgeon to perform the procedure, and the services of the Pathology department for the analysis of the biopsy sample.

Thus, during any consultation or procedure encounter, the patient may utilise all the resources and services of the department managing the patient's care. Equally, consultation and procedure encounters may give rise to departmental encounters, as the resources of the department other than that managing the encounter (in the form of clinical tests / examinations or assessments) are utilised to form part of the care given. Figure 4.6 gives and overview of how consultation and departmental encounters are related during the process of care provision (the situation is very similar for procedures and departmental encounter types).
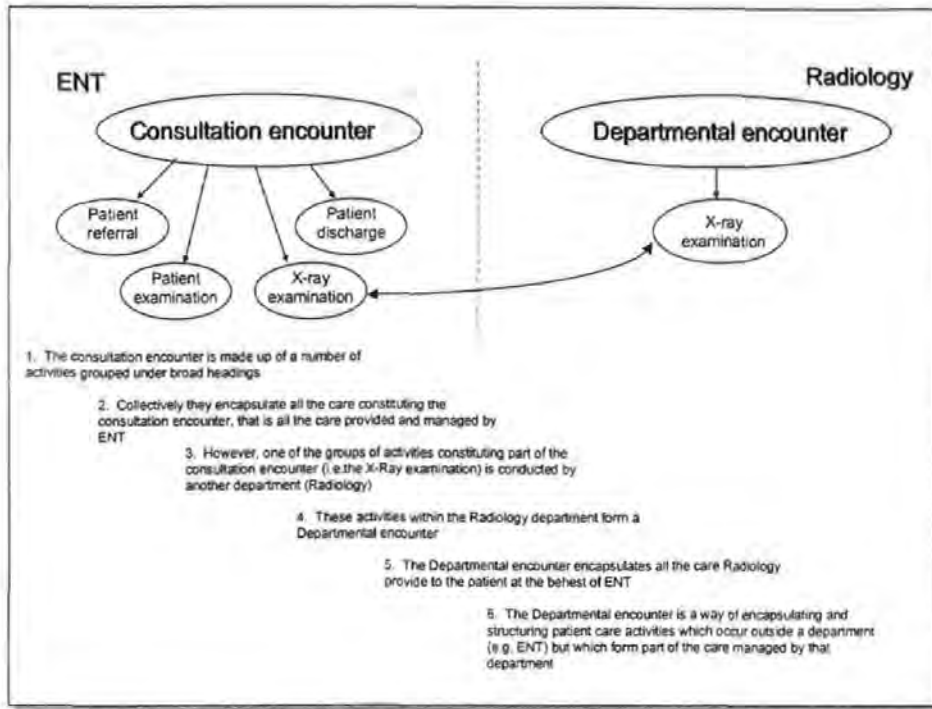
Figure 4.6 – Consultation and departmental encounter types.

It should be noted that the consultation and procedure encounters were defined on a logical basis to reflect what were seen as fundamental differences in the types and organisation of the various activities necessary to facilitate both the discussions with and examination and treatment of patients (consultations) and their surgical care (procedures).

Obviously, due to the diverse nature of care provision, there are numerous patient encounters which could be argued as constituting both consultation and procedures. For example, the removal of a mole on a patient's arm requiring a local anaesthetic could be defined as a procedure in that the patient has a surgical intervention in a theatre. However, the patient does not require pre-admission assessment, admission

to the wards or pre-procedural test / examinations, activities which are fundamental to constituting a procedure. So, here the encounter is seen as a consultation encounter within which the removal of the mole forms a consultation treatment.

Equally, different forms of biopsy are achieved via different encounter types. For example, a Liver biopsy might constitute a procedure encounter as a full theatre team, general anaesthetic, time in recovery and ward admission are required. However, a Breast biopsy may be accomplished as part of a consultation via a local anaesthetic. Thus, it can be seen that a patient's care needs are met primarily through consultation and procedure encounter types, but that the actual encounter type defined is determined by the nature of the care required in accordance with the encounter type definitions given.

4.5.2.1 Encounter care processes

It can be seen that the three types of encounter identified are, at a high level, the basic structures through which care provision is achieved. The types of encounters defined are themselves comprised of a number of different care process types. A care process type enables a substantive and logical aspect of care provision within an encounter to be achieved. From a care process type, a number of specific care processes are derived. Each care process enables the constituent care process activities to be structured / organised so that the differences within care provision (apparent between departments and HCEs when the same aspect of care provision is accomplished) are

accommodated. To illustrate the findings with respect to care processes an example is discussed.

Within a consultation encounter, the referral of the patient and their administration before any care is applied form substantive and logical aspects of the encounter's care provision. Thus, Consultation referral and Consultation administration are both consultation encounter care process types. Care processes of Consultation referral care process type must basically enable the patient to enter the care provision system via the completion of the following activities:

- any encounter request responded to (e.g. letter from GP etc.);

- appointment given if appropriate;

- patient informed of appointment time and date;

- patient records being requested for the appointment.

Consultation encounters within the ENT and Speech Therapy departments both consist of care processes of the type Consultation referral. However, the actual care processes utilised are slightly different. The activities accomplished within the ENT and Speech Therapy Consultation Referral care processes are detailed in Table 4.1.

Consultation referral care process type activities					
Department	Request	Decision	Appointment	Letter	Information
ENT	Department receives communicatio n requesting appointment for the patient (e.g. letter from GP).	Consultant determines whether appointment is required and its urgency	Receptionist acts on consultants instructions and gives an appropriate appointment on the PAS	Letter generated and sent to patient	Patient's main HCE notes requested for the date of the appointment
Speech Therapy	Department receives communicatio n requesting appointment for the patient (e.g. letter from GP).	Consultant determines whether appointment is required and its urgency	Receptionist acts on consultants instructions and gives an appropriate appointment on the PAS	Letter generated and sent to patient	Patient's main HCE notes requested for the date of the appointment and separate department records are made available

Table 4.1 – Consultation referral care process type activities

From the table defining the care process type activities it can be seen that broadly the same activities are completed. However, it can be seen that the Speech Therapy department also has to make available any departmental records existing for the patient. Thus, by defining care process types and then specific instances of them, care provision activities are facilitated in accordance with particular departmental needs.

Table 4.2. gives an overview of the care process types defined for consultation encounters and indicates their care provision roles or purposes within the encounter.

Care process type	Purpose	Occurrence
Referral	Requests the patient to be seen by clinician and involves: • the referral correspondence being dealt with; • an appointment given if necessary; • patient notified if the appointment time and date.	Occurs once to enable the patient to be seen
Consultation administration	Enables patient to be correctly administered within the HCE before care is given and involves: • creation of patient records (should none exist); • checking / entering of patient details (e.g. address).	Occurs once to ensure the patient and their care will be correctly administered
Consultation and examination	Enables the care required by the patient to be determined, administered and managed and involves: • patient to be examined / interviewed; • notes to be taken; • departmental tests / assessments conducted (i.e. tests / assessments utilising the resources within the department conducting the consultation encounter); • request of clinical tests / assessments (required from other departments when the resources required might be there and / or under the management of other clinicians); • outcomes defined (such as patient discharged, referred to another HCE etc.).	Occurs once, with its constituent parts: • conducting of various tests / assessments within the department; • request of tests / assessment from other departments; • defining of outcomes occurring in accordance with the patient's care needs
Clinical test	Enables interdepartmental clinical tests / assessments necessary to be completed and involves: • test requested by the consulting department managing the encounter; • request responded to; • test / assessment performed; • test / assessment reported on; • report made available to consultant managing the encounter.	Numerous different instances may occur depending on the tests / services required for the patient's care.
Outcome	Enables the encounter outcome / s to be determined (e.g. patient referred to another HCE for treatment)	Occurs when one or more of the possible outcomes are determined (as required) for the patient.

Table 4.2 - Consultation encounter care process types

Like consultations, procedures were found to be made up of a number of care process

types defined and described in Table 4.3.

Care process type	Purpose	Occurrence
Referral	Requests the patient to have the procedure and involves: • processing of the request; • appointment allocation; • patient notification.	Occurs once to enable the patient to have a procedure
Procedure admission	Enables the correct administration of the patient before the procedure and involves: • checking / recording of address / GP details etc.)	Occurs once
Pre-admission assessments	Enables the generation of information and the performing and completion of the departmental clinical tests / assessments required before surgery.	Occurs once, although the exact tests etc. required depend on the patient's care needs * (* always occurs if local protocol (i.e. that of the HCE, department or clinician) is to have pre-admission clinics)
Pre-procedure clinical data	Enables any interdepartmental clinical tests required from other departments to be completed before surgery (e.g. if ENT is responsible for the procedure and an MRI scan is required from Radiology)	Occurs (if the patient is an in patient) but the number and nature of the different instances depends upon the patient's care needs
Ward data	Enables the facilitation of all the care required during the patient's time on the ward: • patient admission; • consent forms; • medication; • care plans etc.	Occurs when the patient is admitted but the number and nature of the different component parts which can occur depends on the patient's care needs
Theatre administration	Enables the recording of all the necessary Theatre-based patient information such as: • procedure; • theatre staff; • surgery type (elective); • time in recovery.	Occurs once when patient enters theatre

Care process type	Purpose	Occurrence
Procedure clinical data	Enables the request and completion of any clinical tests / assessment necessary as a result of surgery (e.g. the examination of a Biopsy). Also enables the recording of relevant multimedia data during surgery (e.g. video of part of the procedure).	Numerous different instances may occur as required.
Procedure report	Enables the generation of the procedure report	Occurs once
Outcome	Enables the required outcome / s to be determined	One or more of the possible outcomes are determined in accordance with the patient's needs

Table 4.3 - Procedure encounter care process types

By examining the roles / purposes defined for the different care process types it can be seen that some care process types (e.g. Consultation encounter consultation and examination, and the Procedure pre-admission assessment), include the performance of tests and assessments along with other care activities, whilst other care process types (such as Consultation clinical test and the Procedure pre-procedure clinical data) are derived to perform clinical test / assessment activities alone. So there is a distinction whereby, within some care process types, some tests / assessment activities are made in conjunction with other care activities whilst other care process types consist solely of clinical test / assessment activities.

The distinction was made to support the nature of care provision and effectively facilitate the additional activities which are required when tests / assessments are required from outside the department within which the encounter is based. For

example, during a consultation encounter in ENT, the consultant decides that the patient requires a nasal endoscopy examination. This can be performed immediately by the consultant during the encounter within the ENT department. This activity is deemed as part of the ENT consultation and examination care process as it contributes to a substantive and logical part of care provision provided by the ENT consultant during the encounter. However, if during the ENT consultation and examination care process the consultant determines that an X-ray is required, then an instance of the Radiology X-ray clinical test care process is required. The X-ray care process is derived from the clinical test care process type and enables the following activities to occur:

- request for X-ray examination is formally made to Radiology department;

- Radiology department assess the ENT request and decide whether or not to give an appointment (appointment is given in accordance with both the urgency of the request and the availability of the required resources within the Radiology department);

- appointment details communicated to patient;

- Radiology records (if any) obtained for use on appointment date;

- main HCE records requested;

- on date of appointment patient details checked etc.;

- X-ray examination performed;

- results analysed;

- X-ray examination report generated;

- report communicated to ENT for review by ENT consultant.

It can be seen that the conduct of the X-ray involves substantially more activities than that of the nasal endoscopy (due to the fact that the resources of another department are utilised) and that it enables a substantive and logical aspect of care provision to be achieved. Thus, clinical test / assessments from outside the department managing the encounter are defined as a separate care process type.

The separation of clinical tests / assessments between different care process types according to whether or not they are accomplished within the department conducting the encounter enables two basic types to be defined:

- departmental – those performed as part of a care process type occurring within the department conducting the encounter;

- interdepartmental – those whose performance alone constitutes a care process type.

By separating the clinical test / assessments into departmental and interdepartmental types and having the departmental ones constituting an individual care process type, the third encounter type (i.e. departmental encounter) is identified. A departmental encounter contains only one care process type, that of clinical test / assessment. Thus, a departmental encounter is one in which all the activities required to accomplish a clinical test / assessment at the behest of another department are performed. Thus, by examining the example given previously, when an X-ray is required by ENT as part of

the care constituting the ENT encounter, it can be seen that all the activities within the Radiology X-ray care process would constitute a departmental encounter within Radiology.

This section has sought to illustrate how the findings of the research were interpreted so that the complex and multidisciplinary nature of care provision can be structured and defined in such a way as to enable the comprehension and accommodation of its vast array of activities. The findings have a number of implications for a MEHCR, in that any design must support the encounter and departmental based nature of care provision via the support and enhancement of the encounter and care process types identified.

4.5.3 HCE staff

After examining the resources utilised in care provision and the structures through which it is facilitated, the research findings also yielded information concerning the individuals working within the current care provision system.

4.5.3.1 Staff types

The staff types identified are as follows:

- consulting - Consultants, Speech Therapists etc. (i.e. staff responsible for making clinical decisions concerning the care of the patients);

- clinical - Radiologists, Microbiologists etc. (i.e. staff performing or reporting on clinical tests);

- nursing - all nursing staff;

- administration - staff booking appointments, procedures etc.;

- secretarial - staff performing secretarial duties, typing of clinical reports and correspondence letters;

- reception - staff who check and amend patient details, locate and move records etc.;

- management - staff responsible for the management of areas of the HCE's operations (includes IT staff).

These seven types were identified throughout a number of departments and were classified roughly in accordance with their duties, responsibilities and training. The staff types identified loosely corresponds to those found by other researchers (Barber & Davey, 1996; Furnell, 1995). Obviously, many of the staff actually undertook work from the realms of staff types other than their own. For example, a senior nurse might be responsible for managing the numbers and grades of nurses on wards etc., but this does not make the nurse a manager as the classification of the staff into types is done on the basis of their foremost responsibilities and training.

The findings surrounding the staff types identified have implications for the MEHCR in that it must broadly support the staff roles identified and be flexible enough to support staff having roles spanning the categorisations so that at all times the MEHCR aids the provision of clinical care, its administration and the management of the HCE.

4.5.3.2 Working practices

For the different staff types participating in care provision, a number of different working practices, clinical and administrative, which occur during care provision were identified, as follows:

- core static;

- core flexible;

- supportive.

The core static working practices are those which are required, in their existing form, within a care process to facilitate care provision activity. For example, a consultant must be able to freely examine a patient during a consultation encounter to ensure that the correct clinical care is given. Thus, no matter what MEHCR is devised it must enable and support the practice of patient examination.

The core flexible working practices are those which are required, in some form, within a care process to facilitate care provision activity. For example, this type of working practice would include the recording of data in the patient records. This practice must occur for the effective recording and provision of patient care, but the way in which the data is entered could be re-engineered (in accordance with the clinician's wishes), so that the practice required is performed in a more efficient and effective manner.

Finally, the supportive working practices identified were those which were required to support the other two types of existing practices. They include the duplication of

patient data on request forms and the transporting of the patient records around the HCE. As such, these practices are not fundamentally an essential element of care provision because, it is the nature of the existing patient records and other systems used during care provision which necessitates their presence rather than the actual provision of care itself.

For the MEHCR, the findings with respect to the workings practices identified mean that it must support and enhance the core static working practices, re-engineer the core flexible working practices and make the supportive working practices redundant where appropriate so that care provision is made more efficient.

4.5.4 Patient records

The research findings revealed a variety of facts with respect to the patient records. They concerned the types of records found, the problems associated with their use, the ways in which they are used and the use and roles of their constituent data.

4.5.4.1 Types of patient records

From the research it was seen that the limitations of paper-based records (i.e. their single location / access nature, their inability to hold and present multimedia data) mean that they are not suited to the recording of modern multimedia patient care within HCEs. As health care has developed, this situation has led to the establishment and use of other more specialised paper-based, and separate media based records (in

conjunction with the main HCE records), to try to alleviate some of the limitations and numerous problems experienced.

At present there are often three different types of records found:

- main hospital patient records - containing text and numerical data;

- departmental patient records - containing text, numerical and some image data;

- specific media or clinical test / system records - containing text and generally one type of media (image, graphics, video or audio).

This situation means that none of the records are comprehensive or truly multimedia (especially as multimedia data such as video and audio tends to be stored in such a way that it can only be viewed via one isolated system). This results in clinicians being unaware of the existence of some data and unable to easily view other information, increased administration overheads, delays in the obtaining of information, and information within the different records being inconsistent or inaccurate. For example, departments may use their own departmental records alongside, or in preference to, the main hospital records (as these can be difficult to acquire and may not be suited to recording the care they provide). So, if the patient moves house, the main records are updated as they are always used but, unless the patient has a departmental encounter, the information in the departmental records will remain inaccurate.

Thus, the non-composite and non-comprehensive nature of the records, in tandem with their non-multimedia state, can lead to the situation (as shown in table 4.4) where the presence and availability of patient information (especially multimedia data) is greatly diminished, to the point where it may be insufficient to ensure effective and efficient care provision.

Care giving rise to data	Original data format	Original data recorded	Availability of original data	Original data recorded in another media	Form of other media	Availability of other media
Nasal endoscopy	Video	No	None	Yes	Textual account in consultation notes	Main HCE records
MRI scan	Image	Yes	Department records	Yes	Text report	Main HCE records
Voice assessment	Audio	Yes	Separate media repository	Yes	Text account	Department records
Plastic surgery	Image	Yes	Separate media repository	No	None	None
Barium swallow	Video	No	None	Yes	Text report	Main HCE records
ECG examination	Graphic	Yes	Separate media repository	Yes	Text report	Main HCE records

Table 4.4 - The recording and availability of care provision data

It can be seen that the continued use of the different types of paper-based records is not only failing to enable clinicians to have access to and record comprehensive information, it is in itself creating problems and inefficiencies within health care.

Thus, the MEHCR must not only permit the generation and recording of appropriate multimedia data within care provision, but also permit its flexible presentation, availability and use, as required within other care processes and encounters.

4.5.4.2 Practical patient records usage

A variety of problems associated with the "real world" use of the patient records and the data therein were identified. For example, administrative and clinical time, and resources, are often deployed to request, locate, query and transport both the patient records and items of patient data, to wherever they are needed.

Records are often difficult to use due to their current format. Some patient records may constitute two or more complete folders, and may be cumbersome to use due to their sheer size and weight. The records can, on occasions, be in a rather dishevelled state due to their age, their frequency of use (experts estimate that the typical record may be used by up to 77 different people during the average HCE stay (Doyle, 1995)), and can thus be difficult to search and examine. In this state it is also easy to lose items of data from within the records.

The nature of the records also enables what are seen as "interesting" items of patient data to be removed by clinical staff for further consideration in the context of other cases, or a research topic. The data may then be re-appended to the record in the wrong place, or lost altogether. These are just a few examples of how the nature of the records can impact upon the efficiency of care provision.

Problems were also identified with respect to the risks associated with the production, accuracy and use of data (in this case, the term "risks" is applied with respect to the risks of decreasing data availability (loosing data) and the compromise of data integrity (i.e. alteration of items of data)). Examples of these problems included the possibility of clinical requests, reports and samples being lost, incorrectly labelled, or incomplete. They also concerned the possibility of errors being made as taped or written instructions of poor quality are transacted by clerical and clinical staff. More problems concerning the possibility of patient information, such as the patient's GPs name and address, being out of date, and therefore incorrect, were identified. Again, these are just a few examples of the patient data risks found.

It was also found that, in the practical environment, the patient records were not secure. There were found to be numerous occasions when the security (i.e. the integrity, availability and confidentiality), of the records was open to compromise. It was felt that this could lead to items of patient data being viewed by unauthorised personnel, and being maliciously or accidentally altered, or lost. Fortunately, in practice, the presence of a "trust culture" (i.e. when individuals are trusted or assumed not to maliciously alter, view, utilise or discuss patient information), means that it is rare for the security of the records to be intentionally compromised, but the nature of the records means that, if compromised, any breaches in security are difficult to identify.

As far as the MEHCR is concerned, these findings have a number of implications with respect to its design. Obviously, the electronic nature of the MEHCR can be utilised

to obviate the problems defined. For example, being electronic means that, as long as sufficient infrastructure is in place, records will have immediate and HCE-wide availability, thus, negating the need to physically transport them. Equally, comprehensive security can be implemented to both prevent data being removed or altered, or enable all alterations to be shown and underpinned by comprehensive audit capabilities. Thus, the MEHCR must consider the problems described here and incorporate measures to overcome them.

4.5.4.3 Record utilisation

The research showed that the records were utilised, during care provision, in the following ways:

- reviewed to obtain relevant medical histories for the patient's current problems. For example, before care is actually given during an encounter the patient's relevant previous medical history (e.g. care given for previous broken foot), is reviewed before treating the patient's current problems (another break to the same foot). The data reviewed pre-dates the patient's current problems and may need updating if inaccuracies are found;

- reviewed to obtain information required for the patient's correct administration or management during care provision. For example, details surrounding the patient's home circumstances may be reviewed to determine whether or not the patient needs a home help in the

management of their current problems. Again, the data reviewed pre-dates the patient's current problems and may need updating;

- reviewed to obtain information relating to care given thus far. For example, in the treatment of a patient's current problem X-rays are required, the X-ray report generated will be reviewed and utilised as part of the patient's current care provision to aid the definition of the next stage of the patient care required;

- creation of new data detailing the care provision occurring. For example, an ENT consultant treating ear problems makes notes during the encounter detailing his examination findings.

These findings lead to the definition of the records two modes of use defined as follows:

- historical - concerns the review / updating and use of patient information during care provision which pre-exists the current encounter or its conclusion;

- current - concerns the creation and utilisation of information generated as part of the patient's current care.

For each mode outlined, there are two modes of operation, as follows:

- established - for the review of all the existing data;

- creative - for the creation and generation of new data.

For the historical mode of record usage, the established mode of operation *(established historical mode)*, would, for example, involve the review of the patient's GP details at the front of the record to ensure that any correspondence goes to the correct GP, and the creative mode of operation *(creative historical mode)*, would involve the correction or updating of the said patient GP details.

For the current mode of record usage the established mode of record operation *(established current mode)*, would involve the reviewing of any test results requested during an on-going encounter, whilst the creative mode of operation *(creative current mode)*, would be utilised to generate further appropriate patient data or initiate a care processes such as an encounter outcome (e.g. a further departmental patient appointment).

An examination of the findings could be viewed as an over complication of basic information browsing and creation operations. However, as the MEHCR must be capable of facilitating care provision itself (i.e. it is a delivery tool) it was felt that it was extremely important to thoroughly investigate how the records are used and formalise these findings. Thus, by formally defining the modes of use and operation the MECHR, by its support of the modes, will be able to fully support care provision operations.

4.5.4.4 Record data roles

Whilst observing the ways in which the records are used during care provision it was also found that collections of data items and individual data items could be seen to

serve, or be related to, a particular role within care provision at any one time. For example, the patient NHS number, date of birth, surname, forename, address, next of kin, etc. could be seen to enable the identification of the individual patient. Equally, it was found that the collections of data items and individual data items may be utilised (in some cases duplicated) numerous times as care provision progresses whilst fulfilling either the same or a different role. For example, a MRI examination of a patient's neck might form part of the care constituting a particular ENT encounter. Thus, the MRI data is defining the patient's current care. However, some months later the same MRI data might form part of another encounter's relevant medical history.

To accommodate these findings four basic information roles were defined:

- definition – enables a patient to be uniquely identified (e.g. the patient's HCE number, date of birth, surname, forename, address, next of kin, telephone number and address, GP details etc.).;

- historical – enables a patient's relevant history to be defined (e.g. any medical procedures undergone, any prescribed medication which the patient has, or is receiving, and any medical conditions from which the patient is suffering, or has suffered);

- care – enables the care provided to be defined (consultation notes, procedure reports, clinical test requests, clinical test reports and the actual clinical test data, such as an X-ray or blood test result);

- administrative – enables the patient to be administered within the care provision system (e.g. dates and times of procedures and appointments; and the clinicians involved in the care of the patient).

By defining these information roles it is possible to see how items of data or data collections may be utilised numerous times and sometimes change their roles as different care provision circumstances prevail. Thus, the MEHCR must enable data to be presented numerous times in various care provision situations whilst being held only once. In this way the MEHCR will enable data to be effectively utilised within care provision.

4.6 Overview of research findings

A review of the research modelling and analysis shows that a variety of findings were gained, as illustrated by figure 4.7.
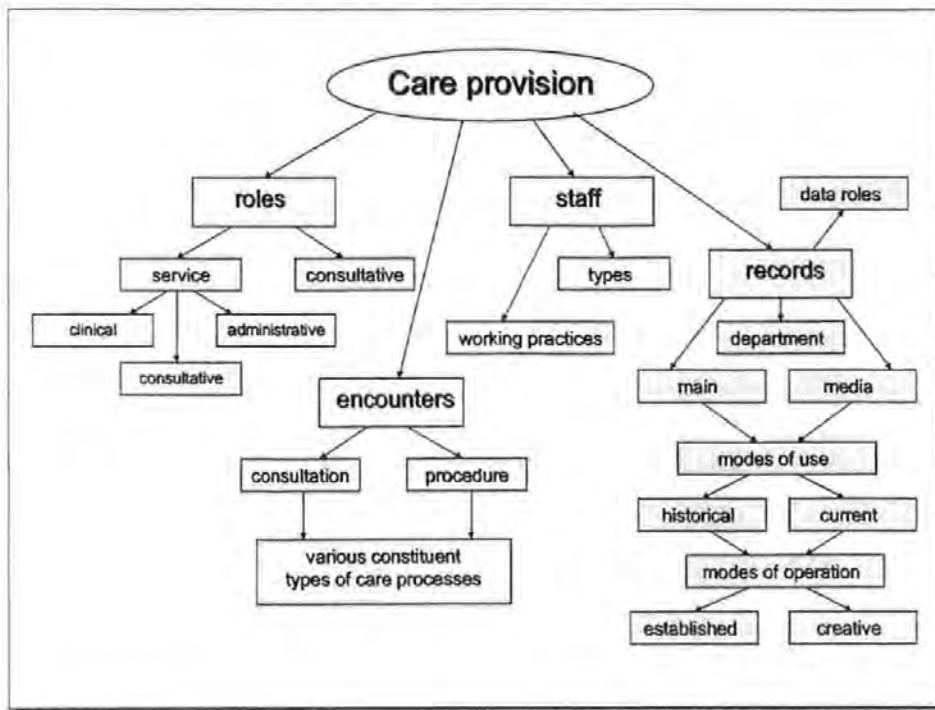
Figure 4.7 – Overview of findings

To summarise, the research led to a number of findings, which in turn facilitated the definition of the MEHCR's requirements with respect to the support and enhancement of the following:

- dynamic and multiple deployment of resources and the roles assumed as different aspects of care provision occur;

- departmental and encounter based nature of care provision;

- staff roles defined:

- accommodation, re-engineering and elimination of core static, core flexible and supportive working practices respectively;

- records role, modes of use and operation;

- negation of problems associated with paper-record use.

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After identifying these requirements via the analysis of health care provision, it was possible to start formulating, developing and refining the ideas for a flexible, composite and comprehensive MEHCR capable of meeting both the immediate requirements, and accommodating those which will arise as health care develops. The next chapter moves on to discuss the ideas defined to facilitate the development of a suitable MEHCR framework.

Chapter 5

MEHCR conceptual design and design environment

Introduction

This chapter gives an overview of the conceptual design defined to give a MEHCR capable of meeting the needs of care provision. The structural composition, interfaces and capabilities of the conceptual design are discussed in more detail. The form of the design environment, which provides an intermediate means of both realising and developing the MEHCR without compromising its composite and comprehensive nature is also commented upon, as is its utilisation.

5.1 Design formation

The HCE investigations enabled different aspects of care provision and the use of patient records to be analysed and, from this, the requirements of a MEHCR to be established. After this it was possible to move on to the process of formulating and refining the MEHCR's conceptual design to enable the following:

- composite, comprehensive and efficient provision of patient care in accordance with patient needs;

- generation / recording / presentation of patient data (of any media), in a way which reflects the patient care required / given;

- coherent system's evolution to embrace multimedia health care developments.

Before discussing the conceptual design which defines the form of the MEHCR (i.e. its structural organisation), its appearance and its capabilities it should be noted that, during its formulation, consideration was given to the fact that an MEHCR cannot simply:

- replicate the existing paper-based patient records;

- replicate the workings of the current health care system in an electronic form;

- enforce the existing care provision culture;

- automate all health care processes.

To do so will not answer the problems of health care (as detailed in chapter two). In fact, the perpetuation of some practices in an electronic form might introduce further inefficiencies, enabling the MEHCR to provide only very limited, if any, benefits to health care. Throughout the design process consideration was given to the need to utilise and accommodate both previous and on-going work in the MEHCR field, and the work of more specialised groups advancing aspects of MEHCR operations (such as data security and entry methods), in order to enable the effective utilisation of these other advances within the project, and to avoid re-inventing the wheel.

5.2 MEHCR conceptual design

In order that the conceptual design can be described in a coherent manner, the discussion is segmented into four parts as follows:

- overview – outlining the basic form of the conceptual design;

- composition – defining how data is structured throughout the MEHCR;

- interface – expressing how the MEHCR appears and is utilised;

- capabilities – stating the operations the system is capable of.

5.2.1 Conceptual design overview

The conceptual design shows that the MEHCR is made up of numerous autonomous patient records. Each record (one per patient) has a hierarchical nature and is comprised of four basic sections as follows:

- Patient Information (PI) - contains all the information necessary to comprehensively define the patient (e.g. patient's name, address, next of kin, GP, occupation, etc.);

- Medical History (MH) - contains a concise summary of the patient's current and historical health status by detailing previous and current medical procedures, conditions and medications;

- Private Health Care (PHC) - contains all the information required to fully describe any private health care insurance, or private health care treatments which the patient is undergoing (or has undergone);

- Hospital Departments (HD) - contains numerous individual sub-sections for each hospital department. The sub-sections contain all the multimedia data recorded in connection with the patient's care.

The definition of the four main record sections enables various aspects of the MEHCR's utilisation in care provision to be effectively supported. The PI section permits the separation of the administrative tasks surrounding the collection and maintenance of patient information and provides a composite area for its review. Equally, once present,

any of the sections constituent data can be utilised within both patient administration operations and clinical care as follows:

- presence of GP and Next of Kin details within the PI section means that the data can be utilised as required throughout the record to ensure the patient's correct administration within the HCE. For example, within the requesting / reporting of clinical tests, on consent forms, correspondence, or for billing purposes;

- presence of data within the PI section concerning patient's personal circumstances would reveal whether or not a patient might be in need of home visits, or support from the Social Services as part of their care.

So, as a whole, the PI section provides a means of comprehensively defining the patient so that they can be effectively administered within the HCE and so that any personal circumstances which might impact upon care can be identified.

The MH section supports the capture and updating of a concise summary medical history of the patient. This comprises of an account of all the patient's previous and current details surrounding prescribed medications, conditions suffered (e.g. migraines, asthma etc.) and surgical procedures undergone (e.g. hip replacement). The data capture and updating processes within this section can be either automatic or manual as follows:

- automatic – the care provision process results in data (e.g. the prescription of a drug to a patient) being recorded within the HD section of the record as care is given. The system (via the implementation of a comprehensive data coding and rules set) sees the data as pertinent to the MH section and enables a sub set of the data recorded surrounding the drug prescription to be presented as a new summary record in the MH medication sub-section, without any data duplication;

- manually – summary accounts of care provision events currently outside the auspices of the MEHCR (e.g. the diagnosis of asthma within another HCE not linked to the MEHCR) are recorded by suitably qualified staff and form a new summary record entry in the MH conditions sub-section.

So the process of effectively creating and maintaining a composite repository of a patient's current and previous medical history or status is enabled. The section's constituent information can then be utilised during care provision to ensure that any treatments defined for patients are given in the full knowledge of the patient's previous / current history.

The PHC section facilitates the effective collection and maintenance of all of a patient's private health care cover, and treatment details. This enables any care given under any private policy cover to be determined and administered effectively. The section also provides a point of reference for clinicians in that it gives full details of all private or

alternative health care treatments that the patient may have had, or be undergoing, and prevents clinical decisions being made in ignorance of these facts.

It should be noted that, throughout the PI and PHC sections, the data collection and updating processes can be automated as in the MH section if the MEHCR is suitably integrated with an external system holding the required information (e.g. private insurance company database holding policy details).

An overview of the PI, MH and PHC sections shows that they are primarily concerned with enabling the effective gathering and maintenance of a variety of pre-determined data sets which facilitate the definition and administration of the patient within the HCE. Equally, they logically separate the data creation / updating processes in such a way as to complement the care provision process. For example, when a patient arrives at the ENT clinic reception for an appointment with the ENT consultant (having been referred by a GP) the receptionist can access the PI section and check / update all the relevant patient, GP and Next of kin details held. Equally, before actually seeing the consultant, a clinician can discuss and update information surrounding any medication the patient is on or prescribed etc., so that the MH section is up to date. Also at this point the PHC section can be accessed and any private treatment details present, such as the fact that the patient is receiving private Physiotherapy reviewed and updated if required.

The purpose of the HD section is, however, slightly different from the three discussed so far. It is concerned with facilitating the provision and recording of multimedia patient care between and within different hospital departments (and HCEs if the MEHCR encompasses more than one HCE), in accordance with the patient's needs.

Each of the four main sections has a number of sub-sections. These are further sub-divided so that the record's form and use complements and enhances specific aspects of care provision. For example, within the PI section, the patient's address details are held separately from the patient's GP details so that different aspects of the information defining the patient are effectively separated to reflect their distinct utilisation within the MEHCR (e.g. here a patient may move house but stay with the same GP or vice versa, thus, capturing and maintaining the data sets independently within the same main record section is appropriate). Figure 5.1 gives an overview of the record's sectioning.
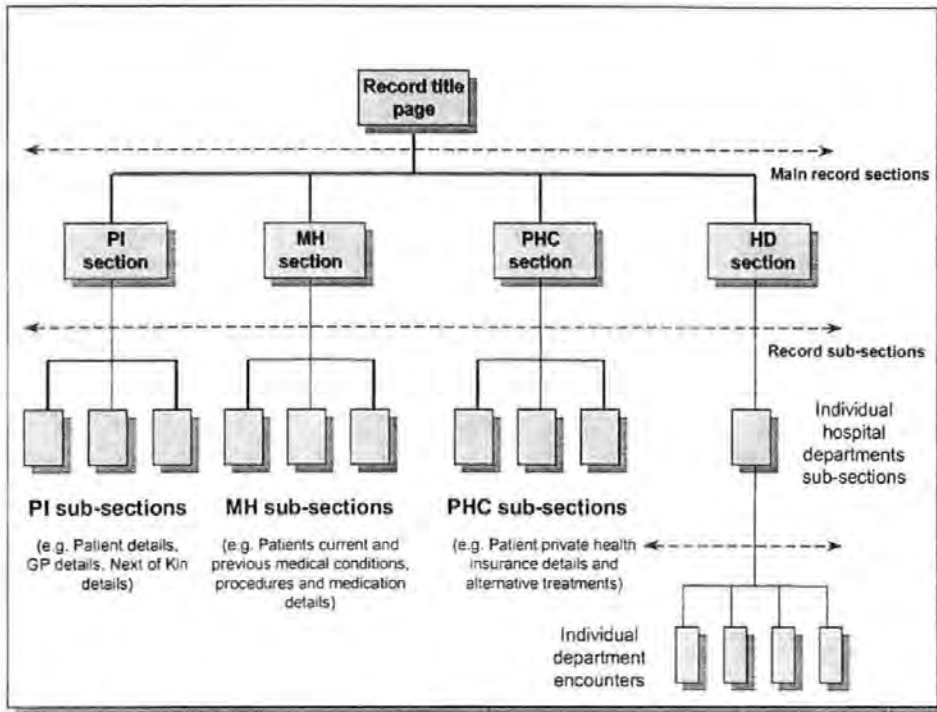
Figure 5.1 – Overview of the conceptual design sectioning

5.2.2 Conceptual design composition

The precise structure of the conceptual design is best described by visualising the MEHCR as having a hierarchy of framework structures which act as its skeleton, providing support for the systems interfaces and its inherent capabilities. For each patient, the upper hierarchical levels of the records are the same (reflecting the same basic information being held about each patient in the four main record sections and sub-sections).

However, the order and form of the framework structures within the sections differs for each patient. This is because the sections expand through various sectioned layers of framework structures so that ultimately all the information constituting the patient's health care record is held in a way which reflects the care provision received by each patient. For example, within the record of one patient there may be a large amount of data within the ENT sub-section of the HD section relating to, and presented via, seven separate encounter structures, reflecting the fact that the patient has had seven ENT encounters. However, within the same sub-section of another patient's record there may be no data showing that the patient had received no care from ENT. Thus, the structure of each patient's record is given to reflect the care received.

Each of the framework structures present within the hierarchy consists of a backbone and a number of components. Each of the backbone components is able to present (via a suitable interface) either another lower level of the record's hierarchy, or an item / items of multimedia patient data. Figure 5.2 illustrates the principle of the MEHCR being made up of a series of layered framework structures and appropriate interfaces. The diagram shows part of a HD sub-section and covers three layers, showing a component from the upper layer giving rise to another hierarchical layer (the middle layer) via one component. The backbone and components of the middle layer in turn support both data directly and a further hierarchical level (the lower level).
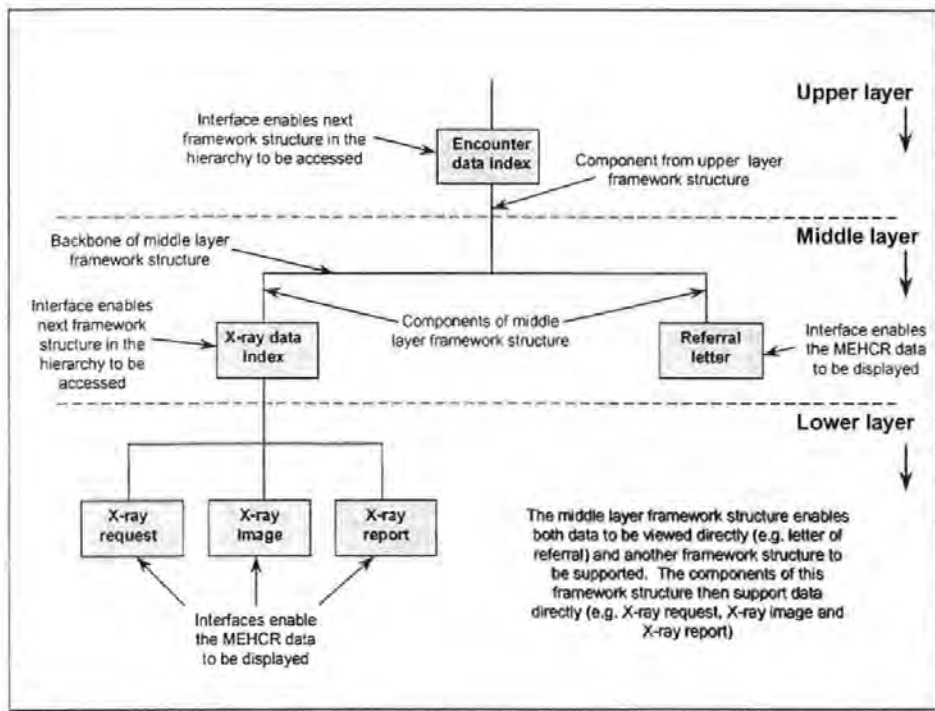
Figure 5.2 – Framework structures

There are several different types of framework structures within the MEHCR hierarchy (e.g. within each of the HD sub-sections there is a departmental framework structure, departmental consultation and procedure encounter framework structures and departmental care process framework structures etc., all supporting different aspects of care provision).

The framework structures present depend on the record sections / sub-sections examined. For example, no framework structures for the generation / review of care provision data (such as that given during an encounter) would be present within the PI section as direct

care provision is not provided through this section. The only types of framework structures present here would be those required for the generation / maintenance and review of pre-defined data sets. Thus, the patient address details framework structure would be present to support the appropriate PI section data.

The various types of framework structures within the MEHCR are defined by different structural descriptions. The structural descriptions enable the different types of framework structures to fulfil their various purposes within the MEHCR by defining the number of components they have and the data / other framework structures supported. Thus, collectively the various types of framework structures defined enable all aspect of care provision to be supported.

The framework structures present within each of the PI, PHC and MH sub-sections are similar and relatively simple as the sub-sections maintain data required for the definition and administration of the patient during care. The components of the backbones are utilised for the support interfaces for the creation and editing or manipulation of a number of pre-determined data sets (e.g. within the PI section, the pre-determined data sets would include Patient details, Patient address, Next of kin, GP details etc.). Figure 5.3 shows the generic sub-sectional structure utilised with the PI, PHC and MH sections.
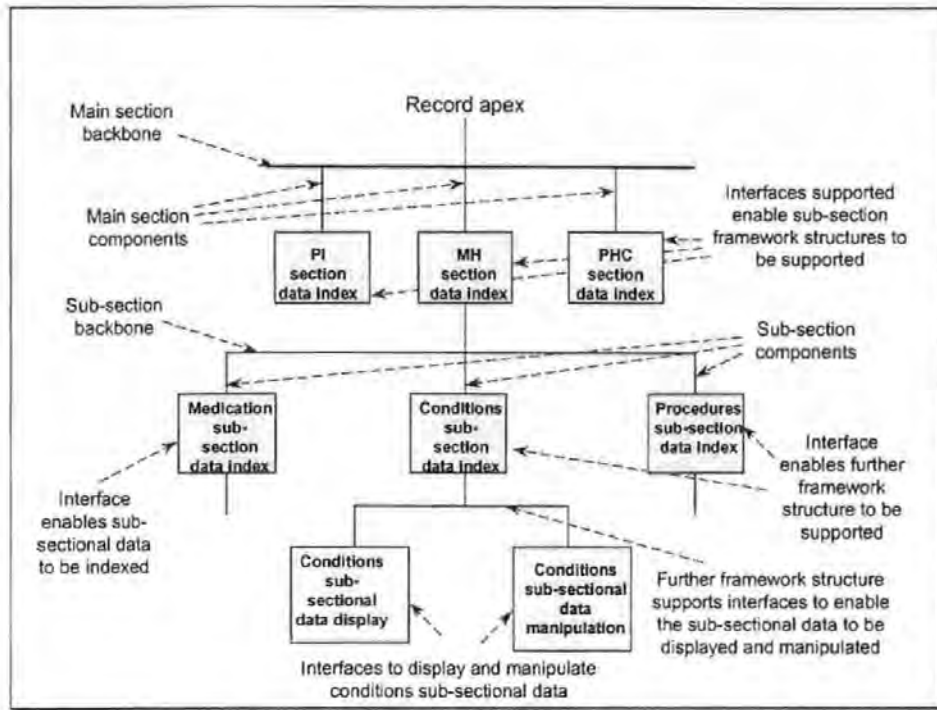
Figure 5.3 – Overview of PI, PHC and MH sub-sections

The HD record sub-sectional structure is slightly different and more complex as it is concerned with supporting the actual delivery and recording of patient care. Each hospital department has an autonomous hierarchical structure composed of a layered series of framework structures. The framework structures and interfaces are tailored exactly to the department's needs and facilitate the effective and efficient provision of multimedia patient care within the department, in accordance with the department's operations and duties.

The structure of each department sub-section reflects the episodic or encounter-based nature of direct patient care provision. So at the apex of each department sub-section is a department framework structure. This has a number of components, each of which supports either a consultation, procedure or departmental encounter framework structure. Collectively, the components of the consultation, procedure or departmental encounter framework structures enable access to all the data (of any media) associated with a single patient encounter. Individually, the components of the consultation, procedure and departmental encounter framework structures support either individual care process framework structures, or items of multimedia data directly. For example, a single item of data being supported would involve a component sustaining a scanned letter of referral. However, a component would support a care process framework structure if, as part of the encounter, the patient undergoes a care process (e.g. X-ray). So, here the component supports a care process framework structure which supports the care process data (i.e. X-ray request, image and X-ray report data). Equally, the care process framework structure components can support both items of multimedia data and further sub-care process framework structures in a layered arrangement until all the patient information (of any media) concerning a particular encounter is held. Figure 5.4 illustrates this principle.
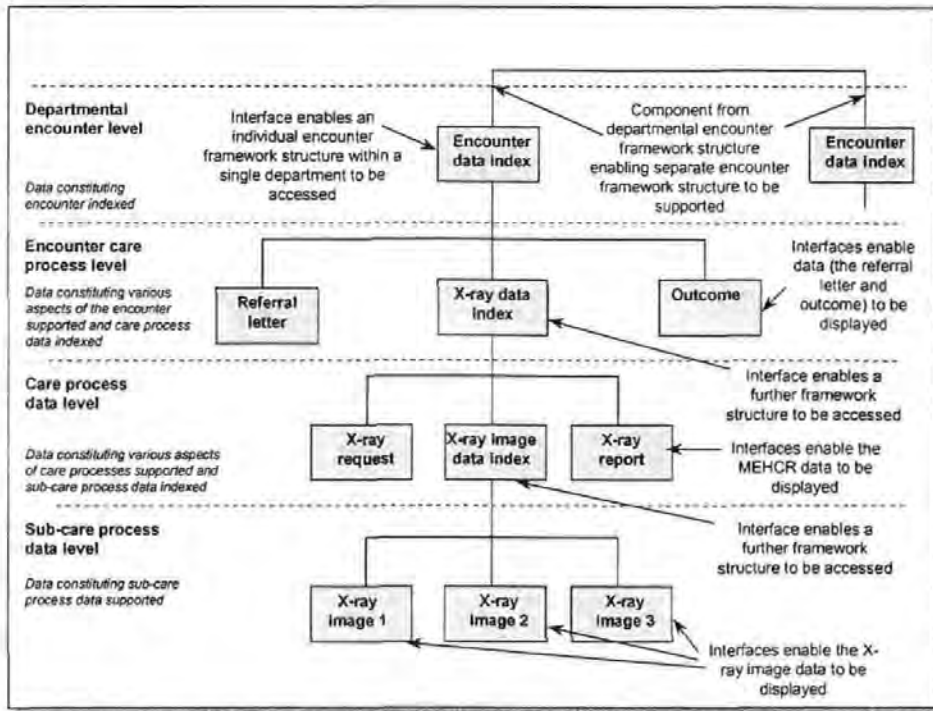
Figure 5.4 – Departmental framework structures

So it can be seen that, by utilising different types of framework structures, a record can be constructed which permits the support of care provision via the following:

- effective separation of different logical aspects of care provision enabling the creation and maintenance of administrative details, a summary medical history, private health care details and actual care provision records;

- support of all patient data constituting the record in a manner which reflects the care provision given.

5.2.3 Conceptual design interface

The framework structures collectively give the organisational form of the record. However, the record's user interfaces provide a means of enabling human interaction with the system. Thus, they are the medium through which information can be created, maintained and reviewed as required to aid the provision of patient care.

The conceptual design forms a composite and comprehensive means of care provision, as such its interface designs need to be highly flexible so that the diverse operational requirements (e.g. the presentation, addition and alteration of basic text data in the PI, MH and PHC sections, the presentation, manipulation and recording of video, audio, graphics etc. in the HD section, and the navigation of the entire system), can be accommodated. To meet these needs, various types of system pages were developed to form the basis of the system's interface.

There were four main types of page defined as follows:

- display pages - for the presentation of multimedia data already held within the record;

- entry pages - for the entry / creation of new data (of any media) within the record;

- manipulation pages - for the entry and updating of small multimedia data sets held within the PI, MH and PHC record sections;

- index pages - enabling the structuring of, and access to, data items (they

  index the items of data present within different sections and sub-sections

  of the record).

Each type enables a specific part of the record structure to present an appropriate interface

to the user. For example, within the ENT HD sub-section, the framework structure of a

record might reflect the fact that a patient has had an ENT encounter which required an

X-ray examination. Equally, it could show that the encounter outcome is still on-going in

that the consultation is still assessing the patient's needs as no encounter outcome has

been defined. Figure 5.5 shows the framework structures and types of system pages used

to support the encounter and its constituent care processes, and reflect the patient care

thus far.
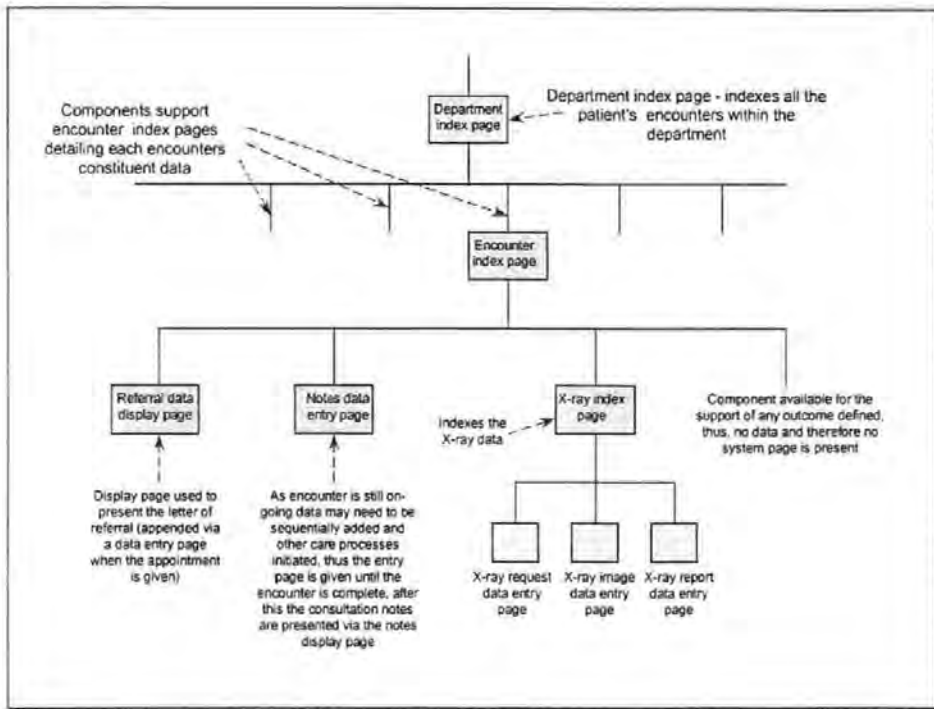
Figure 5.5 – Utilisation of framework structures and system pages

The various types of system pages utilise toolbars, menus, command buttons, icons, MCI's (Multimedia Control Interface) and other graphics as appropriate, throughout the MEHCR, to give good functional availability, data visibility, and feedback. Each type of page utilises the aforementioned controls in different ways to fulfil their basic purpose within the MEHCR. For example, the data entry, display and manipulation pages use menus in conjunction with tool and status bars, to enable the MEHCR's utilisation to be as non-intrusive as possible. This leaves most of the screen available for the presentation, entry, or manipulation of multimedia patient data items through workspace areas (Carey et al, 1996). Workspace areas (which may be shared to enable clinical collaboration) are

present and used for the display and the entry or creation of multimedia patient data. Thus, the page types are able to serve their purpose of enabling the entry, manipulation and display of data within the record. Equally, the data index pages also use menus, tool and status bars, but not workspace areas as their purpose is to index the MEHCR data held rather than present or record it directly.

From the types of pages defined it is possible to tailor individual pages of each type so that specific operations within the MEHCR are supported. For example, within the ENT department sub-section of the HD section, various data entry and display pages are present to enable the department's operations to be supported fully. Thus, within the record section there will be pages whose operations are tailored to the entry and display of consultation notes data, endocscopy examination and report data, audiology test results etc., so that the pages collectively present enable the structuring (via index pages), creation (via entry pages) and review (via display pages) of any ENT data.

5.2.4 Conceptual design capabilities

Thus far, the conceptual design has been discussed in terms of how its framework structures enable data to be structured and how the different types of system pages enable the system's utilisation. However, to demonstrate how these aspects enable the MEHCR to operate in a dynamic event / status driven manner (i.e. the operations of the system responds to the care activities requested or being enacted), and thus provide a composite

and comprehensive means of multimedia care provision and recording, a basic example of the system's operation is given.

In the example, the patient requires care from several HCE departments during an ENT consultation encounter. As part of the ENT encounter (arising from a GP referral), X-rays of the patient from the Radiology department are felt to be necessary to help define the extent of the patient's problems. To enable the completion of the necessary X-ray examination means that, within the ENT encounter, an instance of the Radiology X-ray examination clinical test care process is required. This constitutes a departmental encounter within the Radiology department. The conceptual design means that ENT consultation encounter framework structure has a component available to support the Radiology department framework structure, which in turn supports all the data associated with the X-ray clinical test care process (i.e. request, image and report). The component is always available within the ENT encounter framework structure, but only utilised (giving a layered arrangement), if X-rays are required.

In the example, the ENT Consultant needs to request the X-ray examination from Radiology. This is done using one of the menu options on the consultation notes data entry page, from which the progress of the encounter is controlled as it provides a means of initiating other care provision processes and encounters in accordance with the patient's needs. Here, the selection of the appropriate menu option generates an instance of the Radiology departmental encounter framework structure. This has three

components, to support the X-ray request, X-ray data and X-ray report. On screen the ENT consultant sees the X-ray request data entry page. On the page, details already held by the system (e.g. GP details) or known to it (e.g. Request time and date) are presented pre-entered within the request page. The ENT consultant uses any of the data entry methods available (e.g. keyboard, graphics tablet etc.) to enter the remaining request details (e.g. type of X-ray requested and additional comments on the patient's condition) via the appropriate workspaces. The consultant then confirms the request. Figure 5.6 shows what the consultant sees during the X-ray request, along with the framework structures and data sources utilised.
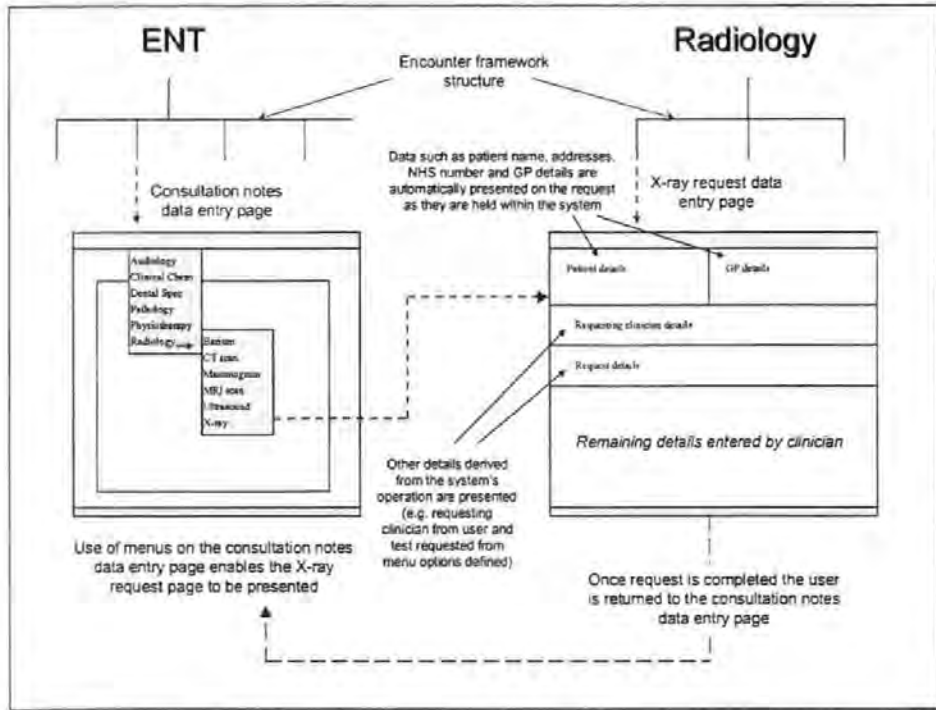
Figure 5.6 – Consultant's view of system

After confirmation, the request data supported by the Radiology departmental encounter framework structure can be seen within the Radiology record section as a departmental encounter through which the required X-ray examination (the clinical test care process requested by ENT) can be completed. Figure 5.7 shows how, once generated, the X-ray request is seen within the Radiology record section where it can be dealt with as appropriate.
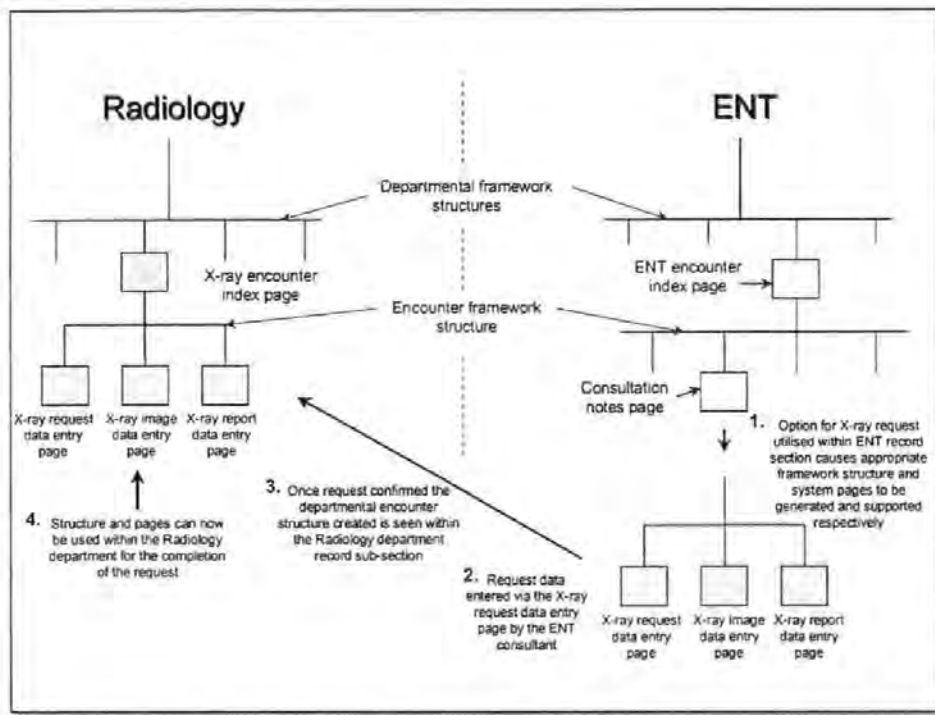
Figure 5.7 – Inter-departmental operational overview

The responsibility for the acceptance, scheduling and completion of the X-ray request now passes to the Radiology department. Appropriate staff within the Radiology

department can now examine the request, and allocate an appropriate time and date for the patient's Radiology encounter, and record it using the same X-ray request data entry page the ENT consultant used, but now the data entry options available have changed to reflect the progress of the patient through the care system. So on the X-ray request data entry page, the only workspace areas available are those for the recording of the appointment time and date. Equally, the system responds to the data values entered in that, if the examination date is in the future, the pages inhibit any inappropriate data entry (such as the examination duration, type and Radiographer details) being recorded as these cannot be known at this point. However, if the date of the examination is the current date then the page enables the details to be recorded as it knows the data will be generated on this date and thus require recording.

Once all the data which can be entered via the X-ray request data entry page is present, the information is subsequently viewed by a complementary data display page. The display page enables identical operations with respect to the navigation of the system to be utilised but its data entry operations are restricted to enabling only data append operations to be executed, when details may need to be added to in the light of new information. Thus, it can be seen that during care provision there is a dynamic alteration of the following:

- data entry activities within the data entry pages (i.e. the operations available within the system via the interface respond to reflect the

patient's progress through the care provision system, ensuring as far as possible that only further actions appropriate to a patient state can be enacted);

- the type of page shown (i.e. once all data entry activities are complete the appropriate data display page is used as the interface medium for the review and amending of data).

The recording of the X-ray image and report data is accomplished in a similar fashion using appropriate data entry pages for the creation of the data and complementary display pages for its review.

When the X-ray is complete (i.e. the clinical test care process is complete, so the X-ray request has been processed, the X-ray examination performed and the image generated, and the X-ray report is written), all the data (text, numerical and image) constituting the Radiology departmental encounter is made available to, and seen within, the ENT department records, as a clinical test care process within the appropriate ENT encounter.

So it can be seen that the appropriate component of the ENT encounter framework structure supports the entire Radiology department framework structure. Hence, all the data generated by the Radiology department (at the behest of the ENT department), is seen within the ENT encounter record. Thus, the Radiology data can be viewed within

both the ENT and Radiology department record sections without duplication. This principle is illustrated by Figure 5.8.
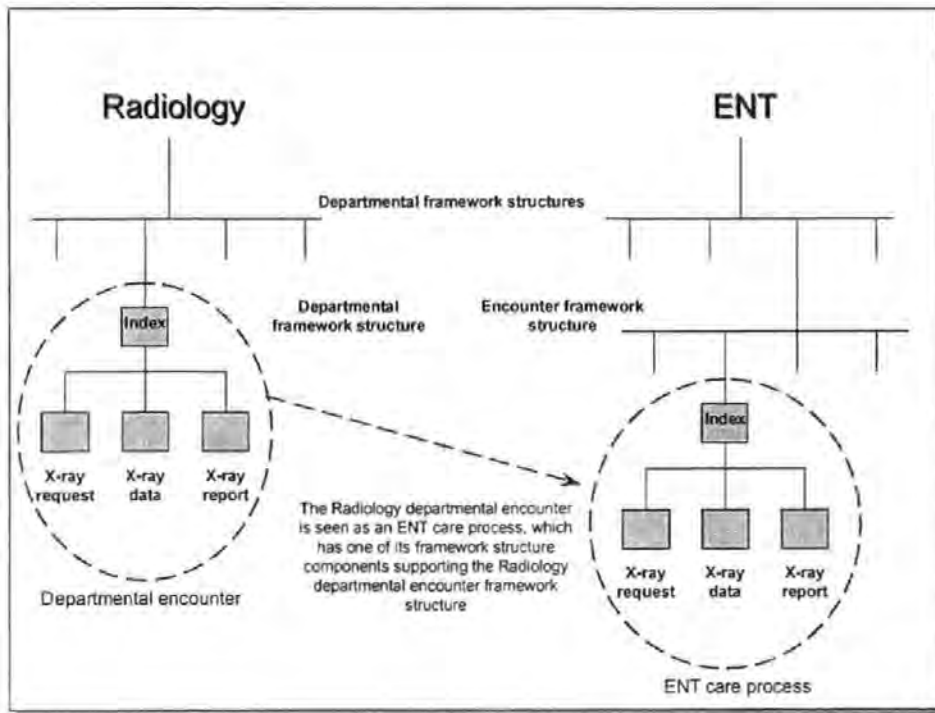
Figure 5.8 – Dual framework structure data presentation

This structured dual presentation of multimedia data to give comprehensive and composite departmental care records (i.e. for Radiology the department performing the work) and encounter records (i.e. for ENT the department managing the care), is possible because of the flexibility of the MEHCR's framework structures. In this way the Radiology department can provide, and maintain, a multimedia record of the patient's care within the department (within its own HD sub-section), and ENT has a composite

and comprehensive multimedia record of all the care given to the patient as part of the ENT encounter.

By looking at the example given it can be seen that the framework structures and types of system pages defined can be utilised in such a way as to enable all aspects of care provision to be supported and co-ordinated between departments whilst maintaining departmental control. Equally, it can be seen that the system's operations are dynamically tailored so as to be appropriate with respect to the status of any care provision activities occurring. Thus, collectively the framework structures and system pages support operations which enable the creation and maintenance of complete multimedia departmental records and comprehensive and composite multimedia encounter records for those departments managing or co-ordinating patient care without any duplication of data.

The conceptual design's ability to permit the dual presentation of data as described between departments, is utilised in other ways within the MEHCR to enable comprehensive records to be given. For example, as part of a new Speech Therapy encounter, the search capabilities of the MEHCR could be utilised to extract a relevant patient history known as an Enhanced History Data Set (EHDS). This contains any existing patient information which is felt to be relevant to the patient's current problems. Here searching the MEHCR shows that, in a previous encounter, the X-rays performed at the request of ENT are of the patient's neck, and as such form part of the patient's

relevant history. To enable the X-ray data to be presented as part of an EHDS within the

Speech Therapy consultation encounter framework structure, a component of the

framework structure is available for the support of an EHDS framework structure. The

EHDS framework structure has numerous components available for the support of

relevant patient data. One of the components is used to support the X-ray framework

structure which supports the Radiology data (from a previous encounter) which is felt to

be of relevance to the current Speech Therapy treatment. Equally, other components can

be utilised as required for the support of other relevant data. Figure 5.9 shows an

overview of this situation.
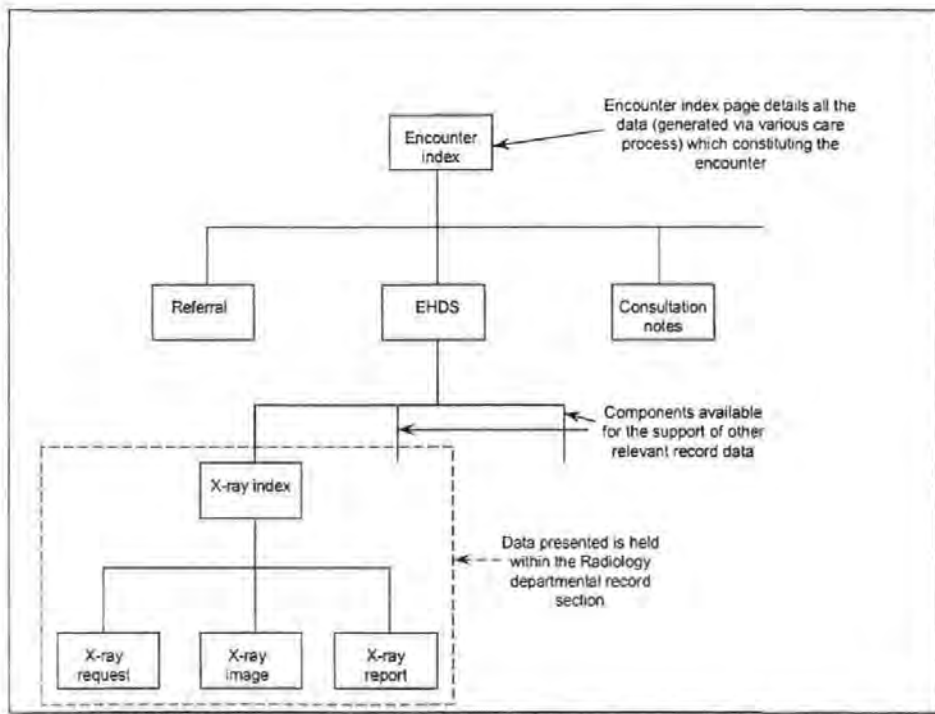
Figure 5.9 – Framework structures support of EHDS

In this way, the framework structures and interfaces enable Ubiquitous Multimedia Data Availability (UMDA), so that data can be presented numerous times whenever it constitutes part of the care given, or a relevant history to care provision. Thus, composite and comprehensive multimedia departmental and encounter patient records of all care provision are given.

5.2.5 Future development of the conceptual design

Thus far the definition of the conceptual design has centred upon the MEHCR's structures, interfaces and operations and how they facilitate the formation of composite and comprehensive multimedia patient records now. However, to benefit care provision now and in the future, the conceptual design must accommodate health related advances whilst maintaining its composite and comprehensive nature over time. Thus, the conceptual design must enable the following:

- introduction and utilisation of new systems;

- introduction and utilisation of new health care services;

- enhancement of its own capabilities.

The nature of the conceptual design's framework structures and interfaces facilitates the above. As stated earlier, the form of the MEHCR is given by using structural descriptions to define the different framework structures used to organise and support all

the data within the MEHCR. Each structural description defines how many components each framework structure may have and what data it supports.

The ability to alter structural descriptions and create new ones enables the conceptual design to accommodate change. For example, if a new clinical system is introduced to the HCE for the visualisation of Dental Specialities data, the following must occur:

- new structural description is created to give a framework structure to support the utilisation (via suitable interfaces) of the new system and the subsequent review of the data generated within the MEHCR;

- existing Dental Specialities consultation encounter framework structure's structural description is altered to enable a new component to be available for the support of the visualisation system's data;

- existing Dental specialities interfaces altered to enable the presence of appropriate options for the request of visualisation data;

- new interfaces created to permit the structuring, entry and display of the new systems data within the MEHCR.

The principle of altering existing framework structures and creating new ones to accommodate change is given in Figure 5.10.
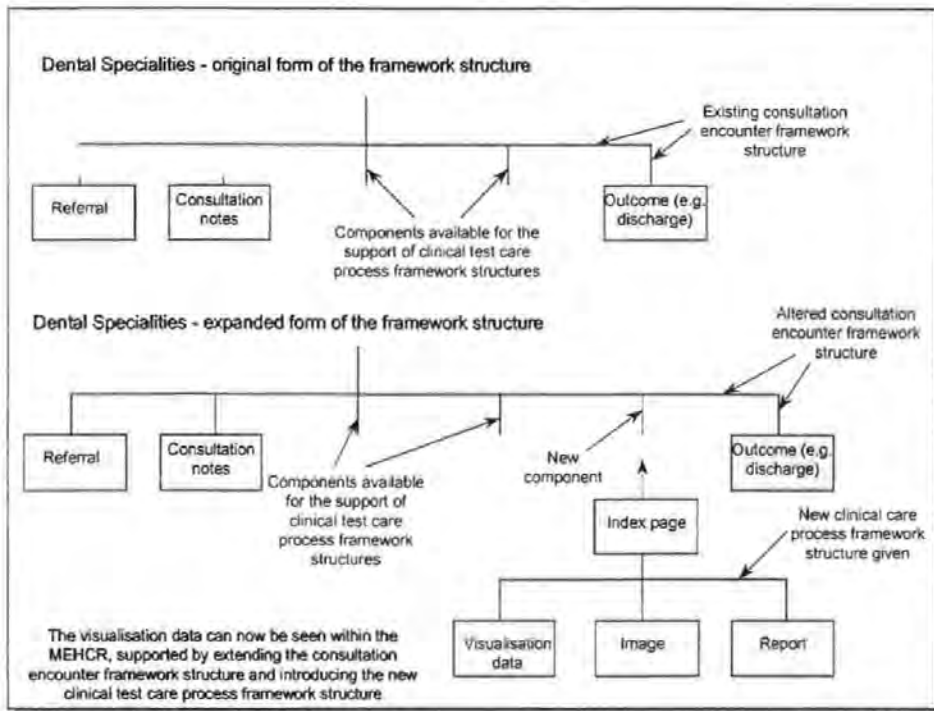
Figure 5.10 – Expansion of the framework structures

5.3 Design environment

From 5.2.5 it can be seen that a fundamental part of the conceptual design is that its structures, interfaces and operations can alter and develop in response to the inevitable future advances of health care. However, defining a system which is capable of accommodating change is itself not enough, there has to be a mechanism for enabling change both solely within the MEHCR and between the MEHCR and other systems. Thus, a "design environment" was defined to facilitate the MEHCR's achievement of the following in the future whilst remaining composite and comprehensive:

- integration of MEHCR operations with those of external medical bodies
  (e.g. GPs, other HCEs, Community services etc.);

- support of new systems and their associated care processes;

- changes in care provision practices.

For a HCE, the design environment consists of one Institutional View and numerous Structural Views. Their purpose is as follows:

- Institutional View (IV) - representation of all the systems involved in care provision within a medical establishment, their relationships to each other, and to the Institutional Views of other medical establishments;

- Structural View (SV) - representation of an individual medical system, its form, constituent data, internal relationships and relationships to other systems enabled via one or more IVs.

Within the design environment the Structural Views are all defined using a common basic model, which enables a simplistic representation of each system form, content and capabilities to be given. Figure 5.11 shows an example of part of a system's SV.

Chapter 5: MEHCR conceptual design and design environment
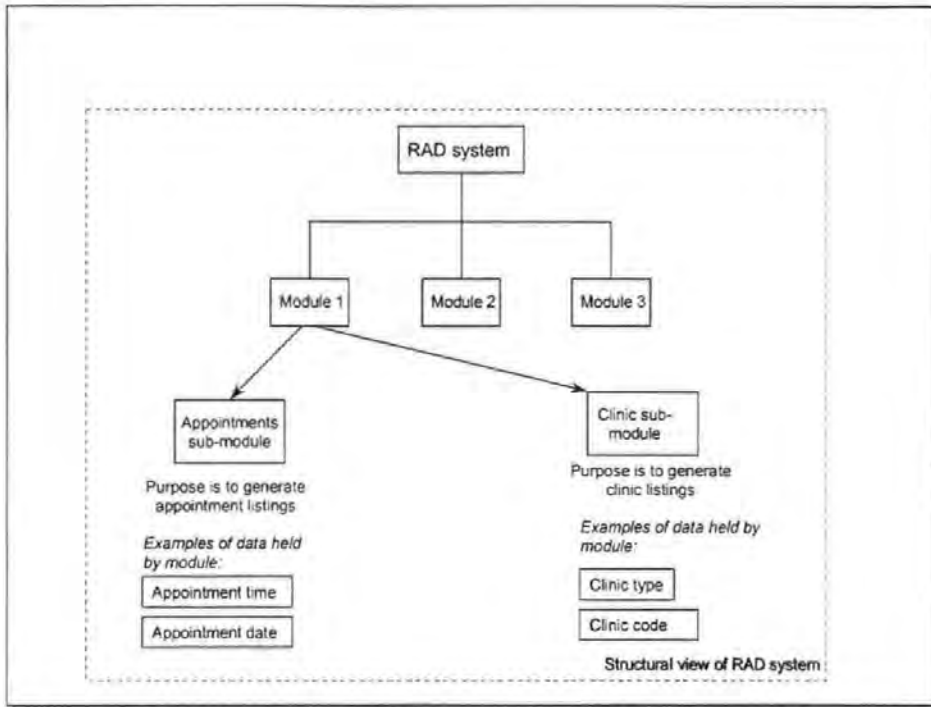
Figure 5.11 – Structural View

The Institutional View is an equally simplistic representation of the communications infra-structure within a HCE between its systems and the systems of other external medical bodies if they play a part in the care provision given by the HCE. Figure 5.12 shows an overview of the IV.
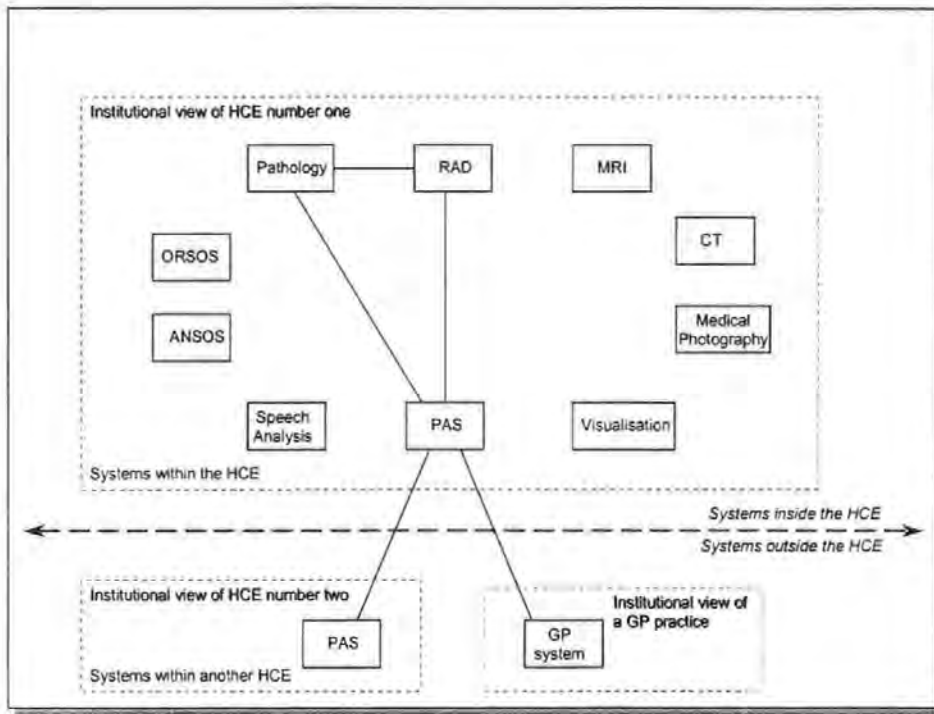
Figure 5.12 – Institutional View

Thus, the design environment enables a comprehensive and easily understood picture of the systems and communications structures involved in care provision to be given within the scope of the MEHCR. This is an important point as it means that the design environment is scaled to the scope of the MEHCR's operations. For example, if the MEHCR were to be implemented and utilised within only one HCE, then the design environment would consist solely of one IV (i.e. that of the HCE involved). However, if the MEHCR is to serve multiple HCE's (perhaps constituting a NHS Trust), and numerous external bodies (such as all local GPs) then the design environment would consist of multiple IVs (one per institution involved).

The design environment has a dual purpose in that it provides a means for the following:

- initial realisation of the composite and comprehensive MEHCR regardless of implementation approach;

- maintenance of the MEHCR's composite and comprehensive nature as care provision evolves.

5.3.1 MEHCR realisation

The process of realising or implementing the MEHCR defined by the conceptual design can be approached in one of two ways, Evolutionary and Revolutionary (defined later), each having their own advantages and disadvantages (detailed in tables 5.1. and 5.2 respectively).

Evolutionary	
Advantages	Disadvantages
• Retention of legacy systems • Incremental implementation • Less disruption • Reduced costs • Greater inherent flexibility (more easily capable of accommodating health care advances)	• Limited functionality • Limited design scope • Integration problems

Table 5.1 - Evolutionary design approach advantages and disadvantages

Revolutionary	
Advantages	Disadvantages
• Total integration • Full functionality • Total design freedom	• Increased costs • Increased time • Greater disruption

Table 5.2 - Revolutionary design approach advantages and disadvantages

The use of the design environment means the MEHCR's initial implementation with, for example, a single HCE can be achieved using either approach as follows:

- revolutionary - MEHCR's conceptual design is represented as a single Structural View (that of the MEHCR) within the HCE, as here the MEHCR is a completely new system whose operations replace those of all existing systems;

- evolutionary - MEHCR's conceptual design is achieved by defining a MEHCR Structural View which utilises (via the Institutional View) the operations of existing systems (as defined by their Structural Views) and enables the development of the remaining operations required.

To illustrate how the design environment could be utilised in the realisation of the conceptual MEHCR, an example is discussed. The example involves the evolutionary implementation of one part of the MEHCR, that of the patient address details. The following points mean that the evolutionary approach is the most likely to be adopted for

the implementation of a MEHCR such as that defined in the conceptual design, hence the example given:

- disruption accompanying the revolutionary approach would be unacceptable to health care (the nature of modern HCE care provision being that even the temporary withdrawal / reduction of non-critical services may adversely impact upon patient care);

- costs associated with the revolutionary approach, especially those connected with the removal and replacement of existing systems are unacceptable (especially in a climate of financial restraint).

The conceptual design states that, within the Patient Information section of the MEHCR, the following patient address data is held and, at application level (i.e. what the user sees), shown simultaneously on screen:

1. House name;

2. House number;

3. Road;

4. District / Area;

5. City / Town;

6. County;

7. Country;

8. Postcode;

9. Home telephone number;

10. Home fax number;

11. Home e-mail address;

12. Personal mobile number.

By examining the design environment representing the situation prior to any MEHCR development it can be seen by looking at the SV of the PAS that it holds a number of the required details (data items labelled 1-9), whilst some (data items labelled 10-12) are unrecorded. So, to achieve the conceptual design (as far as patient address details are concerned) the design environment needs to be developed to appear as follows:

- Structural View of PAS shows that it holds data items 1-9 within its patient address information module;
- Structural View of MEHCR shows that its holds data items 10-12 within its patient address sub-section and utilises data items 1-9 from the PAS;
- IV shows the communications infra structure linking the two systems.

The MEHCR application which presents an embodiment of the conceptual design examines the MEHCR's Structural View to determine which data items are required and from where they are to be obtained (i.e. items 1-12 are required and that 1-9 are obtained

from PAS, via the Institutional View, whilst 10-12 are held directly by the MEHCR).

Figure 5.13 shows an overview of this situation.
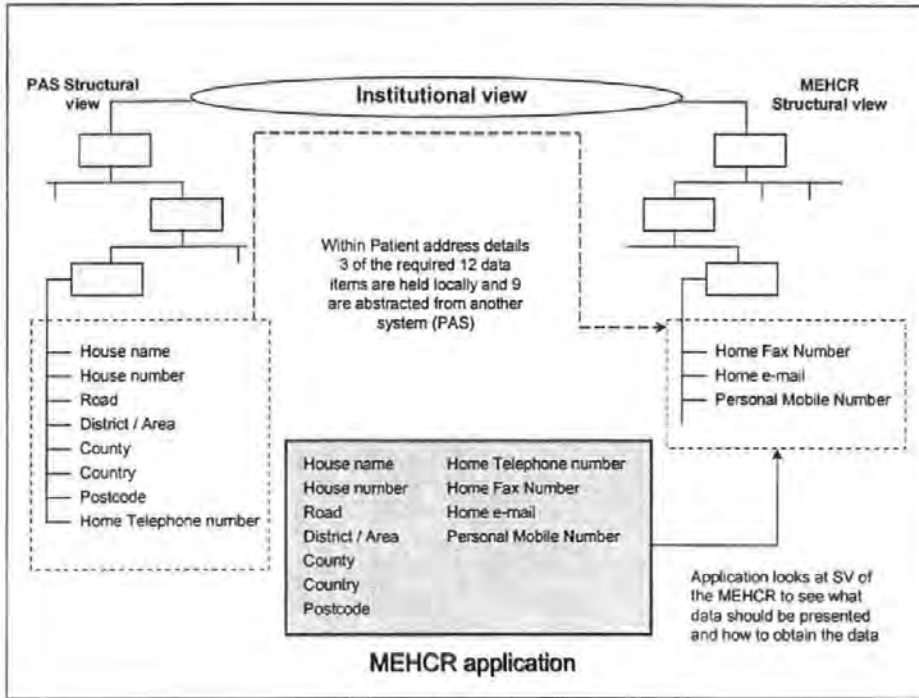
Figure 5.13 – Design environment overview

Obviously, here the design environment presents a greatly simplified picture of the how

the implementation approach can be achieved. However, this common high level form of

representation is necessary as an intermediate stage from which suitable technologies can

be exploited to permit the actual development, integration and interoperability of systems

and hence enable the desired MEHCR to be realised.

To illustrate the use of the design environment in the realisation of the conceptual design (via the evolutionary approach) an example scenario covering the technical realisation of the MEHCR from the design environment is given below. It shows how object oriented component technologies are utilised to enable the actual realisation of the type of systems data interchange required. The example above, of the evolutionary implementation of the patient address details has thus far discussed how conceptually the Structural Views and Institutional View are utilised by the MEHCR application to enable the required MEHCR patient address data to be seen. To realise this in actuality, a component object orientated technology such as the Common Object Request Broker Architecture (CORBA) could be used (OMG, 1999).

The common representation used by the design environment enables data items to be defined (e.g. 1-12). From this representation, it is possible to use CORBA to define the data items as objects and using typing (sub and super) to define their origin or location (i.e. the systems they reside in) and their behaviour (the operations which can be performed on them).

Within CORBA, the MEHCR application is seen as a client which uses a variety of objects (i.e. the objects used are those representing data items 1-12). The Object Request Broker (ORB) is used by the client to access objects. As far as the client (i.e. the MEHCR application) is concerned, it does not matter whether the objects are located locally (i.e. 10-12 within the MEHCR database tables) or remotely (i.e. 1-9 located within

the PAS database tables) as the client merely acquires the object reference of each object and manipulates this to facilitate the use of the object as if it is located within the application's memory. The client relies on the ORB to control all mechanisms to enable the location of the object's implementation, whether the object is actually remote or local to the MEHCR system, the passing of requests to it and the transportation of any replies to the client (OMG, 1995). Thus, the client can transparently use objects distributed between various systems and platforms.

To enable the MEHCR application (i.e. client) to present the required patient address details on screen, it acquires the necessary object references of objects 1-12 and requests their presence. It does this by invoking a method per object (e.g. get (...)). So far as far as the client is concerned, objects are simply requested and their location (remote or local) is of no interest. The method is described in an Interface Definition Language (IDL) which forms a file (IDL file). This acts as a contract between the client and the server (the server being the implementation of the required object e.g. Patient Postcode Server Object). When the IDL file is complied the client stub (known as the stub) and the server stub (known as the skeleton) are generated (Chung et al, 1995).

The client stub is written in the client language, and can be thought of as means of making calls to the ORB core (i.e. the part of the ORB providing basic object representations) via private and optimised interfaces. It uses the ORB to translate its language specific operation call in to a Generic Inter-ORB Protocol (GIOP) request. This

is then passed to the network transport processing layer which enables both the GIOP object location information to be translated into the transport-specific address of the object implementation, and the creation of a transport message containing the GIOP. This transport message is then sent by the client ORB to the server ORB (Chizmadia, 1998).

The server ORBs transport processing layer abstracts the GIOP request and processes it to give the language and platform specific format required by the object implementation. The skeleton stub then calls the appropriate function on the object implementation (e.g. if Patient Postcode Server Object is the object, then the function on the object might be *get (postcode value)*). The appropriate reply (in this case the Postcode value) is then returned by the object implementation to the skeleton stub and passed back to the client. Figure 5.14 illustrates this example.
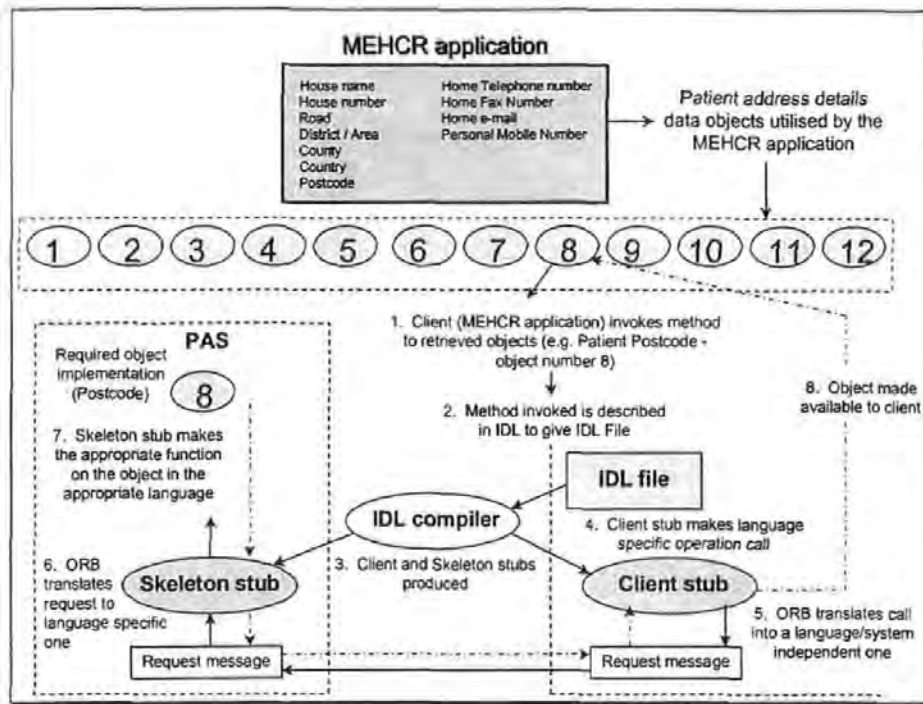
Figure 5.14 – CORBA overview

So it can be seen that it is possible to move from the desired MEHCR system (as defined by the conceptual design) to the design environment and realise the required system via the use of an Object Orientated component technology such as CORBA.

The example illustrates the principle of using component technologies. However, in reality when implementing any system numerous factors such as processing and communications overheads would have to be considered. In the example given to decrease these overheads rather than invoking one method per object, one per system might be used. So here the client invokes one method within nine arguments (one per

object) to obtain the required patient address data from the PAS. Equally, it might be felt that for one patient, all associated data should be gathered in one sweep rather than issuing requests for particular data objects as they are required / utilised by certain parts of the MEHCR application. It should be emphasised that the example defined is only way in which the design environment could be utilised.

5.4 Summary

This chapter has sought to discuss the form, appearance and capabilities of the MEHCR given by the conceptual design defined. Equally, the purpose, form and utilisation of the design environment has been described as a means of enabling the realisation and development of the MEHCR within the health care environment. The next chapter moves on to discuss how the conceptual design and the design environment can collectively give a system which benefits care provision.

Chapter 6

MEHCR benefits to care provision

Introduction

This chapter defines an example of a Multimedia Electronic Health Care Record (MEHCR) implementation and patient care scenario. The MEHCRs utilisation is described as the required patient care is given. From the utilisation described the benefits given by the MEHCR are commented on with respect to the use of electronic communications, systems integration, modes of use, support of working practices, obviation of current record problems and the further expansion of health care. The chapter concludes with a brief summary of what the designs defined have achieved.

6.1 Scenario basis for benefits discussion

The previous chapter defined the conceptual design for a MEHCR and a design environment as an intermediate means of both its initial realisation (independent of implementation approach) and its continuing evolution. However, it did not give any feel for the form or use of the system from a user perspective, and thus, did not demonstrate the true benefits available to care provision from the designs defined.

To enable the capabilities of the designs with respect to aiding of care provision to be seen an example of the systems utilisation is described. The example devised is based upon the following implementation:

- full conceptual design functionality - the MEHCR has the capabilities given by the conceptual design;

- scope of the design environment - includes a number of local GP practices, two large private care insurance companies and a HCE within which the MEHCR is based;

- evolutionary implementation – existing systems such as the PAS, RAD etc. are maintained where appropriate and integrated into the MEHCR's operations;

The basis above was determined for the example as it represents the type of MEHCR implementation which could realistically be achieved at this point in time.

6.2 Example scenario

The example of the MEHCR's use centres around one patient's care needs. Here the patient goes to her local GP worried about a lump which has developed within one breast. The GP is concerned about the patient and decides that an Out Patient referral to a consultant at the local NHS HCE is necessary.

The request for the referral is generated as part of the patient's GP record. Thus, details such as the patient's name, address, data of birth, NHS number, the time and date of the referral request being made and the requesting GP etc. are all automatically pre-entered within a basic *HCE referral request* word processor template. The remaining referral data such as the consultant and referral reason are all defined by the GP. Once complete the request is inserted into an e-mail and sent to the appropriate HCE department as the GP's practice is linked to the local HCE system.

The HCE Out Patient department receives the e-mail and the referral request document is read by the one of the department secretaries. As a referral must be seen by the consultant for assessment, the request is forwarded to the appropriate consultant. The consultant reviews the request. At this point the consultant can chose to search the MEHCR system to see if the patient already has a hospital record and view a summary of their medical history.

In this case, however, from the information in the GP's letter the consultant simply decides that a referral should be given and that it is urgent. The referral assessment

data (i.e. the acceptance of the referral and its urgency) is added directly to the referral request document sent by the GP. The document is then forwarded to the department administrator. The administrator searches the MEHCR to locate the appropriate patient record (if no record exists one is created). Here, the patient has a record, so the administrator accesses the appropriate Out Patient record sub-section.

Within the *Out Patient departmental index page* a menu *appointments* and one of its options *GP referral* are utilised to enable a departmental appointment to be given. As the conceptual design was achieved using the evolutionary approach, the PAS (Patient Administration System, responsible for the maintenance of some patient details and the booking of appointments) was integrated into the MEHCR's operations. Thus, the use of the option causes PAS operations to be presented (via new interfaces) and utilised so that the required appointment can be given. The interfaces enable the PAS to present a number of appointment options to the user, and for one to be selected. When selected, information from the MEHCR (such as the patient's name, and NHS number) is passed to the PAS automatically so that the patient whose record is requesting the appointment is seen as having been given the appointment.

Once an appointment has been given, the patient appointment notification is generated. This is generated automatically by the MEHCR in the form of a letter. A template can be used in accordance with the type of appointment given (clinic to be attended etc.) and the constituent data fields (such as time, date, consultant and other advice (e.g. do not eat on the day of the appointment etc.)) are automatically completed. Equally, if the patient has an e-mail address (recorded within the PI

section) the system can be set to send reminder e-mails etc. near the appointment date, or to solicit a confirmation of the patient's attendance. Alternatively, paper-based reminders can be automatically generated, or reminder phone calls prompted via system diary operations in accordance with the HCE's operations. Figure 6.1 gives an overview of the MEHCR's utilisation in booking the appropriate patient appointment.
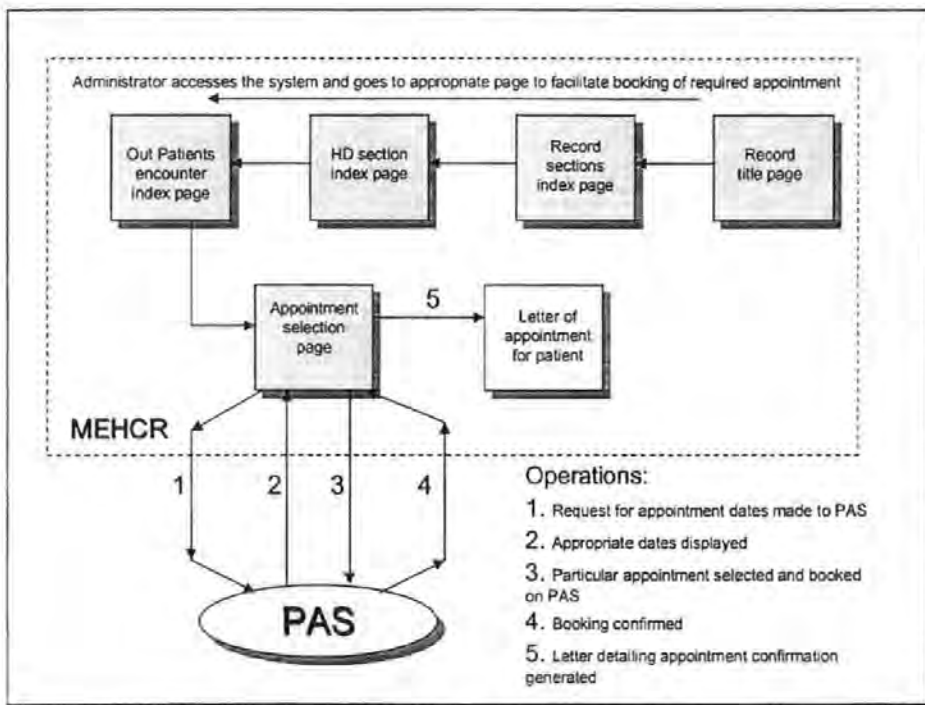
Figure 6.1 – Overview of referral booking operations

Selection of an appointment enables the MEHCR to automatically create instances of the framework structures and interfaces necessary for the creation and support of the data which may be given by the patient encounter that will follow. Thus, once the appointment has been given, the item of data defining the referral request (i.e. the document sent by the GP and completed by the consultant) can be appended to the

record within the Out Patient record section as the referral data item of the consultation encounter now booked. Figure 6.2 gives an overview of the occurrences to this point.
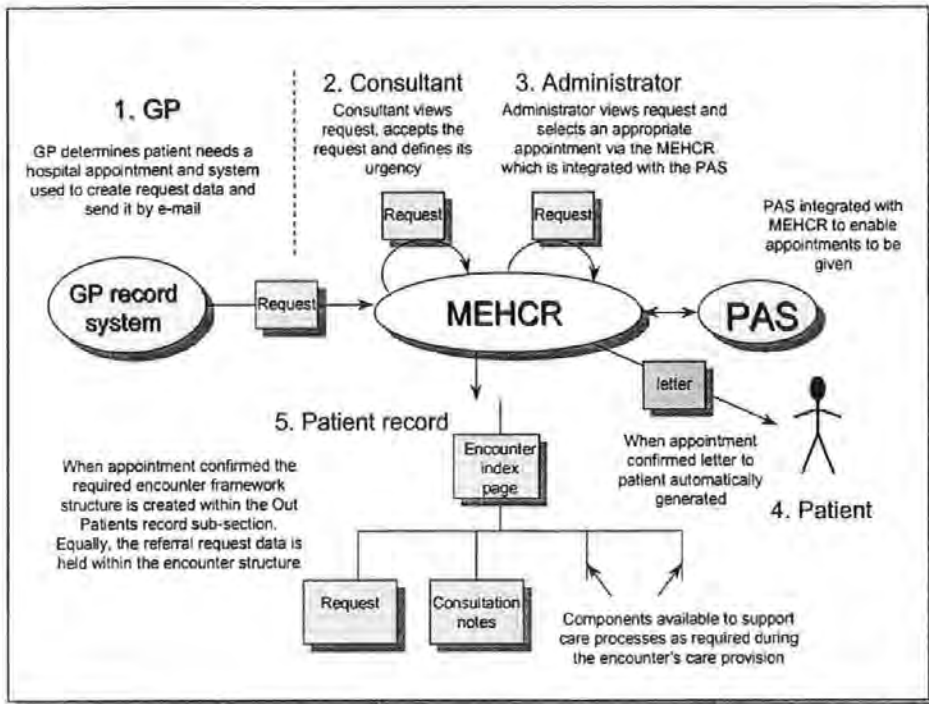
Figure 6.2 – Overview of patient referral

Now, if the GP accesses the HCE's MEHCR system to enquire as to the progress of the referral request made, he sees that an appointment has been given to the patient. Alternatively, the system can be configured to trigger an automatic e-mail to the GP as the appointment is booked. The actual access the GP has to the MEHCR can be tailored as appropriate, depending on the wishes of those managing the MEHCR's operations. For example, only a summary record of the patient's encounters may be available to the GP, or only details of those encounters they referred.

Equally, from this point on the consultant may, in preparation for the patient's visit, view the MH and PHC sections for background information, or access directly the *departmental encounter index page*. The page shows the presence of the encounter data produced thus far, so here the Referral data item is indexed. The page also shows that the consultation notes can be accessed. Figure 6.3 illustrates what the consultant sees within the Out Patient departmental section at this point.
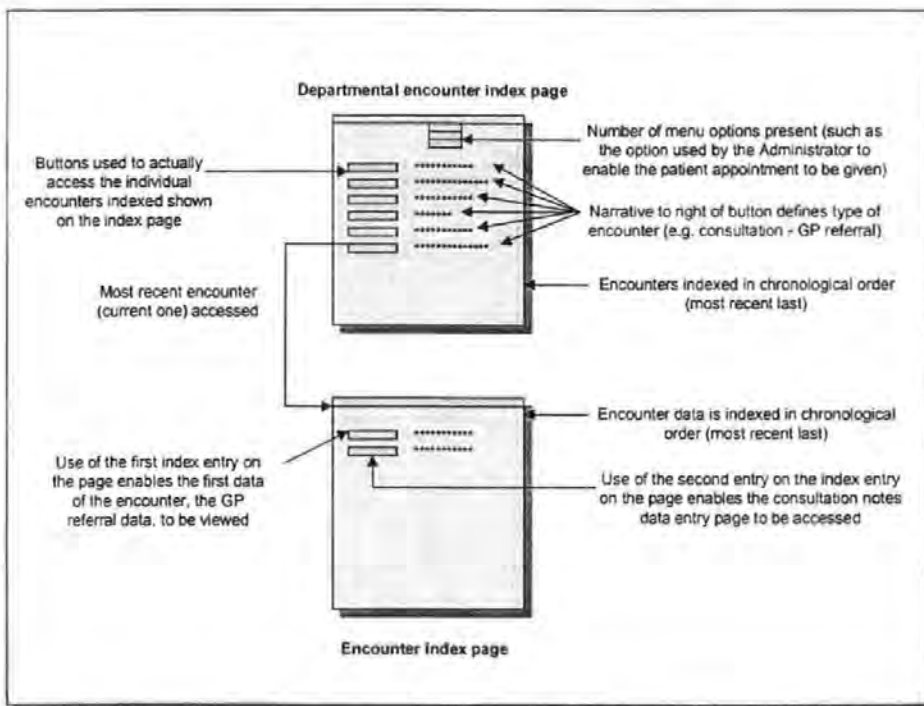
Figure 6.3 – User view of Out Patient department record section

The consultant accesses the referral data to study the information from the GP. Within the GP letter is information stating that the patient had Breast implants two years ago. The consultant now searches the MEHCR for any relevant information. The search returns data surrounding three encounters in the Plastic surgery

department, relating to the patient's initial consultation, surgery and follow up appointment. This data can be examined by the consultant.

The consultant then goes back to the *encounter index page* and accesses the *consultation notes data entry page.* At present there is no data constituting the consultation notes. However, the *consultation notes data entry page* is present to enable data to be entered and other care processes to be initiated and / or completed (e.g. menus on the page enable X-rays, physiotherapy assessments, ECG examinations etc. to be requested). Within the page the menu options can be used to enable the Plastic Surgery encounters (returned by the search) to be selected and linked to the encounter as the EHDS (defined in chapter five). Thus, the MEHCR has enabled the consultant to prepare for the appointment as all the relevant data available at this stage (i.e. within the auspices of the MEHCR) has been collated and reviewed. Figure 6.4 gives an overview of the form of the encounter within the MEHCR at this point.
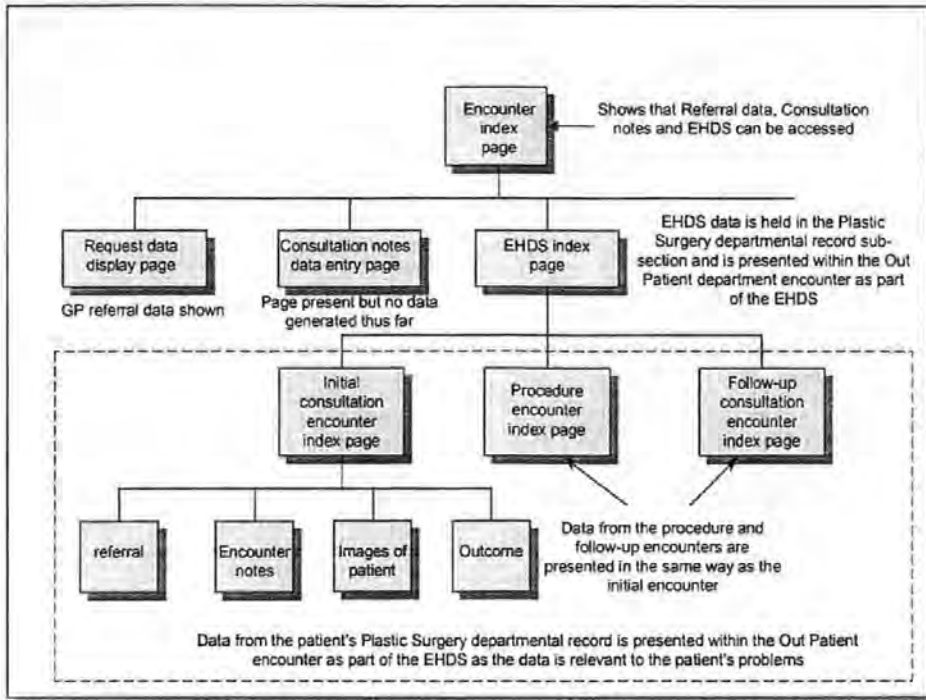
Figure 6.4 – Overview of encounter structure thus far

On the date of the appointment the patient arrives at the Out Patient department. The receptionist accesses the MEHCR system, searches for and selects the patient's record. The record's PI section is accessed and the patient address details etc. are verified and updated as required (here the patient has changed jobs, thus, these details are updated; in this case any changes in the GP details are automatically updated as the practice is networked). After this, the Out Patient department sub-section is accessed and on the *departmental encounter index page* the appropriate encounter listing is selected and menu options used to note the patient's attendance. This information is then transparently updated to the PAS system to show that the patient attended the appointment given.

The patient then waits in the reception area until they are called by the nurse. The nurse then accesses the MEHCR via either a workstation or suitable laptop / cruise pad device. The patient's MH and PHC details are checked and updated as required (e.g. fact that the patient has finished a course of medication is recorded within the medications sub-section of the MH record section).

The patient now sees the consultant. The consultant accesses the *encounter index page* and, via the selection of the GP referral and EHDS buttons, reviews the GP and EHDS details again (the GP data being presented via the appropriate display page and the EHDS being further indexed and presented via the appropriate Plastic Surgery pages). He then starts with the patient to discuss her current problems. As the consultation progresses, data is incrementally added to the *consultation notes data entry page* within the appropriate workspace areas.

The entry of the data can be done via a variety of methods (e.g. speech to text, keyboard, graphics tablet etc.) depending on what the consultant prefers, and what is felt to be most suitable in the consultation environment. The various data entry methods available can be utilised by the means of selecting appropriate consultation notes menu options. Equally, the form of the page and its workspace areas can be tailored to the department's operations. For example, one department may choose to have the consultation data entry page organised in such as way as to collect information relating to aspects of the patient's problems. They may perhaps chose to define an area for the taking of the patient history, and within this have sub-sections to define the problem time scale, extent of impact upon daily life, degree of pain /

discomfort experience etc. Alternatively, the page may simply have one workspace

for the recording of all data (i.e. the consultation notes), and display certain patient

information (e.g. patient name, age etc.). Figure 6.5 gives an example of the format of

the *consultation notes data entry page.*
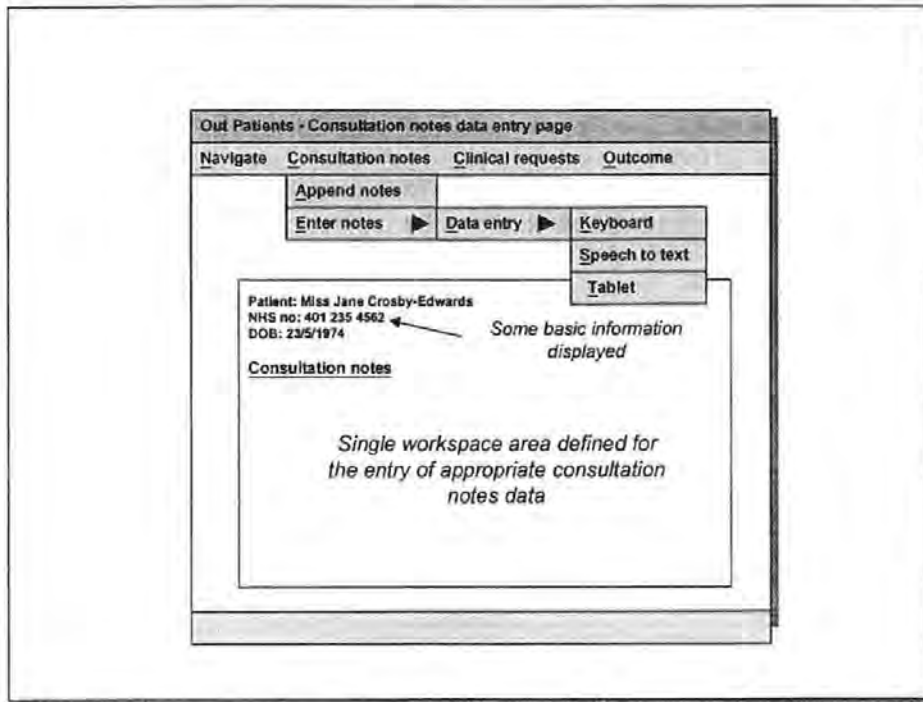
Figure 6.5 – Consultation notes data entry page

During the consultation, the consultant physically examines the patient and feels that

both a Needle test and Ultrasound examination are required. In addition to enabling

data concerning the consultation to be recorded, the *consultation notes data entry*

page also acts as the means through which the care required as part of the encounter

(in the form of different instances of the various care processes) is determined and

initiated. So, as well as permitting the direct recording of the consultation notes (as

mentioned) the operations of the page also permit the initiation, or starting, of different care processes. This is accomplished via a formal request (should the care process required be based outside the department) or without a request (should the care process be based within the department).

The actual initiation of the care processes is done by accessing the clinical request menu on the *consultation notes data entry page* tool bar. Each menu option names a particular HCE department (including the department in which the encounter is occurring) and branches to reveal the services / tests etc. offered by each department (further branching may be present for those departments such as Radiology offering a wide variety of services). In the example, the consultant selects Radiology, then Ultrasound. The system then presents the Radiology request data entry page. On the page, numerous details are pre-entered (e.g. patient name, type of examination etc.) so that the consultant only has to complete a few details (such as urgency, area of body to be scanned and any other relevant comments). On the *Radiology request data entry page*, the data entry method can be selected as appropriate by the user (as in the *consultation notes data entry page*). Figure 6.6. shows how the *consultation notes data entry page* is used to enable requests to be made and care processes initiated.
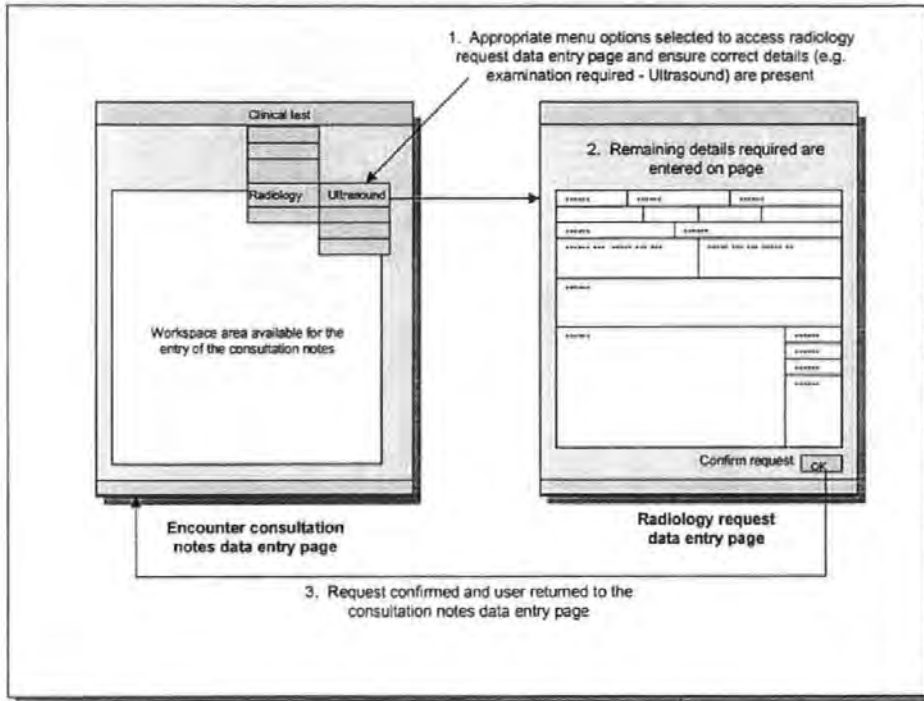
Figure 6.6 – Request initiation

Once the details are complete, the Ultrasound request is confirmed. After confirmation, the appropriate framework structures and interfaces are given so that the request is seen within the Radiology department record section as a departmental encounter. Figure 6.7 illustrates this process.
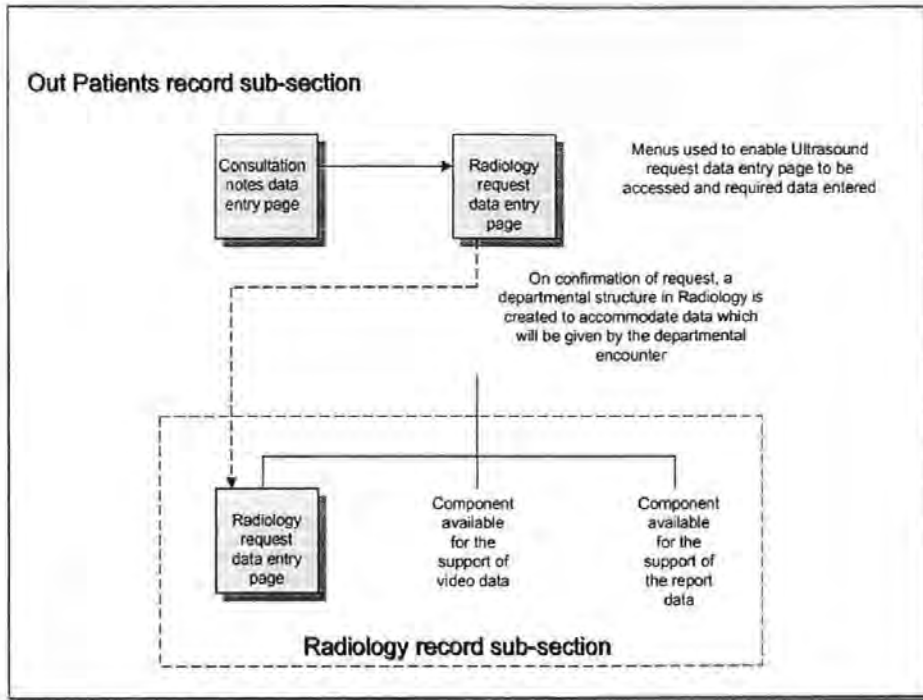
Figure 6.7 – Overview of request confirmation process

In the example, the *Radiology request data entry page* enables the requesting consultant to enter the appointment date (i.e. current date). Normally, this item of data cannot be entered by the requesting clinician as the Radiology department will give an appropriate appointment time and date in accordance with their departmental schedule. However, because of the nature of the request, the system knows that the Breast Clinic requests are dealt with immediately (same day) by Radiology. Thus, for this request, the integrated RAD system (which manages the Radiology department appointments and thus workload) is bypassed.

Before the patient leaves to attend the Ultrasound examination just requested, the consultant performs a Needle test. This abstracts fluid and cells from the lump, the

cells are then analysed by Pathology to indicate whether or not there are any abnormalities. Again, the consultant uses the clinical test menu, selecting the *Pathology* option and its *Cell analysis* branch. As before, the utilisation of the option presents the consultant with the appropriate *Pathology request data entry page*. Equally, as before, numerous details are pre-entered so the consultant only has to complete a few details. When the request is confirmed, Pathology see the request within their departmental sub-section of the patient's records. The sample is then labelled (the bar code label being automatically generated by the MEHCR as the request is made within the system), and sent to Pathology. The patient is then sent along to Radiology for the Ultrasound and asked to return to the clinic at a specific time in the afternoon.

On arrival at Radiology the patient goes to reception. The request from the consultant is seen within the patient's records as a departmental encounter scheduled for the current date. As before, the receptionist checks the patient details within the PI section. The patient is then taken to have the Ultrasound examination. Before starting, the clinician reviews the request details and completes the data surrounding the time of the examination and the clinician conducting it. Equally, the clinician can review the Out Patient breast clinic encounter data generated if necessary to furnish further relevant background information. In addition to this, any Radiology treatments undergone by the patient (e.g. X-rays, CT scans etc.) are usually reviewed by examining any other Radiology encounters present within the departmental records. Here, within the Radiology record section, the patient has had no other encounters so the examination is initiated and completed. All the Ultrasound scan

data is recorded and appended to the record via the *Ultrasound images data entry page*. This enables the digital video recording of the examination to be added to the record and additional information (e.g. graphical annotations, textual notes, contrasting images etc.) to be overlaid on to the video images generated. Thus, in the example, an area of some thickening within the breast tissues revealed by the Ultrasound images can be clearly defined by the use of annotation with a graphics tablet.

Once added to the record, the annotated video data is displayed via the *Ultrasound images data display page* and the clinician can move on to enter the report data. This is entered via the *Ultrasound report data entry page* (similar to the *consultation notes data entry page*) and reviewed by its complementary data display page. In the report, the clinician states that the information gathered is inconclusive and that a Mammogram is required to yield more data. This examination is initiated from the *Ultrasound report data entry page*. This page permits the initiation of other Radiology examinations, as it can be the case that once the examination requested is performed it becomes apparent that another examination of a different type is required. Thus, the interfaces within Radiology cater for and reflect the department's needs.

The Mammogram is initiated by the use of appropriate branched menu options (as before). Many of the request details are pre-entered (as before) and confirmation of the request enables the examination requested to be seen as another Radiology departmental encounter. This encounter is also linked to the Breast clinic encounter,

as the Mammogram is seen as another of its clinical test care processes, as it is providing information / services forming part of the care managed through the Breast clinic encounter. The Mammogram request details are completed to indicate the time, date and clinician performing the examination and then presented within the record via the appropriate display page. Equally, the Mammogram image data generated is appended to the record through the appropriate data entry page and annotated as appropriate. Finally, the clinician's report on the examination is entered and presented via the appropriate data entry and display pages. Once an examination report is complete the departmental encounter as a whole is reviewed and signed off as complete by a suitably qualified member of staff.

When the Ultrasound and Mammogram examinations have been signed off, the results can be seen (within the Out Patients record section) as a clinical test care process of the Breast clinic encounter. In the example, the examination reports and the signing off of the examinations will be done immediately as the results are required by the Breast clinic that afternoon when the patient re-attends the clinic. So now all the data constituting the Ultrasound and Mammogram examinations within the Radiology department can be seen as part of the patient's on-going Breast clinic encounter.

Meanwhile, the patient's cell samples have arrived at Pathology. A scanner, linked to the MEHCR, is used to scan the bar code label on the sample. This enables the correct patient record to be selected and the user taken directly to the Pathology record sub-section and to the departmental encounter now present to enable the request to be responded to. The encounter has an encounter index page from which the request

made can be reviewed. Equally, when the analysis required is complete the image data generated can be added to the record and annotated as required via the *Pathology analysis data entry page* (as in Radiology). After this the report data can be entered via the *Pathology report data entry page*. The data generated is then reviewed via the appropriate data display pages and once signed off the departmental Pathology encounter (comprising of the request, analysis and report data) can be seen within the Out Patients Breast clinic encounter record as different instances of the clinical test care processes of the said encounter.

Hence, when the patient re-attends the Out patients clinic in the afternoon, all the relevant information concerning the Ultrasound, Mammogram and Cell analysis examinations is available to the consultant. Figure 6.8 gives an overview of the record structure to this point.
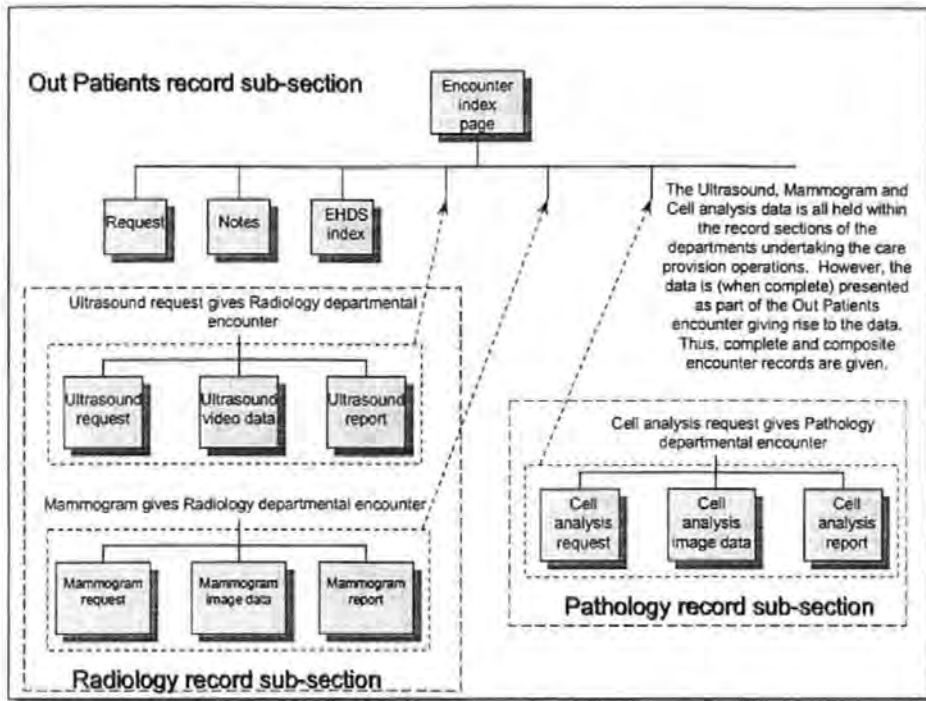
Figure 6.8 – Overview of encounter data thus far

In the afternoon, before the patient is actually seen, the consultant can review all the patient data generated thus far so that he is in full possession of the facts when the patient arrives. On seeing the consultant, the patient is told of the results gained from the earlier examinations and can, if felt appropriate, be shown certain items of data within the record to aid her comprehension of the findings. In this case for instance, the fact that a definite lump has been found can be demonstrated to the patient by actually showing her the Ultrasound video (within which the area of thickened tissue is highlighted) and the Mammogram image which shows the lump more clearly. Equally, the patient's fears as to the nature of the lump can be addressed by informing her that the Cell analysis showed no abnormalities.

Here, as there is a definite lump present, the consultant decides to take a Biopsy just to confirm that the lump is purely a fibrous one. Thus, within *consultation data entry page* of the Out Patients breast clinic encounter, menu options are utilised as before to enable Pathology to analyse the Biopsy sample once obtained. The appropriate menu enables the Biopsy request to be made and an appropriate sample label generated. The label is then adhered to the vessel containing the sample which is obtained directly from the patient by the consultant using a Biopsy gun. The sample is then sent to Pathology, where it is expected as the required departmental encounter structures become present within the Pathology record sub-section when the Biopsy request is confirmed by the consultant.

Before the patient leaves, the consultant talks to her and decides that further information should be provided. A number of appropriate information leaflets are printed out from the MEHCR and given to the patient. The patient is then informed that as soon as the Biopsy results are known she will be contacted. The patient then leaves the HCE.

The Biopsy results will take about three days (depending on the Pathology department workload), but in the meantime the patient has been extremely anxious about what will happen next and decides to ring the help line number detailed in one of the leaflets she was given. On ringing the Breast clinic help line the patient is spoken to by an Out Patient nurse at the HCE. Whilst answering the call the nurse accesses the MEHCR system and locates the patient's record, she then locates the appropriate

breast clinic encounter and accesses the *encounter index page*. This indexes the following:

- GP referral data;

- consultation notes;

- ultrasound examination;

- mammogram examination;

- cell analysis examination;

- biopsy request (at present as the Biopsy has not been completed so only that fact that it has been requested is available to the nurse).

The nurse uses a menu option on the *encounter index page* to enable her to record the patient's phone call as part of the encounter data. The use of the appropriate menu option reveals a *patient contact data entry page* and enables the nurse the record the time, date, nature (phone call, email etc.) of the contact, its content (e.g. what the patient is concerned about), the level of concern, and other pertinent factors. Equally, the page enables any actions arising to be recorded (e.g. if the patient is very distressed she may be advised to come back to the Breast clinic for further information or go to her GP. Alternatively the information given may be quite sufficient and no further actions are required).

When Pathology have completed the Biopsy analysis and released the data (i.e. request, annotated tissue analysis image data and report), the Out Patient consultant can see the findings within the Beast clinic encounter record. The results show that no

abnormalities are present and, thus, the consultant can determine the outcome of the encounter (i.e. that a follow up appointment is required in two months time). The outcome is initiated by the use of the outcome menu and follow-up appointment option present within the *consultant notes data entry page*. Equally, the consultant automatically generates a letter (constructed using a template linked to the Biopsy results) to the patient detailing the Biopsy findings (this can be edited as required before it is finalised and sent to the patient). At this point the encounter is defined as complete. Figure 6.9 gives an overview of the form of the encounter data.
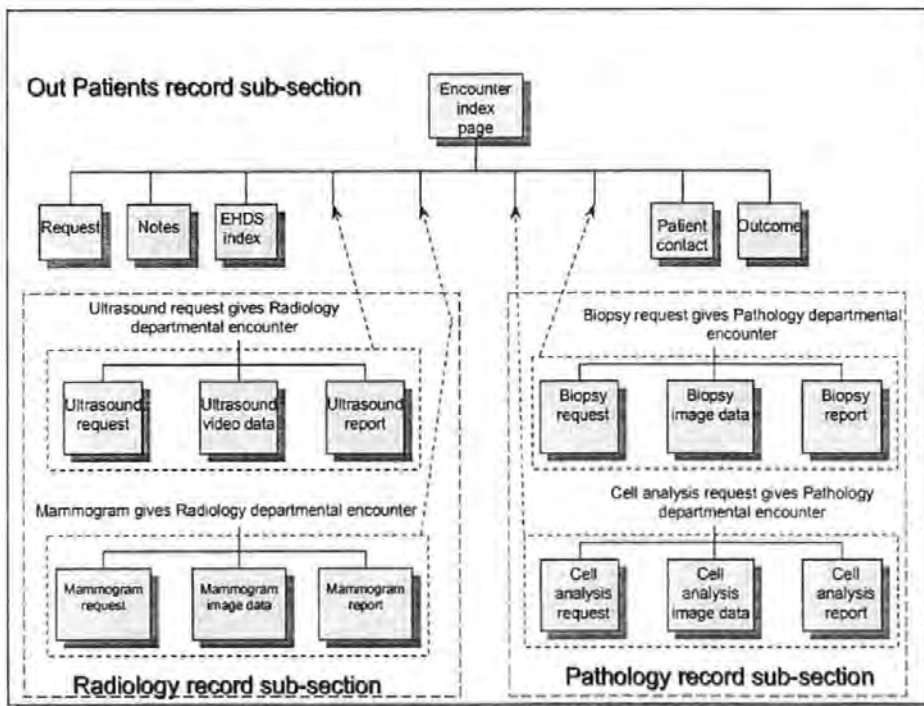
Figure 6.9 – Overview of encounter data

So now, when the encounter is accessed the consultation notes and all other data is viewed via the appropriate data display pages as no further data is added to the record

with respect to the patient's care, although amendments can be entered in addition to the existing encounter data to correct any incorrect data present.

6.3   Care provision benefits

The scenario described is a relatively simple example of a patient's progress through the health care system. As such, it provides a means of demonstrating a number of benefits which the MEHCR (as defined) brings to care provision. The following, subsections discuss these benefits.

6.3.1 Electronic communications

For many years the automation of HCE communications, in the form of the electronic entry of orders, has been seen as a means of increasing the efficiency and quality of care provision (Weiner et al, 1999). For example, computerised order entry systems in conjunction with decision support have been found to reduce medication errors by more than 80% (Bates et al, 1999). Currently, the vast majority of communications between clinicians occur via paper (e.g. request of clinical test from another department, report on a clinical test being made available to the requesting clinician in another department etc.). However, in the example these occur electronically (e.g. the Ultrasound request and the availability of subsequent Ultrasound report), as does the initial referral of the patient.

In addition to facilitating electronic communications between clinicians (and patients when appropriate), the proposed system also aids the generation of communications

data by its effective utilisation of data within the MEHCR and other integrated systems. Data is utilised in two ways by the system:

- reuse – when existing data is utilised within various operations;

- derivation – when data required is abstracted from the systems operations.

Data reuse is illustrated in the example when the Ultrasound examination is requested. A request to Radiology for the Ultrasound requires around 25 items of data and further clinical comments to be recorded. However, the majority of the data required is already held by the MEHCR system. Thus, administrative data, such as that held in the PI section (e.g. Patient name, NHS number etc.) is presented automatically (i.e. reused in the request). Equally, clinical data such as that surrounding previous Radiology care (e.g. previous MRI = YES / NO, previous CT = YES / NO etc.), is automatically presented. For example, if within the Radiology departmental section the patient has undergone MRI, CT or X-ray examinations the fields relating to previous MRI, CT and X-ray examinations on the Radiology request form will be automatically set to YES (indicating that these types of examinations have occurred). Although the system automatically sets appropriate values in accordance with the information available to it, information from outside the scope of the MEHCR's operations needs to be added manually (e.g. on the Radiology request form if no Radiology treatments have been undergone by the patient at the HCE, then the fields relating to previous treatments will be set to NO (as this is the limit of the systems

knowledge). However, these values can be manually overridden by the requesting clinician as required.

Data derivation concerns information being derived from the operation of the system, such as the user requesting the test, request time and date and the test type required etc. For example, on the Radiology Ultrasound request the examination required data is automatically set to Ultrasound as this was the Radiology menu option utilised when generating the request. The information derived can, thus, be automatically presented as appropriate within the communications being generated.

The electronic nature of communications with the reuse and derivation of information, along with the following:

- use of pre-determined data options (e.g. in assessing mobility of patient options of fully mobile, requires help or wheelchair are present):

- data validation (e.g. if a date is required as part of the communication then the data entered must be in a form capable of being converted into a standardised data format);

- categorisation of data fields – data is defined as mandatory or optional (e.g. on a clinical test request data concerning the tests to be completed must be entered, whilst the entry of further comments is optional).

means that collectively the following could be achieved:

- reduction of data entry tasks (by 80% in some cases for requests);

- reduction in data entry errors (pre-determined options and validation of field entries aid this, as does reduced data entry burden);

- elimination of incomplete requests / reports being generated (system demands presence of all essential data);

- elimination of manual communications delivery (and the opportunities for its loss);

- permanent records of communications to be maintained (MEHCR holds communications as part of the encounter record).

Thus, the MEHCR enables communications to be quicker, more easily generated, more easily available / reviewed and more informative and comprehensive (as all the required data is always present). This benefits care provision by making it more efficient, as less time is spent waiting for and generating communications, and the communications are maintained as a structured part of the record.

6.3.2 Systems integration

The conceptual design stipulates that care provision is both enabled and recorded via the MEHCR. This means that the operations of other systems utilised during care provision must be supported, either directly via the MEHCR's operations (replacing those of existing systems) or indirectly via systems integration.

Within the auspices of the conceptual design, the term "system" refers to both existing computerised systems (such as the PAS, RAD, ORSOS etc.) and various items of equipment (such as the MRI, ECG and Ultrasound systems) which generate digital / analogue data that forms part of the patient record. Within the example, the MEHCR's ability to support systems is demonstrated by the integration of the PAS and its operations, and the operations of the Ultrasound and Mammogram systems (i.e. data from the latter two being converted if necessary and recorded in a digital format suitable for appending to and presentation through the MEHCR as appropriate).

So the operations of computerised systems (such as the PAS and ORSOS) which have roles in care provision administration and recording can be seamlessly integrated so that they are supported from within the MEHCR application. Thus, the MEHCR does not duplicate the operations of existing computerised systems, but offers a new way to support and enhance them so that they are utilised efficiently during care provision.

Equally, other HCE systems, such as those defined in chapter two as isolated clinical systems (e.g. MRI, visualisation tools, speech analysis systems, numerous monitoring systems etc.), creating, or giving rise to, multimedia data can all be utilised as required during care provision. But now in addition to being utilised during care provision as data is generated it can be made available (in a suitable format) for appending to, and presentation within, the patient record via the MEHCR. For instance, in the Breast clinic example, the Ultrasound scan can occur as required with the MEHCR integration being structured so as to permit the automatic digital

recording of the analogue Ultrasound data to give digital video data. The clinician then accesses the MEHCR and imports and appends the Ultrasound scan digital video data and annotates it as required through the *Ultrasound images data entry page.* Once complete the video data is viewed via the *Ultrasound images data display page.*

The ability of the design to support the integration of the operations and data of existing systems means that:

- systems which effectively support certain operations can continue to be used but in an integrated environment:

- all patient data recorded (including multimedia data) forms part of a comprehensive patient record;

- some familiarity in operations is maintained where appropriate;

- disruption to care provision in kept to a minimum;

- development time and costs are minimised without compromising the MEHCR's operations or care provision;

- alterations to existing systems operations are only implemented if appropriate (the implementation of change without justifications is prevented).

Hence, collectively the MEHCR's support of other systems operations and data benefits care provision in that it enables both multimedia care provision and the creation, recording and maintenance of composite and comprehensive multimedia patient records.

6.3.3 Modes of use and operation

As previously mentioned (in section 4.5.4.4), the research defined the ways health

care records are used. There were found to be two modes of use *(historical and*

current), each having two modes of operation *(creative and established)*. To be an

effective aid in the provision of multimedia care and its recording, the MEHCR must

support and enhance the modes of use and operation defined.

6.3.3.1 Historical mode of use

The historical mode of use occurs before care is given to the patient. It ensures the

correct administration of the patient within the HCE, and the accuracy and availability

of the existing information relevant to the patient's current problem. Its established

mode of operation *(established historical mode)*, enables the review of both:

- information constituting a relevant previous history:

- information required for the patient's administration during care (such

  as GP details, Next of Kin details etc.).

Alternatively, the creative mode of operation *(creative historical mode)* enables

amendments or corrections to this information to be made.

The sectioning of the MEHCR and its interface designs aids the records historical

mode of use (as far as ensuring that the information required for the patient's correct

administration is concerned), by enabling the personal circumstances and private

health care details of the patient to be created, grouped, manipulated and presented, throughout the MEHCR and other systems. Thus, this information can be readily utilised in the patient's administration. In the example, before the Breast clinic encounter actually commences, the receptionist reviews the PI section and its constituent sub-sections *(established historical mode)*, and discovers that the patient has changed jobs. Thus, within the Patient details sub-section the appropriate details are updated (i.e. a new patient occupation and employers data set is created) *(creative historical mode)*. This new data set can then be used throughout the MEHCR and the other HCE systems (via the Institutional view) as required, to ensure the accurate administration of the patient within the HCE.

At present, due to the use of disparate systems and numerous types of HCE records (media, departmental and HCE) which are collectively non-comprehensive the effective administration of the patient, before care actually begins, can be hampered by the following:

- non-availability of data – data may not be recorded at all, or may be held in forms / repositories not easily utilised or accessed;

- data inconsistency – data may be held in more than one location (record or system) and be inconsistent between them.

However, the MEHCR (as defined) enables the data held to be comprehensive (e.g. next of kin and full employers details are recorded etc.), to be consistent (due to

systems integration data is only held once) and to be available as required via the MEHCR application throughout the HCE.

Equally, the MEHCR supports the record's historical mode of use with respect to the effective creation and review of a patient's relevant previous medical history. In the example, the search capabilities of the MEHCR are used to identify existing information, of any media, relevant to the patient's current problem (i.e. previous Plastic Surgery encounter records). The *creative historical mode* enables all the relevant information to be checked and any additional or corrective information (gained from the patient or other sources) to be generated and appended and to the original items of data. This data is then linked as a whole to the current patient encounter to form the EHDS. The EHDS can be displayed and reviewed during the encounter to furnish clinicians with all the relevant historical or background information already held within, or available to, the MEHCR. Hence the *established historical mode* (when existing record data is reviewed) is supported and enhanced.

At present, the ability to define existing data relevant to the current encounter, link it to the encounter and then annotate and review it from within the current encounter's structures, does not exist. This is due to the fact that, for paper records, the following problems exist (as detailed earlier in chapter two):

- relevant data may be electronic in nature and not available in the paper records;

- paper records can be difficult to search for information;

- presentation of existing relevant data within the encounter record requires either the duplication of the relevant data or removal from its original location in the notes and its relocation to an area within the current encounter record.

So, before any patient care is given, the MEHCR uniquely enables the records historical mode of use, and its modes of operation, to be fully supported. Hence, patient care is correctly administered throughout the HCE and all the multimedia information relevant to the patient's current problems is present, correct and available to clinicians.

6.3.3.2 MEHCR current mode of use

The current mode of use is concerned with the actual provision of patient care during an encounter. Its established mode of operation *(established current mode)*, refers to the use of the record during care provision in the gathering and evaluation of information already held within the MEHCR, which (as care is given) is felt to be relevant to the patient's problems. The current creative mode of operation *(creative current mode)*, is concerned with the actual provision of patient care, and the generation of the multimedia data facilitating and recording the care given.

Both the *creative current mode* and the *established current mode* are aided by the designs defined. For instance, in the example, if as the consultation progressed the patient revealed other relevant information, such as a history of Breast cancer in the family, then the appropriate family member records can be searched, selected and

linked as in the EHDS to form an "additional encounter history data set" (AEHDS). This contains only data not already in the EHDS. The AEHDS, like the EHDS, is presented within the encounter structure so that as the encounter is examined all the information felt to be relevant to care as it is given is available.

Numerous AEHDS can be created as different existing data becomes relevant to the patient's problems as care is given. For instance, referring to the example again, another AEHDS (AEHDS(2)) might be created if, after the Ultrasound, other data within the record was now felt to be relevant to the current encounter. The EHDS and the various AEHDS's are separated rather than just adding all the AEHDSs together to give one AEHDS and then adding this to the EHDS, so that the progress of care provision can be seen over time. This means that, when records are reviewed, the progress and nature of care provision can be seen and understood with respect to the patient data available at different times. For example, by looking at the Breast clinic scenario again, the Biopsy results may give unexpected information which then causes other existing data to become relevant, forming AEHDS(3). The data contained in AEHDS(3) may then cause a change in the course of care provision already determined. The ability to maintain separate AEHDS's over time as an integrated part of the encounter structure, in a way which reflects the progress of care provision, means that the pattern of care provision is shown and can be comprehended. This is because care provision actions can be related to both findings as they occur and existing data found to be relevant at different times. Hence, clinicians should be protected from groundless retrospective claims of inappropriate care provision as the

information available when care was prescribed can be seen, and thus its suitability assessed.

This type of background information gathering and linking capability is of great use during care provision in that it:

- prevents relevant data of any media from being overlooked;

- enables greater meaning to be imparted by the data presented, as it can be presented in any media as appropriate;

- saves clinical time when searching records;

- saves clinical time as there is no need to re-record / reference existing data to give comprehensive records;

- prevents clinicians from having to rely so heavily on patient memories for past histories, when patient recall can be biased and unreliable (Boyer et al, 1995);

- enables different clinicians to gain a full appreciation of all relevant multimedia data when they need to review records, or participate in care provision.

Thus, the MEHCR is seen to fully support the *established current mode*, as information recorded prior to the patient's current problems and held within the MEHCR, and felt to be relevant as care is given, can be presented and reviewed to give a comprehensive record of all the data connected with the patient's care provision.

The MEHCR further supports the *established current mode,* in that it eases the problems associated with reviewing and evaluating all information generated and gathered as part of the current encounter when it spans a lengthy time period. This often occurs when the care for a single encounter requires the actions of several departments. This can lead to the time-scale associated with the care provision increasing. At present, from the requesting of data to the results of the request being made available to the consultant managing care may take two weeks or longer, and an examination of the existing patient records would show only a note to state that a request has been made. However, within the MEHCR, the exact status of all aspects of patient care within an encounter are shown clearly. While a clinical test result is awaited, the care process is shown within the encounter records as pending, with its exact status (e.g. examination performed and report awaited), also automatically indicated. In the example (which is actually conducted in only a few days), the ability to track precisely the progress of various aspects of the encounter's care provision within the HCE and its departments is illustrated. Here, for example, the consultant can view the progress of the Biopsy requested from Pathology at any time to see what has been done (e.g. sample analysed and report awaited).

This "care tracking" is possible as the MEHCR uses the presence of data within its structures to define a "data status" for the various care processes of an encounter. As mentioned for the Breast clinic example, the consultant may wish to examine the progress of the Biopsy request. Thus, within the MEHCR and the Out Patients departmental section he accesses the *encounter index page.* On the page the Biopsy is indexed but the data itself cannot be seen as the Biopsy clinical test care process is not

yet complete. However, its progress is shown to the consultant as a narrative (such as "analysis complete, report complete, sign off awaited") seen against the Biopsy entry on the index page. This tells the consultant that the required work has been completed and that the data will be available to him as soon as the analysis and report have been reviewed and determined as satisfactory by a suitably qualified member of staff. So, here care tracking enables the consultant (and any other appropriate clinicians) to easily ascertain (via the MEHCR) the progress of care.

The care tracking capability of the MEHCR benefits care provision as considerable time and resources are currently utilised in making and responding to enquires as to the progress of care and the availability of data (Coiera & Tombs, 1998). Thus, in the example, the consultant no longer spends time ringing the Pathology department for information and the Pathology department no longer spends time and resources in the answering of enquires.

Obviously, as far as the Breast clinic example is concerned, care tracking simply enables care to be more efficient as data is readily available throughout the MEHCR as appropriate. However, the real value of this capability as far as patient care is concerned can be shown by another example. For instance, consider that an Orthopaedic Surgeon is managing the care of a patient, and MRI scans and a Physiotherapy assessment are requested as part of the encounter. When the MRI data (i.e. scan details, scan images and scan report) is made available to the Orthopaedic Surgeon through the MEHCR, it becomes clear that the patient requires urgent attention and the Physiotherapy assessment request is required immediately. The

progress of the Physiotherapy assessment request can be traced through the MEHCR (i.e. request accepted and appointment given for two weeks time). As, the Orthopaedic surgeon is aware of the progress of the request he can now take appropriate actions (e.g. change of urgency data appended to the request, and an e-mail prompt sent to the appropriate Physiotherapy clinician), so that the care is managed in accordance with the patient's needs. In this way, being able to review the existing data created during the encounter, and examine the progress of requests made, means that the *established current mode* (i.e. review and evaluation of data generated during the current encounter) is aided. Thus, health care provision is benefited and patient care can be managed in a more efficient and responsive way.

The *creative current mode* is that which actually enables care to be given. As such it is here that the MEHCR's ability to support numerous of the research findings can be seen to benefit care provision. The research showed that care provision occurs on a departmental basis through various types of encounters. The MEHCR benefits care provision in that it enables the departmental nature of care provision to be supported. For instance, in the Breast clinic example, the patient is referred to Out Patients. The MEHCR enables Out Patients to control or determine the acceptance and urgency of the referral and for an Out Patient encounter to be used as the means through which care is provided. Equally, within the encounter, the resources of other departments are utilised as instances of different types of care processes (e.g. Radiology department resources are utilised within an instance of the Radiology clinical test care process). The utilisation of the resources of other departments occurs and is recorded

within their individual record sections, enabling them to maintain departmental control over the acceptance and management of work.

In addition to enabling the departmental and encounter based nature of care provision to be supported during care, the MEHCR also enables its multimedia nature to be catered for. In the Breast clinic example for instance, multimedia data in the form of video (Ultrasound) and images (Mammogram and Biopsy) constitutes part of the care given. As such, the MEHCR enables its generation and recording to occur as an integrated part of care provision.

So, collectively, the MEHCR supports the departmental, encounter and multimedia nature of care provision in that departments can effectively:

- control the workloads;

- request and manage care provision through encounter structures of different types;

- generate, record and review data of any media.

Hence, the MEHCR enables composite and comprehensive multimedia encounter and departmental records to be produced as care is enacted, thereby supporting the *creative current mode*. Thus, the MEHCR benefits care provision in that more data having greater meaning is given as care is provided in a way which supports its basic nature.

6.3.4 Support of working practices

The research identified three types of working practices, as follows:

- core static - those which must occur and need to be maintained in their

  current form;

- core flexible - those which must occur but can be changed or altered in

  some respects;

- supportive - those which are required for the support of the other two

  types of practices identified.

The MEHCR benefits care provision by enabling its constituent care processes (currently made up of all three types of working practices), to be facilitated in a more efficient manner, as it supports the core static practices, permits the re-engineering of the core flexible practices and the obviation of redundant supportive practices.

This can be demonstrated by looking again at the Breast clinic example. Now when care is provided, the core practices such as the actual performing of the Needle test and that of the Ultrasound scan itself are supported as the MEHCR in no way impacts upon them. Thus, these practices continue to occur as required in their current form.

Alternatively, the flexible practices identified are re-engineered. For example, the request of the Ultrasound scan is altered so that numerous items of data are automatically presented, the presence of all mandatory or essential request data is

ensured, and the request forms a structured part of the record. Equally, the creation

of the examination report can be made more efficient. At present, brief audio

instructions are recorded by consultants, collected by the medical secretaries and

transcribed and structured to give complete reports. The MEHCR, however, enables

these tasks to be re-engineered and accomplished in one of the following ways

(according to user preference), so that care provision is made more efficient:

- brief audio instructions are recorded within the MEHCR, then

  transcribed and structured into a full report by medical secretaries;

- one of a number of basic report templates can be used, and the

  remaining report details entered using speech to text, to give a full

  report;

- speech to text used alone to generated the full report.

To illustrate further how the MEHCR enables flexible working practices to be re-

engineered, Table 6.1 contrasts how three aspects of the X-ray clinical tests care

process (i.e. its request, the recording of the X-ray data and the generation of the

report), occur at present and with the MEHCR.

Care process aspect	Current practices required (paper-based records)	Practices required by MEHCR
X-ray request	• Request for X-ray examination noted in main records • X-ray request form completed by the consultant • Request form checked by nurse / clinician and any missing data is added • Request form posted via HCE mail • Request form arrives in Radiology • RAD system used to give appointment • Request form completed, appropriate data added • Separate Radiology department records obtained, request form appended	• X-ray request entry page given (80% of data pre-entered*) • Remainder of data entered manually • Request automatically checked by MEHCR • Request appended to system • Request seen immediately within Radiology record section of the patient's MEHCR • Integrated RAD system gives appointment within Radiology record section • X-ray request automatically completed and maintained within Radiology record section *(Estimated that clinical and administrative time taken should be reduced by 80%)*
X-ray image / data recording	• Photographic X-ray image taken • Image labelled • X-ray details recorded in Radiology department records • Image added to Radiology records • Radiology records stored and administered separately • No access to image data (except via Radiology department records)	• Photographic X-ray image taken • Image labelled • X-ray details recorded within MEHCR • Image scanned into Radiology section of the MEHCR and appended using appropriate data entry page • Image can be annotated / linked to other data to aid understanding • Image and X-ray details readily available through the MEHCR (displayed by appropriate data display page, supported by care process framework structure) within the Radiology section as a departmental encounter, and within the departmental record section of the department requesting the X-ray as an encounter care process
X-ray report generation	• Radiology records required • X-ray image held within Radiology records analysed • Report dictated to audio tape • Tape transcribed to RAD system • Printed copy generated for main records and sent to requesting clinician • Requesting clinician appends report to the Radiology section of the main HCE records • Duplicate copy printed for and appended to Radiology records	• MEHCR accessed and image analysed • Report entered on to MEHCR directly (via audio - speech to text, written via graphics table, or typed) or typed on to the RAD system and presented via MEHCR • Report data immediately available via the MEHCR, along with the X-ray request details and image data, and seen as a care process of the requesting departments encounter records, and as a Radiology departmental encounter *(Estimated that clinical and administrative time reduced by 50%)*

(*figure calculated relating the data items required and those held by the MEHCR and other integrated systems)

Table 6.1 - The re-engineering of flexible care practices

Thus, the flexible health care practices or processes, such as requesting a referral and the construction of a clinical report, are made more efficient and the record more comprehensive, so care provision is improved.

Finally, as the MEHCR enables the following:

- numerous and correct details to be pre-entered;

- prevention of incomplete requests, data and reports from being issued (as data of any media can be held and checked);

- comprehensive multimedia departmental records to be generated and maintained (as data of any media can be utilised within and recorded during health care provision);

- composite multimedia encounter records to be generated and maintained (as multimedia data, and information from other departmental / HCE sources can be recorded / presented);

- all communications to be electronic (facilitating efficient interactions and the easy utilisation of multimedia data).

the supportive practices, such as the following:

- sending of data and between departments and / or external clinicians (e.g. GPs);

- chasing up of information*;

- checking of request details*;

- transport and administration of the main patient records, and / or departmental records;

- cross referencing of records (e.g. for previous Radiology treatments etc.).

are all made redundant (*or greatly reduced). Thus, again care provision benefits by being made more efficient.

6.3.5 Obviating current record problems

The research showed that there are three different types of records found, and that collectively they are failing to enable effective and efficient multimedia care provision and its recording due to their paper-based, non-composite, non-comprehensive, and generally non-multimedia nature.

Currently, within HCEs, the Breast clinic example defined earlier could not be supported as described with the Ultrasound, Mammogram, Needle test and Biopsy data being recorded and presented as an integrated part of composite and comprehensive departmental and encounter records. For example, at present with a Radiology department, the Ultrasound and Mammogram examination data might only be recorded as one or more images (in fact usually the Ultrasound data is only recorded as an image at all if abnormalities are found). The image data is then only available to the Radiology department as it is held separately in the departmental records. Equally, Pathology do not as a matter of course record images of sample

analysis data and, if they did it, would not be available within the patient's HCE records.

However, as the Breast clinic example shows, the MEHCR as defined does uniquely enable:

- comprehensive departmental and encounter based records to be created and maintained;

- every aspect of patient care provision to be supported in accordance with the patient's needs;

- data of any media to be created, recorded and reviewed as required;

- operations of other HCE systems to be integrated and embraced;

- information to be managed and not duplicated within the MEHCR and other systems;

- ubiquitous record data availability (through any suitable terminal).

The MEHCR's capabilities mean that the different types of records currently utilised are redundant as the MEHCR performs, and expands, all of their operations. As such it also eliminates the numerous problems (such as the non-availability of data, inability to record data of certain media, inconsistency of data between various records etc.) associated with the use of the existing types of records. Thus, the MEHCR enables care provision to become more efficient and effective as it is no longer held back by the limitations of paper-based records and the use of disparate / non-integrated systems.

The benefits of the MEHCR, as compared with the existing multi-record type situation, are also demonstrated by reproducing some of table 4.1 to illustrate how the MEHCR enables multimedia data to be recorded and made available.

Care giving rise to the data	Original data format	Original data recorded	Availability of original data
Nasal endoscopy	Video	Yes	Throughout HCE via MEHCR
Oesophageal voice test	Audio	Yes	Throughout HCE via MEHCR
ECG examination	Graphical	Yes	Throughout HCE via MEHCR
X-ray examination	Image	Yes	Throughout HCE via MEHCR

Table 6.2 - MEHCR's multimedia data recording and availability capabilities

By examining Table 6.2 and comparing it with Table 4.1 it can be seen that the MEHCR enables multimedia data to be available throughout the MEHCR, and eliminates the practices of creating textual reports to substitute for the recording and availability of multimedia data.

6.3.6 Expansion

As described in chapter five, the conceptual design was defined to enable and record composite and comprehensive multimedia care provision now and in the future. As such, the ability to embrace and accommodate health care advances was a fundamental element of the conceptual design.

The conceptual design enables change via its ability to alter existing structural descriptions and create new ones. Thus, the existing framework structures (given by the structural descriptions) and the new ones are available as required to enable developments (such as the introduction of a new system) to be accommodated. Equally, the design environment can be utilised to aid the realisation of the evolved system.

An example of the type of advance the MEHCR might be required to support in the future would be smart cards. Health cards, or Smart cards, are a way of enabling patients to carry administrative and clinical health care information at all times. Numerous types of cards have been developed ranging from the "CARDLINK 2" cards carrying core data sets for emergency health care in the EU (Cardlink 2, 1998), to "DIABCARD" cards developed as an appropriate portable electronic record for patients with chronic diseases such as Diabetes (Diabcard 3, 1998). They offer a way to reduce the costs of health care provision by decreasing the document flow around patients, improving patient care and administration, and increasing the quality of care provision due to their ability to present accurate medical histories.

The advantages given by smart cards (as mentioned) in conjunction with a number of other factors, such as:

- progression of work to ensure common interoperability (Eurocards, 1997);

- progression of work towards a common interface to facilitate medical

  records exchange includes records held on smart cards - indicates that

  cards are seen as an integral part of future health care;

- large and growing number of smart cards in circulation (75 million in

  Germany alone (Health cards, 1997));

- extent of health based smart card use (e.g. in France and Germany),

  and pilot schemes (e.g. the UK and Canada (Neame, 1997)).

all suggest that there will be further health care development, standardisation and

adoption in the future. Thus, it is essential that any MEHCR permits and embraces

their utilisation.

So if, for example, smart cards became adopted by another local HCE (not within the

scope of the design environment and, thus, the MEHCR's operations) as a means of

providing summary patient records, it might be desirable to enable the integration of

the cards and the MEHCR. The integration process would involve the construction

of a Structural view of the smart card system, the alteration of the MEHCR's

Structural view and the alterations to the Institutional view. This would enable the

following;

- reconciliation of data held by both the cards and the MEHCR -

  inconsistencies could be identified and appropriate actions taken (e.g.

  the attaching of notifications to inconsistencies such as different

  patient addresses);

- relevant data from the card could be abstracted and held by the MEHCR to offer more complete records (e.g. the other HCE's pharmacy details could be added to the MEHCR's medication details).

Although simplified, this scenario shows the principle which the conceptual design facilitates (i.e. that new innovations can be accommodated through the flexible structure of the MEHCR), and that the use of smart cards does not pose a threat to the MEHCR's composite and comprehensive nature.

The patient care scenario defined provides a simple example of how the MEHCR's ability to evolve could be utilised to increase the efficiency and quality of care provision. In the scenario, the consultant merely uses the MEHCR to print a number of standard patient information leaflets. However, a multimedia patient information system could be implemented in the future, and integrated into the MEHCR's operations as follows. On the *consultation data entry page* and the Patient information menu option is utilised to give a window displaying all the available patient information. These can be filtered / searched according to numerous criteria (e.g. medication, procedure, condition etc.) and appropriate selections made. A number of patient specific options can then be used to tailor the information given in accordance with the patient's needs. For example, if the patient is one of the 9% of the population having reading difficulties (Coulter et al, 1998), the appropriate option can be selected and the textual and other information generated tailored to this difficulty. Equally, the multimedia information could be sent in digital form via e-

mail to the patient, or collected form an information point in the HCE being automatically generated and / or ordered by the MEHCR. This would enhance the current situation by improving both the efficiency and quality of care as follows:

- stocks of patient information sources do not have to be carried by the HCE;

- most current information is provided to patients (the patient information system being updated as required);

- most appropriate patient information of any media is given (the information being tailored as required).

The fact that the MEHCR can evolve does not, however, mean that records generated before any evolutionary change will experience problems when utilised. This is because alterations to Structural descriptions (to accommodate developments) are time stamped. The time stamping means that different versions can be maintained and utilised as required to give the appropriate framework structures to enable the organisation / presentation of patient data in a manner reflecting the operations of the HCE at the time of data creation. In this way the MEHCR has the ability to effectively present and utilise data pre-dating developments, and enable current care provision to utilise the latest health care advances implemented within the HCE.

It was decided that the maintenance and use of different versions of structural descriptions and interfaces (i.e. maintain the form and look of the MEHCR at the time the data was created) was preferable to the use of new structural descriptions and the

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24   Chung P. E., Huang Y., Yajnik S., Liang D., Shih J. C., Wang C. and Wang Y., 1995. "DCOM and CORBA Side by Side, Step by Step, and Layer by Layer", The C++ Report, Bell Laboratories, 1998.

http://www.bell-labs.com/~emerald/dcom_corba/Paper.html

adaptation of the existing data to enable its presentation within the new framework structures and interfaces given. This was because it was felt that by maintaining the original presentation formats (via the use of the structural descriptions in place when the data was created), the records and the data therein would be more easily understood.

For example, using the Breast clinic encounter described, imagine that a new pre-Ultrasound breast examination process is introduced to the HCE. The new examination process involves the Breast Ultrasound scan patient answering a number of pre-determined questions as to their general health and any changes in it before the scan occurs. To enable the new process as part of Radiology's Ultrasound operations, the structural description of the Breast Ultrasound framework structure is altered to enable the support of the correct pre-scan questioning data entry and display pages.

So now within the MEHCR all patients requiring a Breast Ultrasound scan can participate in the new pre-scan questioning as the departmental Breast Ultrasound encounter structure now facilitates the recording and subsequent review of the question data. As far as records pre-dating the change are concerned (i.e. Breast Ultrasound departmental encounters completed before the introduction of the new pre-scan questing process), the structural descriptions utilised are those available when the data was created. So the user sees all the encounter data presented in the same MEHCR context as when it was created. If, however, when previous records are reviewed the new structural description was to be utilised the user would see only a blank display page where the pre-scan question data should be. This may cause

confusion as the user wonders why no data was recorded. Hence, to prevent this situation arising, the data is always presented in its creation context.

Having defined how the MEHCR is capable of accommodating developments without causing existing data to be degraded, the importance of this capability can be illustrated. By looking at health care research and development projects, the kind of advances which the MEHCR may be required to support in the future (if it is to continue offering the benefits afforded by composite and comprehensive care provision and recording) can be seen. For example, the field of telemedicine alone has given rise to a number of different applications, many of which may form part of a HCE's everyday operations in the future. The MEHCR would facilitate their use by expanding and tailoring its structural descriptions and thus framework structures, and appropriate interfaces, for their support. Examples of the types of applications which may be supported, and how this might be achieved, are detailed as follows:

- remote patient monitoring - as part of the patient's on-going care the monitored data (perhaps collected by a personal health monitor (Tuomisto & Pentikainen, 1997)) is transferred by the patient or a health care professional to the patient's record either from the patient's home, or a nearby clinic. The data then forms a care process (supported by a suitable framework structure) within the appropriate patient encounter;

- remote / external systems use - a patient might be sent to another HCE or specialist centre for a particular clinical examination / evaluation

not available within the HCE itself. For example, another HCE might

posses a multimedia system for the diagnosis of memory defects

(Grunst et al, 1997), the use of which is particularly appropriate for a

patient. Appropriate framework structures can be created to enable the

requesting of the required service, the allocation of appointments, and

support for the recording of patient data (in any media), and

subsequent reports. The information can then be presented as a care

process of the appropriate encounter;

- remote patient screening - patients could utilise multimedia screening

  applications remotely at GP clinics before going to the HCE. The

  information gained is again held within appropriate framework

  structures and seen as an encounter care process. The information is

  then available to enable clinicians to gain a better understanding of the

  patient's problems and reduces the time spent by patients at the HCE.

The ability to expand the MEHCR also means that other advances or services such as

the NHS Direct initiative (a telephone advice line, staffed by nurses and trained

operators to provide medical advice 24 hours a day (NHS Direct, 2000)) could be

accommodated. For example, the advent of patient help lines could be embraced

within the structure of the MEHCR. When a patient calls the help line the enquiry

could be logged and referenced to the patient's record and a new simplified encounter

framework structure could be created to record the enquiry as an encounter. The

enquiry itself could be recorded directly as audio data, or a textual account (via speech

to text technology), and as with other encounters one or more outcomes would be

given. For example, if the patient is assured that their enquiry requires no further attention then it is seen as being discharged. However, if it is recommended that they seek further advice / medical attention then the outcome will be seen as a referral. The ability to record and maintain an account of the patient enquiry means that a more comprehensive record of the patient's health care is given, and that suggested referrals can be followed up to try and prevent individuals "falling through" the health care system.

On a similar theme, the MEHCR could be expanded to accommodate the results of screening programs already in operation but currently unrelated to the patient records. In this way, programs such as Breast cancer screening could be seen within the MEHCR as another simplified encounter, with multimedia data (such as images) being recorded and presented in appropriate cases.

Equally, other advances, such as the following, could be accommodated by the MEHCR:

- multimedia education aids - as teaching aids become utilised within HCEs, they can be modelled and an appropriate Structural view created. Equally, the MEHCR's Structural view and the Institutional view are altered as required. Thus, it will be possible to utilise the multimedia teaching aids from within the MEHCR during care provision;

- multimedia patient screening systems - as these are developed (TMCC, 1997) and implemented the systems are modelled again, a Structural view created and appropriate changes made as required to other Structural views and the Institutional view, so that the systems can be seamlessly utilised as part of the MEHCR in care provision. For example, a screening aid could be implemented and utilised within the MEHCR's consultation encounter framework structure to perform a new and discrete care process. This might take the form of a pre-consultation clinical patient assessment (when patients complete a series of interactive multimedia assessments before seeing the consultant during a consultation encounter). In this way, the patient completes a discrete care process forming part of the consultation encounter as they utilise the multimedia screening from within the MEHCR. Thus, the composite and comprehensive nature of the MEHCR is maintained, even though new systems are utilised as an integral part of care provision;

- collaborative research - the capabilities of the MEHCR could be utilised to enable specific items of patient data to be abstracted, scrubbed (if necessary) and added to research web sites or posted to clinical research centres to aid research. This type of collaboration would aid research into rare diseases, when small numbers of local patients can hamper advances (de Groen et al, 1998). Alternatively, telemedicine capabilities could be utilised within the HCE or between HCEs (after the alterations to the appropriate Structural views and the

Institutional view), so that clinicians could collaborate via shared workspaces within the MEHCR, so that difficult / unusual cases can be more effectively treated.

Obviously, these are just a few examples of the advances which could be implemented and accommodated by the MEHCR. However, the examples do suggest how the designs defined conceptually enable the integration and exploitation of future advances so that health care can develop and truly benefit care provision as required.

Thus, the evolutionary capabilities of the conceptual design and the use of the design environment offer a way to support and co-ordinate health care advances as they become utilised within HCEs, and ensure that the MEHCR continues to benefit care provision by remaining composite and comprehensive over time.

6.4 Conclusions

From this chapter it can be seen that the MEHCR concept achieves its aims, in that it enables the provision of comprehensive, composite and multimedia patient care and its recording, freeing health care from the current limitations imposed by the use of paper-based records and non-composite non-multimedia EHCRs. As such, it offers a unique way to co-ordinate and advance modern health care now and in the future. The next chapter moves on to discuss a prototype system that has been developed to express and evaluate the key features of the design defined.

Chapter 7

POSEIDON: A prototype system

Introduction

This chapter discusses a demonstration system called POSEIDON (Prototype cOmposite hoSpital multimEdIa recorDs fOr patieNts), developed to illustrate some of the key features of the proposed MEHCR design. It comments on the resources required for POSEIDON's construction and the mechanisms used for its implementation. The definition of a realistic patient case to show POSEIDON's capabilities and operations is discussed, along with its actual use in the treatment of the patient case. Finally, the chapter concludes with a review of the demonstration system's limitations.

7.1 The purpose of POSEIDON

The previous two chapters have discussed the design formulated for a MEHCR, and the benefits which this design facilitates to enable composite and comprehensive multimedia health care provision. To aid the evaluation of the designs formulated, it was felt that there was a need to realise the MEHCR in some way, and thus quantify its success.

Thus, it was decided that a prototype system should be constructed as a basis for demonstration. This would simulate an evolutionary implementation of the MEHCR given by the conceptual design, showing the operations of the departments included in the research base. The simulation was limited to the operations of those departments within the research base as defining an accurate simulation elsewhere within the HCE required further research and resources beyond the bounds of this research project.

Before embarking on the development of the demonstration system, careful consideration was given as to what should be shown. A number of the design's key features, felt to capture the essence of the MEHCR, were defined as follows:

- multimedia data entry and display;

- systems support (e.g. PAS);

- full (complete and composite) departmental records;

- full (complete and composite) encounter records;

- maintenance of departmental control;

- inter-departmental communications;

- record sectioning;

- flexibility (to, using various framework structure, accommodate individual departmental operations);

- expansion (to accommodate health care advances);

- integration of other services (e.g. NHS Direct).

To facilitate the illustration of these key features a clinically accurate demonstration patient case, requiring care from a number of departments within one or more encounters was required (clinical accuracy was necessary so as not to detract from the evaluation). Hence, a suitable demonstration patient case was defined utilising a hypothetical patient found to have cancerous nodes on his vocal cords, necessitating a Laryngectomy.

This demonstration patient case scenario was defined in preference to the Breast clinic example, described in chapter six, as it utilises more multimedia data, has encounters spanning greater periods of time, requires the use of all the encounter types identified (consultations, procedures and departmental encounters) and necessitates a greater degree of co-ordination between departments. As such it provides a more testing care provision scenario for the MEHCR. Table 7.1 defines which of the key features are illustrated by the demonstration patient case.

MEHCR design feature	Feature shown in POSEIDON
Multimedia data entry and display	Yes
Systems supported	Yes
Full (complete and composite) departmental records	Yes
Full (complete and composite) encounter records	Yes
Maintenance of departmental control	Yes
Inter-department communications	Yes
Record sectioning	Yes
Flexibility	Yes
Expansion	No
Integration of other services	No

Table 7.1 - POSEIDON key design features supported

7.2 Demonstration development

The actual development of POSEIDON involved the use of Visual Basic (VB), Microsoft's Access database and other Microsoft Office applications. Collectively, these applications enabled a realisation of the system's form, interfaces and functional / operational capabilities to be constructed.

An overview of POSEIDON shows that it consists of a VB project made up of two parts. The first gives a simulation of the Institutional View. It enables the user to logon, and be presented with a choice of the HCE's systems to which access is permitted. This was achieved using a VB form to permit the user's login, and another form to simulate the user's potential to access individual HCE systems (e.g. PAS, RAD, MEHCR etc.).

The second part of the project gives the MEHCR. This contains one autonomous operational patient record, consisting of a set of VB forms. These give the system pages required for the presentation, entry, manipulation and indexing of all the information within the patient record. The information forming the patient record is held in an Access database, the structure and operations of which are discussed further in Appendix C. The VB forms representing the MEHCR's system pages contain a variety of VB controls used for its operation. The controls present on each form and their nature (menus, MCI's, icons, command buttons, option boxes etc.), is dependent on the purpose of the individual system page represented. For example, the *ENT endoscopy video data display page* contains a MCI control for the playing etc. of the video, meanwhile, the *ENT encounter index page* contains command buttons to enable access to the various items of encounter data.

Within the patient record, controls are available to enable the navigation of the system, so that users can switch between the different record sections, sub-sections, encounters and constituent care processes. Controls also enable the addition of new patient data sets within the PI, MH and PHC sections, and the alteration of particular data items (such as the currency of a private health care policy). In addition to these capabilities, controls are available to enable care provision to be facilitated (within and between departments when other HCE systems are utilised), and for the request, generation, recording and presentation of appropriate patient data, as the system builds a composite and comprehensive multimedia record of patient care.

7.3 POSEIDON demonstration utilisation

This section discusses how POSEIDON is utilised in the care of the demonstration case, and the benefits given. Within the section, a series of tables are used to show what care is being provided, how POSEIDON is utilised during care provision, the key features shown and the benefits given to health care. Also a number of screen shots are given to impart a feel for the system's form. The first table (7.2) details the care actions required from the point where the ENT Consultant receives the consultation request letter from the GP, to where an appointment is given, and the department is ready to receive the patient.

Care provision actions	Role of POSEIDON	Key / features benefits shown
ENT Consultant receives GP letter, looks at record, decides case is urgent	POSEIDON enables number of search criteria to be used to locate the patient record. Equally, the patient record enables relevant data to be searched for and reviewed	• Record sectioning - aids easy provision of relevant data (e.g. medication details) • Full encounter / departmental records - aids full review of relevant departmental data (e.g. previous ENT encounters)
Consultant / Administrator searches for and books a suitable ENT consultation encounter appointment (see screen shot 1)	POSEIDON supports the integrated use of PAS to enable appointment to be found, booked and the required correspondence generated	• Systems support - PAS utilised effectively • Full encounter records – when the appointment is booked the required encounter framework structure is automatically created
GP letter digitised, or put in electronic from by other means, and appended to record (see screen shot 2)	Referral item of data appended to system via the appropriate data entry page (supported by a component of the encounter framework structure) and the use of appropriate data entry options	• Full encounter records - referral item of data held within ENT encounter structure to give comprehensive records

Table 7.2 - POSEIDON utilisation in the allocation and scheduling of an

appointment

Thus, POSEIDON enables all the administrative actions required before the encounter to be completed in a flexible way, reflecting the working practices and care provision role of the department (i.e. appointment is booked, the required consultation encounter framework structure has been created and is ready for use, the referral data item has been appended, and the Patient has been informed of the appointment). An overview of the events to this point are shown by Figure 7.1.
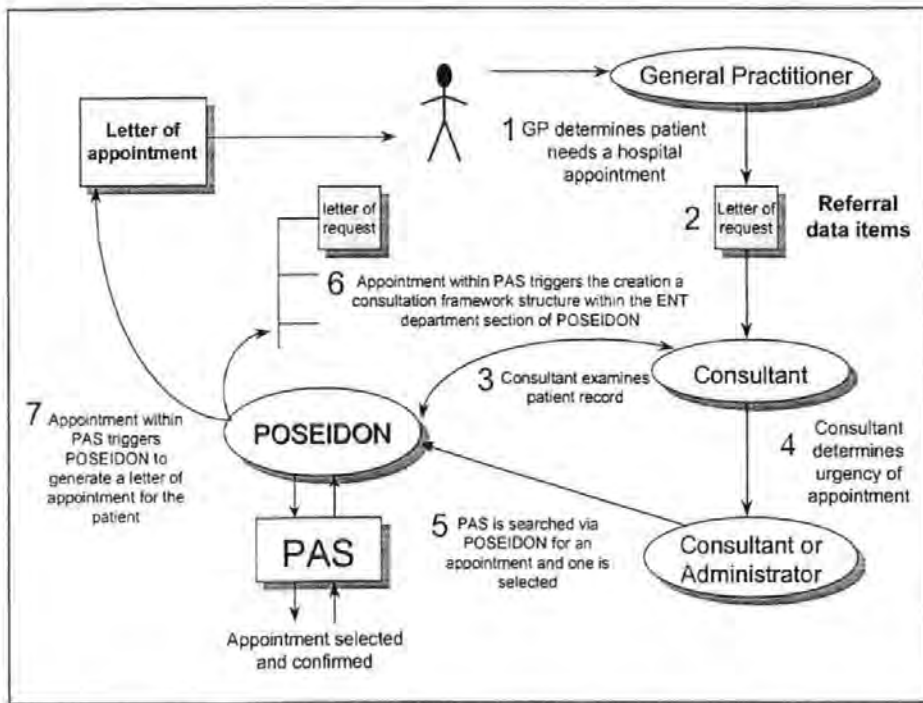
Figure 7.1- Consultation appointment

Screen shots one and two are included to give an appreciation of the system being demonstrated with respect to the operations discussed. Screen shot one illustrates the New Appointment Creation Page with the appointment time and date entered and how the digitised GP letter of referral is added to the system.

```
╔══════════════════════════════════════════════════════════════════╗
║ 🕮 ENT Department New Appointment Creation Page : None System Requests  _ □ ✕ ║
║ View Section....  Navigation  Booking......  Patient Data  Cancel    ║
║                                                                      ║
║   ┌──────────────────────────────────┐                              ║
║   │ GP Referral Consultation         │    Encounter Type           ║
║   └──────────────────────────────────┘                              ║
║                                                                      ║
║   ┌──────────────┐  Date  ┌──────────────┐   Time                   ║
║   │ 13/8/2000    │        │ 13.00        │                          ║
║   └──────────────┘        └──────────────┘                          ║
║                                                                      ║
║   ┌──────────────────────────────────┐    Referral Source          ║
║   │ Patients Current GP              │                              ║
║   └──────────────────────────────────┘                              ║
║                                                                      ║
║   ┌──────────────────────────────────┐    Referring Clinician       ║
║   │ Dr. Dillon Rosetter              │                              ║
║   └──────────────────────────────────┘                              ║
║                                                                      ║
║   ┌──────────────┐  Funding Provider                                ║
║   │ NHS          │                                                  ║
║   └──────────────┘                                                  ║
║                                                                      ║
║   Enter the name and path of   ┌──────────────────────────────┐    ║
║   the letter file or browse GP │                              │    ║
║   referral area                └──────────────────────────────┘    ║
║                                                                      ║
║   ┌──────────────┐                                                  ║
║   │ Browse files │                                                  ║
║   └──────────────┘                                                  ║
║                                                                      ║
║ 📓 13/08/00   🕐 18:59   🕮 ENT Department......  💡 Help........   ║
╚══════════════════════════════════════════════════════════════════╝
```

Screen shot 1 – ENT department: new appointment creation page

Screen shot two shows how the GP Referral letter is presented within the system as the referral data item of the encounter just booked and created.

```
┌─────────────────────────────────────────────────────────────────────────┐
│ 🕮 ENT Consultation : GP Request Letter                          _ □ ×    │
├─────────────────────────────────────────────────────────────────────────┤
│ View Section .....  Relevant History.....  Navigation                     │
│                                                                           │
│      ┌──────────────────────────────────────────────────────┐            │
│      │                          Stretton House Practice,      │            │
│      │                          Stretton House,               │            │
│      │                          George Road                   │            │
│      │                          Mutley,                       │            │
│      │                          Plymouth.                     │            │
│      │                          PL4 3ET.                      │            │
│      │                                                        │            │
│      │                          Telephone; 01752 343456       │            │
│      │                          20ᵗʰ July 2000.               │            │
│      │                                                        │            │
│      │ Mr.Paul Windle-Taylor,                                 │            │
│      │ Head and Neck Directorate,                             │            │
│      │ Derriford Hospital,                                    │            │
│      │ Derriford Road                                         │            │
│      │ Plymouth.                                              │            │
│      │ PL6 8DH.                                               │            │
│      │                                                        │            │
│      │ Dear Sir,                                              │            │
│      │        I am writing to you to ask if you might possibly│            │
│      │ be able to see one of my patients Mr. A Hamilton.  He  │            │
│      │ has been suffering from a sore throat and husky voice  │            │
│      │ for a couple of months, as I can find no infection and │            │
│      │ Mr. Hamilton is a heavy smoker of 25 years I would     │            │
│      │ appreciate your opinion.                               │            │
│      │                                                        │            │
│      │                                                        │            │
│      │ Yours faithfully,                                      │            │
│      │                                                        │            │
│      │                          Dr. D. E. Rosetter            │            │
│      └──────────────────────────────────────────────────────┘            │
│                                                                           │
├─────────────────────────────────────────────────────────────────────────┤
│ 🗔 25/09/00  │ 🕐 07:51 │ 🕮 Request Display Page..... │ 💡 Help ......   │
└─────────────────────────────────────────────────────────────────────────┘
```

Screen shot 2 – ENT consultation: GP request letter

The next Table (7.3) shows the use of POSEIDON within the ENT department during the actual Patient consultation encounter.

Care provision actions	Role of POSEIDON	Key features / benefits shown
Receptionist locates record, Patient details are checked and corrected as required	PI and PHC sections accessed, constituent data checked and updated as required, using the appropriate data manipulation pages	• Record sectioning - enables all administration details to be checked and corrected by administrative staff (ensuring that staff resources are effectively utilised)
Nurse sees the Patient before the consultation, checks all MH details are correct	MH section accessed, data within checked and updated as required, using the appropriate data manipulation pages	• Record sectioning - enables all the MH details to be checked and corrected by appropriate clinical staff (ensuring that staff resources are effectively utilised)
Consultant sees Patient and discusses the problem	PI, MH and PHC sections viewed for relevant background information, remainder of record searched as required	• Record sectioning - enables medical history to be easily reviewed • Full encounter records - enable relevant encounters to be reviewed
Consultant decides departmental examination (nasal endoscopy) is required to furnish further data (see screen shot 3)	Options available within the *consultation notes data entry page* enable the use of a framework structure component for the support of appropriate data entry / display pages for the entry / review of the nasal encdoscopy video data	• Multimedia data - video data supported • Data entry pages - used to enter data • Data display page - used to present data
Consultation notes entered, and proposed treatment (requiring the co-operation of other departments) discussed	Consultation notes entered and recorded directly using keyboard	• Data entry page – used to enable the consultation data to be entered

Table 7.3 - POSEIDON utilisation during the patient consultation

Screen shot three is shown to illustrate how the nasal endoscopy data is presented when it is recorded to form part of the encounter data.
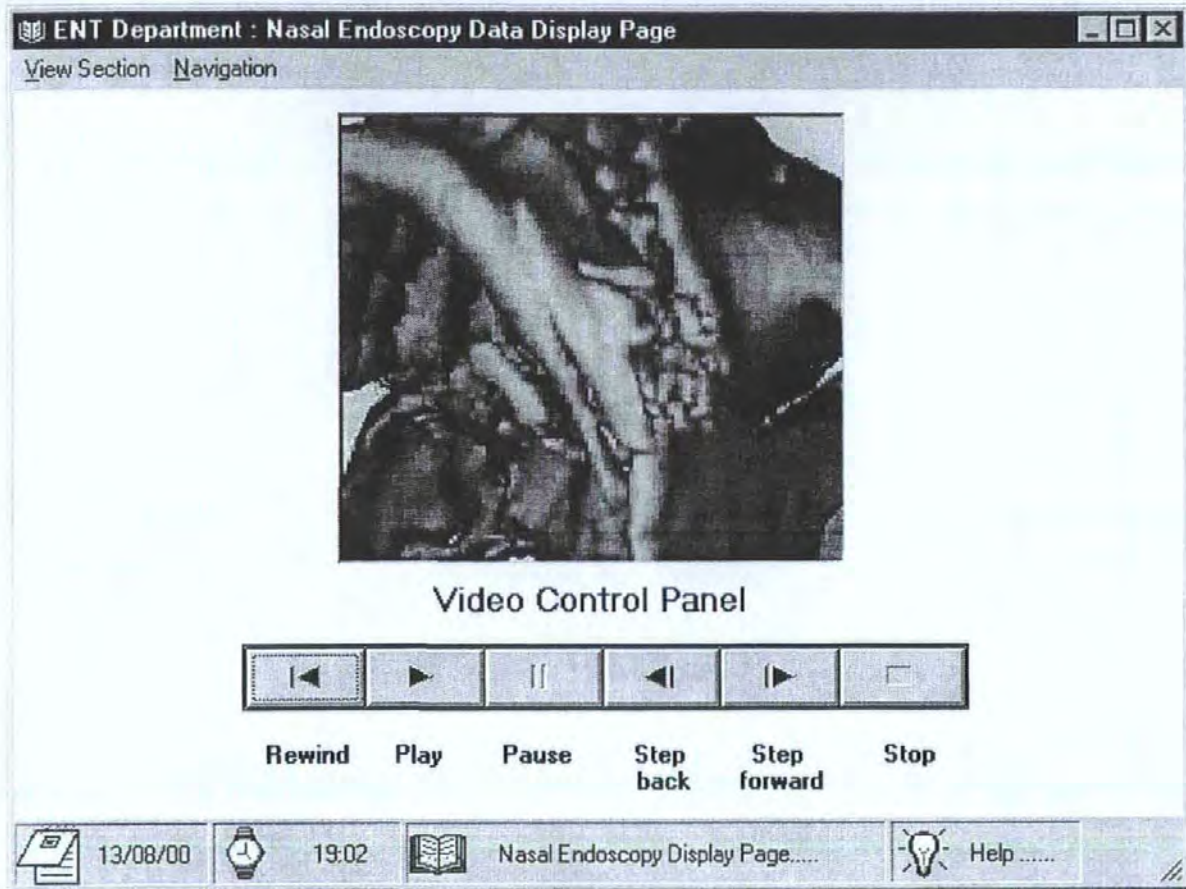
Screen shot 3 – ENT department: nasal endoscopy data display page

An overview of the events up to the entry of the patient's notes is given by Figure 7.2.
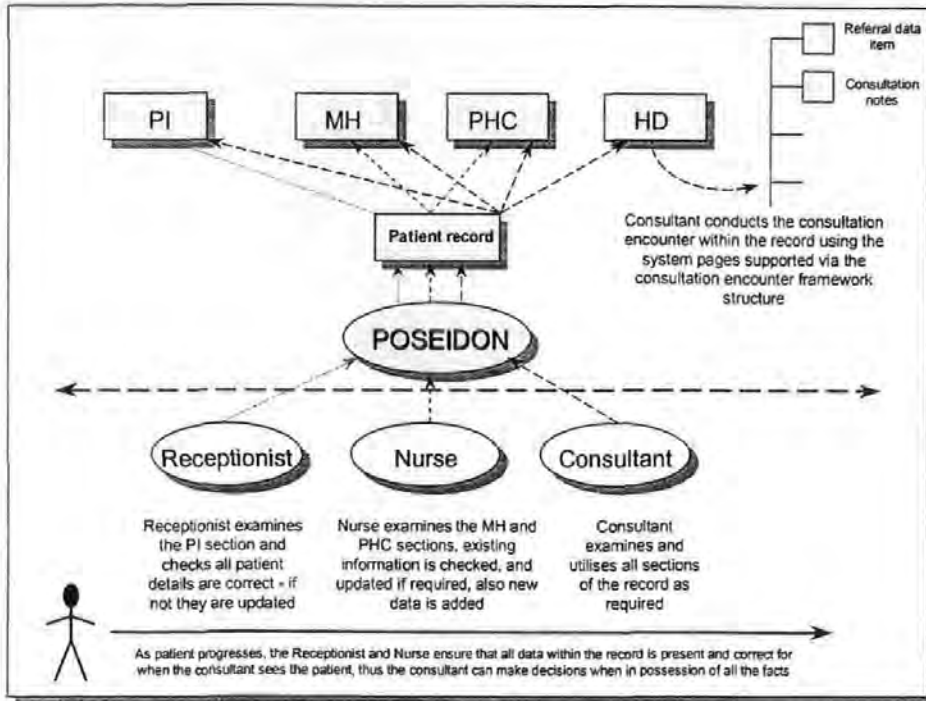
Figure 7.2 – Consultation overview

The nasal endoscopy examination reveals that the patient's vocal cords are discoloured, and a number of nodes are seen. As a result of this the Consultant decides that a Barium Swallow X-ray examination is required (from Radiology), to try and furnish further information about the condition. The request of the required examination occurs via the MEHCR as detailed in Table 7.4.

Care provision actions	Role of POSEIDON	Key features / benefits shown
Consultant requests Barium Swallow examination from Radiology department (see screen shots 4)	On *consultation notes data entry page*, the Barium Swallow menu option is selected. The required data entry page is presented, completed and appended to the system by the ENT Consultant. Simultaneously, the framework structure required for the Barium Swallow examination within the Radiology department is created. Due to the system's "hold once view many times" capability, the existence of the Radiology departmental encounter structure is shown within the ENT encounter record but because Radiology are now responsible for the request patient care the Radiology department record data is not available within the ENT encounter structure until the Barium Swallow examination and report are completed. Equally, as the request is made, a summary of the request automatically appears within the consultation notes	• Time is saved - 80% of the request details required are pre-entered • Clinical efficiency is improved as system automatically checks requests for items of missing data (i.e. if the request has not been responded to within 7 days, or another specified period, the system will issue appropriate reminder / warning messages) • The request is automatically flagged to the attention of Radiology (cannot be lost / delayed in internal post) • Departmental control - maintained as Radiology become responsible for responding to / dealing with the request

Table 7.4 POSEIDON utilisation during clinical test requests

Screen shot four shows the consultation notes data entry page being utilised, through

appropriate menu options to enable the request of the Barium Swallow.
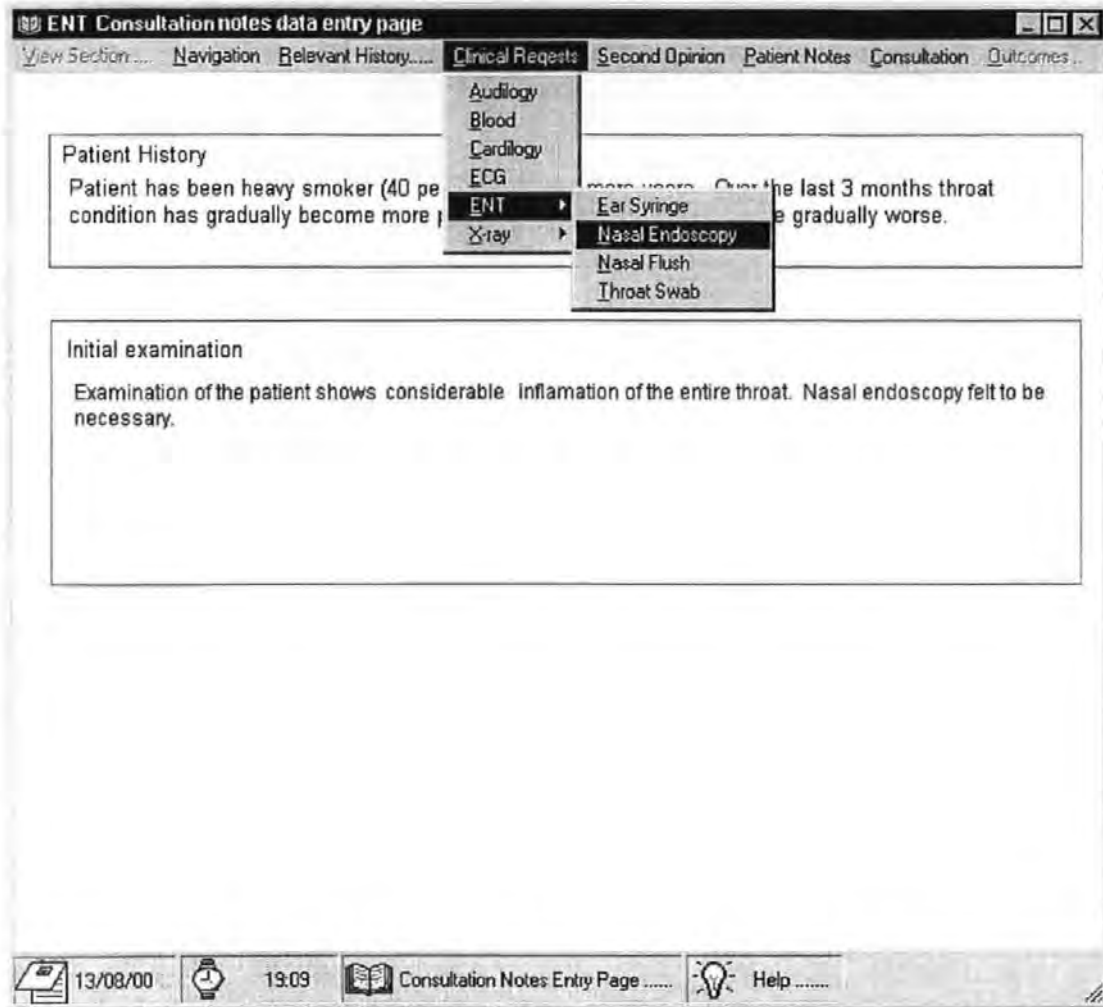
Screen shot 4 – ENT consultation notes data entry page

To show how the Barium Swallow clinical test request is dealt with, performed and concluded, Table 7.5 is used to demonstrate POSEIDON's use.

Care provision actions	Role of POSEIDON	Key features / benefits shown
ENT request (flagged by POSEIDON), and responded to by Radiology	The user views the request within the Radiology department record section. POSEIDON supports the use of RAD so that an appointment can be given, letter to the patient generated and the appointment date and time shown on the request as part of the patient record	• Systems support - use of RAD supported by POSEIDON • Departmental control maintained - Radiology able to manage their workload • Full departmental records - enabled as necessary framework structure required for the Barium Swallow within Radiology has already been created as the request was made • Flexibility – framework structures and thus pages present are tailored to the Radiology department's operations
Patient arrives at Radiology on the appointed day, Receptionist checks details (as in ENT)	Record located, details in the PI and PHC sections are checked and corrected as necessary	• Record sectioning - enables relevant details to be checked • Data manipulation pages - enable details to be corrected • Working practices - supported and efficient use of staff resources facilitated
Radiologist interviews the Patient, reviews the ENT request made, and previous Radiology encounters. The required examination is then performed	The ENT Barium Swallow request is viewed along with any of the patient's previous Radiology data felt to be relevant. Equally, other relevant data (e.g. the circumstances giving rise to the request, as detailed in the consultation notes), can be seen. Examination performed	• Full departmental and encounter records - furnish relevant data (especially from the ENT encounter such as the ENT Consultant's notes) • Multimedia - nasal endoscopy video data reviewed to show problem • Full departmental records - enable request to be viewed within Radiology HD sub-section so complete and composite records of all the care provided by the department are given
Examination details recorded (time of the examination)	Appropriate data entry page used to enable the examination details to be recorded (using suitable data entry methods)	• Full departmental records - enable request and examination details to be fully recorded, presented on single page within Radiology department encounter record
Examination data recorded	Video data constituting the Barium Swallow recorded directly, or imported from another source. Data can be annotated as required (using a variety of means)	• Full departmental records - given as recording of all actual examination data enabled • Multimedia - video data and graphics (added to data) supported • Greater data understanding - given by data being presented in most appropriate media (i.e. Video) and expanded upon as necessary (annotations etc.)
Examination report generated	Report generated either directly straight into the MEHCR, or indirectly by supporting data generated on RAD (data can be generated via a number data entry methods)	• Systems support - data from RAD can be supported

Table 7.5 - POSEIDON utilisation during a clinical test care process

Now, within the Radiology department HD sub-section, all the multimedia Barium Swallow data (i.e. Barium Swallow request, video, and report) associated with the Patient's departmental encounter is structured (as shown in Figure 7.3), and recorded, thus, enabling Radiology to maintain complete and comprehensive multimedia department encounter records.
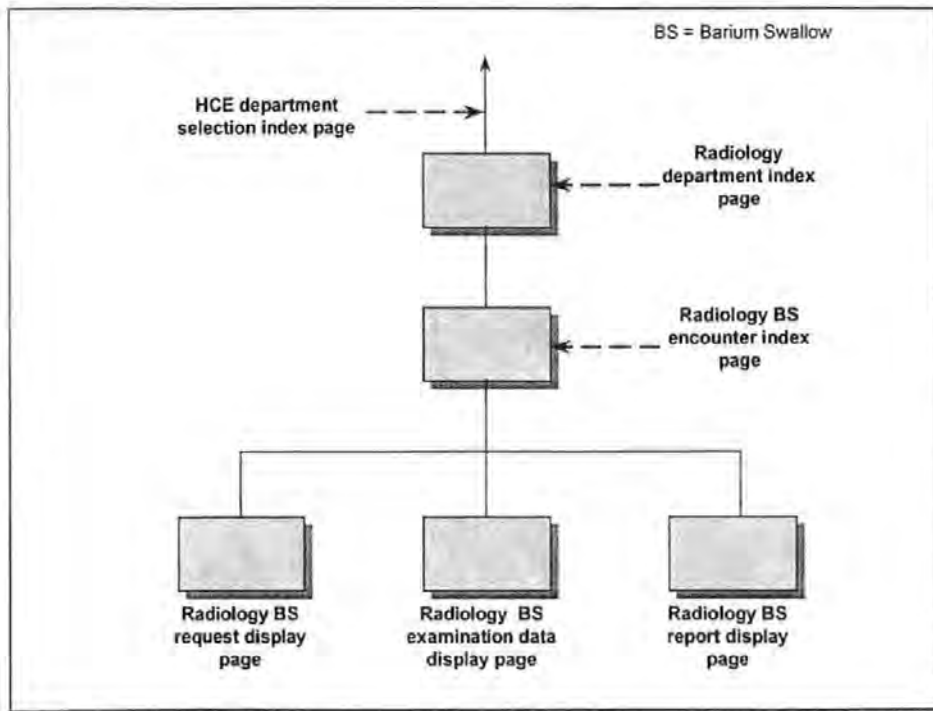
Figure 7.3 – Radiology: departmental encounter structure

Also at this point the Radiology encounter is complete and becomes available to ENT as part of the ENT consultation encounter record, so that Ubiquitous Multimedia Data Availability (UMDA) is given as appropriate. This is achieved by the whole of the Radiology department encounter framework structure being able to appear within the

ENT encounter record structure as a care process of the encounter (as shown by Figure 7.4).
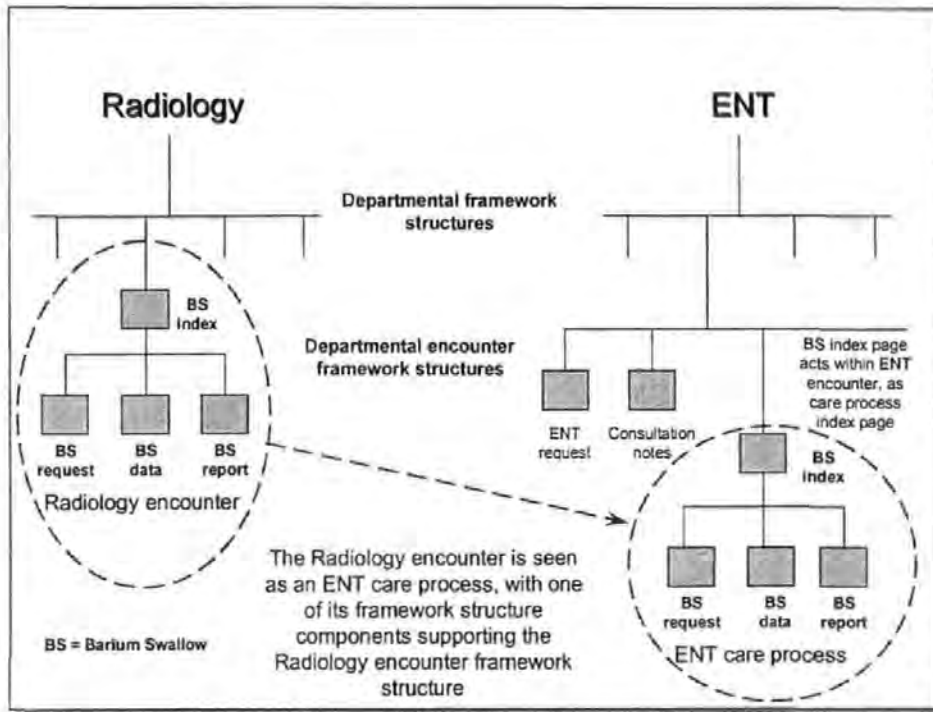
Figure 7.4 – Migration of Radiology framework structures

So, the Barium Swallow request, data and report can be viewed as required as part of the ENT encounter records. Thus, the ENT department is able to maintain complete and composite encounter records of all the work done at its behest as a patient is treated by the department, and the Radiology department is able to maintain complete and composite departmental encounter records of the work it has done for another department.

POSEIDON enables all the inter-department clinical tests to be requested, responded to and completed in a similar way, so that both comprehensive and composite multimedia departmental encounter records (for the department performing the clinical tests) and encounter records (for the department managing care) are generated and maintained. Obviously the exact operation of POSEIDON varies depending upon which tests / examinations are requested from which departments and the other systems involved, but the principle is the same.

After requesting the Barium Swallow and reviewing the results gained, the Consultant is aware that there is a strong possibility that the nodes may be cancerous, and that a Biopsy will probably be necessary to determine the exact nature of the problem. Also, it is decided that the Patient should have a referral to a Speech Therapist (for some time after the Biopsy), in case further surgery is required (the consequences of which will necessitate treatment from the Speech Therapy department).

The consultant requests the Biopsy procedure and Speech Therapy referral in a similar way to the Barium Swallow, in that:

- menu option is utilised to give the appropriate data entry page;

- appropriate data is seen as pre-entered;

- remaining / required data items are entered by the consultant;

- completed request is appended to the system;

- appropriate department takes responsibility for dealing with the request made.

Thus, the same benefits to care provision are given. However, the Biopsy and Speech Therapy referral are outcomes of the ENT encounter, rather than clinical test care processes, and thus, give rise to further procedure and consultation encounters respectively.

The Biopsy procedure requested (as an outcome of the ENT consultation encounter) is responded to and an appointment given. Table 7.6 shows how POSEIDON is used to give an appointment, and enable all the clinical tests and pre-admission assessments to occur as desired before the admission of the patient for surgery.

Care provision actions	Role of POSEIDON	Key features / benefits shown
Biopsy request responded to and appointments given to all the departments involved in care provision for the encounter	Appointment given by General Surgery for the ENT Biopsy procedure encounter. Appointments automatically given for two weeks before the Biopsy procedure for the ENT pre-admission assessments and the required pre-procedure clinical tests (e.g. blood tests, ECG examination), thus, all the required data will be available to the Surgeon before surgery. As the appointments are given, the required ENT procedure encounter framework structure is created containing a component for the support of the pre-admission assessments. Equally, the framework structures required for the clinical tests requested (e.g. ECG) are created within the appropriate HD record sub-sections. Appropriate patient correspondence is automatically generated	• Systems support – PAS, as appointments given • Departmental control - assured for General Surgery when giving the ENT procedure date (i.e. theatre slot given is in accordance with those scheduled for the ENT department) • Inter-departmental communications - seen as appointments given automatically between departments (e.g. framework structure automatically generated in the ECG department to enable ECG to be performed) • Full encounter records - enabled as all the data associated with the encounter (i.e. Request, pre-admission assessments, pre-procedure clinical tests etc.), can be supported by the procedure framework structure components • Full departmental records - enabled as clinical tests required are performed by appropriate departments (e.g. ECG data generated is held in the ECG department record section)
Patient arrives for pre-admission assessments and pre-procedure clinical tests (e.g. ECG) all conducted as required on the same day (see screen shots 5, 6 and 7)	Patient details checked and corrected within the PI, MH and PHC sections. ENT Procedure encounter request examined and Patient sent to appropriate departments for the required tests, and returned to ENT for the pre-admission assessments	• Record sectioning - enables correct administration • Full encounter records - enables requests to be examined • Data entry / display pages - enable pre-admission assessments / tests to be completed as required • Clinical time saved - pre-entry of data • Full departmental records - enabled as clinical test required are performed • Multimedia - data of any media can be recorded / generated / presented as an integral part of the record structure
Test results made available to ENT	Once complete, clinical tests are made available throughout the record both within the HD sub-section of the departments performing the work (as departmental encounter records), and as care processes within the ENT procedure encounter	• Full encounter / departmental records given and maintained • Presence of multimedia data - increases understanding of data given • UMDA - facilitated / ensured

Table 7.6 - POSEIDON utilisation before surgery

Thus, POSEIDON enables all the information required before the procedure (i.e. pre-admission assessments and clinical tests) to be acquired, reported on and made available in the same way as the Barium Swallow was to ENT. Thus, a composite and comprehensive procedure encounter record, containing all the information required before surgery, is given and available to the ENT Consultant performing the procedure.

Screen shots five to seven are included to show how pre-procedure data such as that arising from an ECG examination would be presented. Screen shot five shows the ECG procedure data index page which structures the clinical test care process data.
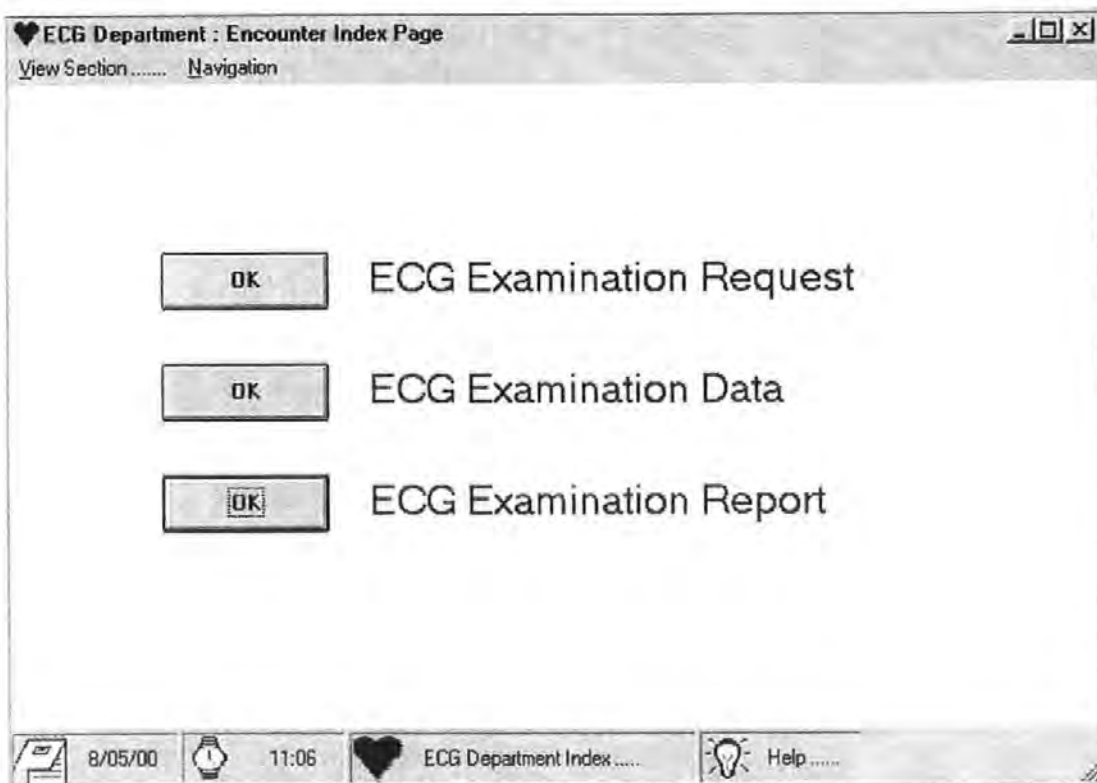
Screen shot 5 – ECG department: encounter index page

Screen shot six shows the request generated within the system and retained to form a comprehensive record.

ECG Department : Examination Request Display Page	_ □ ×

View Section ...... Navigation

Patient Surname Hamilton	Hospital Number 401 223 2137
Patient Forename Andrew	Patient Address Samara House, Flat 4, Mannamead, Plymouth, Devon.
Patient DOB 25/11/42	Tel No. : 01752 453672
Requesting Clinician Mr. Paul Windle-Taylor	Requesting Department ENT

Request Reason Patient undergoing Larynx biopsy	Request Date (decision to admit) 07/07/00

Comments
   None
	Appointment Date
	     06/08/00

	Appointment Time 12:00:00

ECG Department Appointment Request

13/08/00   19:29   ♥   ECG Request Display Page.....   Help ......

Screen shot 6 – ECG department: examination request display page

Screen shot seven shows how the ECG data is presented within the system. The graph generated from the readings being presented within the workspace area of the page.
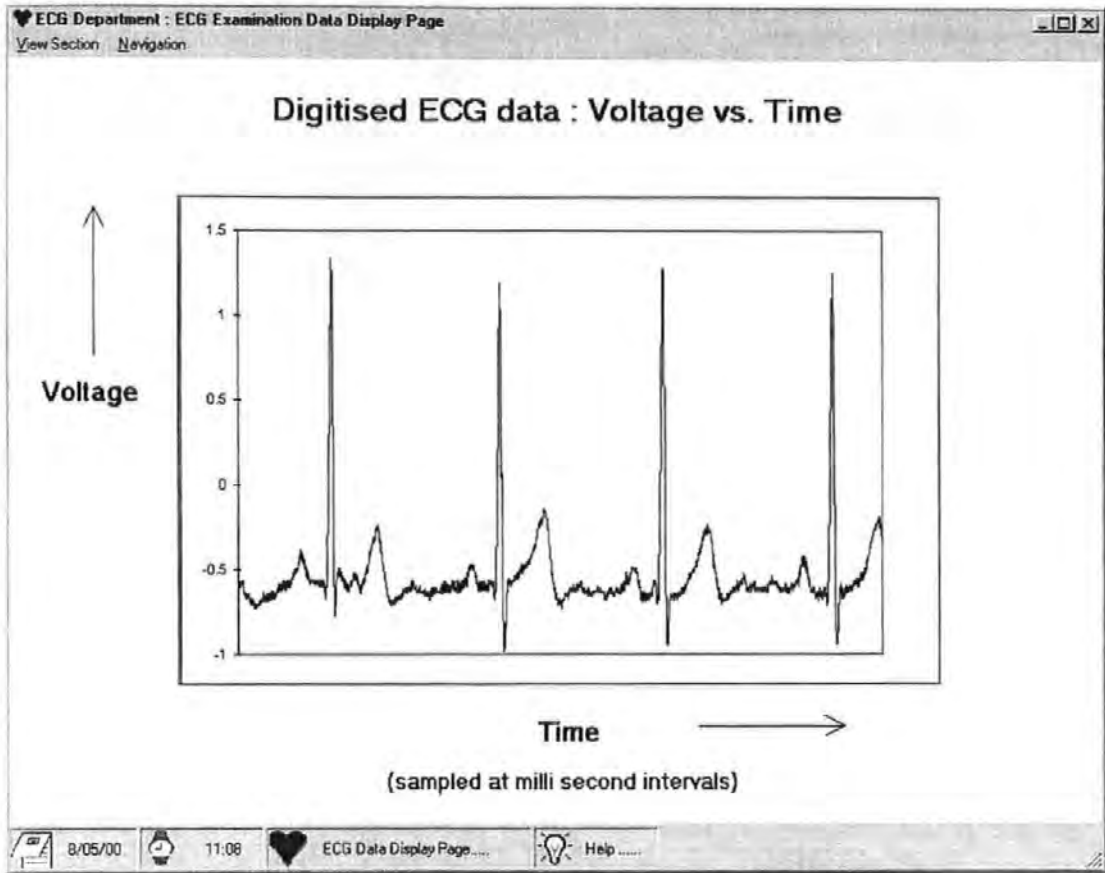
Screen shot 7 – ECG department: ECG examination data display page

The use of POSEIDON during the actual admission of the patient and the performing of the Biopsy procedure is detailed in Table 7.7.

Care provision actions	Role of POSEIDON	Key features / benefits shown
Patient admitted to the ward	Admission forms completed, appropriate ward based nursing data recorded, any care from other departments whilst Patient on wards requested. Consent form completed. Finally, all ward based / related data held as part of the Ward care process of the procedure encounter	• Inter department communications - any services required can be requested and completed as desired • Multimedia - supported by procedure encounter record • Flexibility - ward care process acts as a nested encounter enabling any patient care to be given on the ward or by other departments as required • Full department records - departments performing any requested work maintain records • Full encounter records - all ward related care is presented as part of the ward care process within the ENT procedure encounter record
Patient goes to theatre	ORSOS (theatre system) is integrated with POSEIDON, so that through POSEIDON the required ORSOS data can be entered and recorded (using a variety of data entry methods)	• Systems support - ORSOS supported • Full encounter records - data from ORSOS seen as care process of the ENT procedure encounter
Biopsy procedure performed	*Procedure report data entry page* acts in the same way as the *consultation notes data entry page*, enabling items of data generated during the procedure (e.g. video of the procedure, monitoring data) to be added to the record. Equally, the page enables clinical test care processes required as part of the procedure to be requested (e.g. Pathology analysis of the Biopsy sample obtained)	• Inter department communications - enable requests to be made • Multimedia - data of any media can be recorded as required • Flexibility - surgeon free to record data of any kind throughout surgery as required as the framework structures and thus system pages present are tailored to permit this • Full encounter records - all procedure data presented by procedure framework structure • Full department records - departments performing clinical tests requested maintain full records of work done

Table 7.7 - POSEIDON utilisation during patient admission

After the procedure has been performed the Patient will return to the wards and be discharged after a few days. Meanwhile, POSEIDON is utilised to conclude the procedure (as detailed in Table 7.8).

Care provision actions	Role of POSEIDON	Key features / benefits shown
Procedure clinical tests (i.e. tests on Biopsy sample) are completed and made available to ENT (see screen shot 8)	Procedure clinical tests made available to ENT via POSIEDON. The data can be accessed from the Procedure data index page	• Full departmental records - departments performing post procedure clinical tests maintain records • Full encounter records - all data generated as part of the procedure held within the procedure encounter record • Multimedia - data of any media held as integral part of the record • Data is immediately available - saves time and resources (no posting of results)
Procedure report generated	All appropriate procedure and other data reviewed, and report generated using the *procedure report data entry page*	• Full encounter records - report held within procedure encounter record • Full availability of all multimedia data associated with the procedure enables greater understanding of condition / findings to be imparted
Procedure outcome defined	Consultant uses "Departmental appointment" option on the "Outcomes" menu of the *procedure report data entry page* to request a follow-up ENT consultation encounter	• Full encounter records - outcome determined and recorded within the encounter records • Time saved - pre-entry of request data, and correct data automatically entered onto request • Better administration - request responded to immediately

Table 7.8 - POSEIDON utilisation in procedure encounter conclusion

Screen shot eight illustrates how the Biopsy image data is presented within the system.

Screen shot 8 – Haematology and Clinical Chemistry: biopsy data display page

Figure 7.5 gives an overview of how all the data from numerous systems is structured

within the MEHCR so that composite and comprehensive records are given.
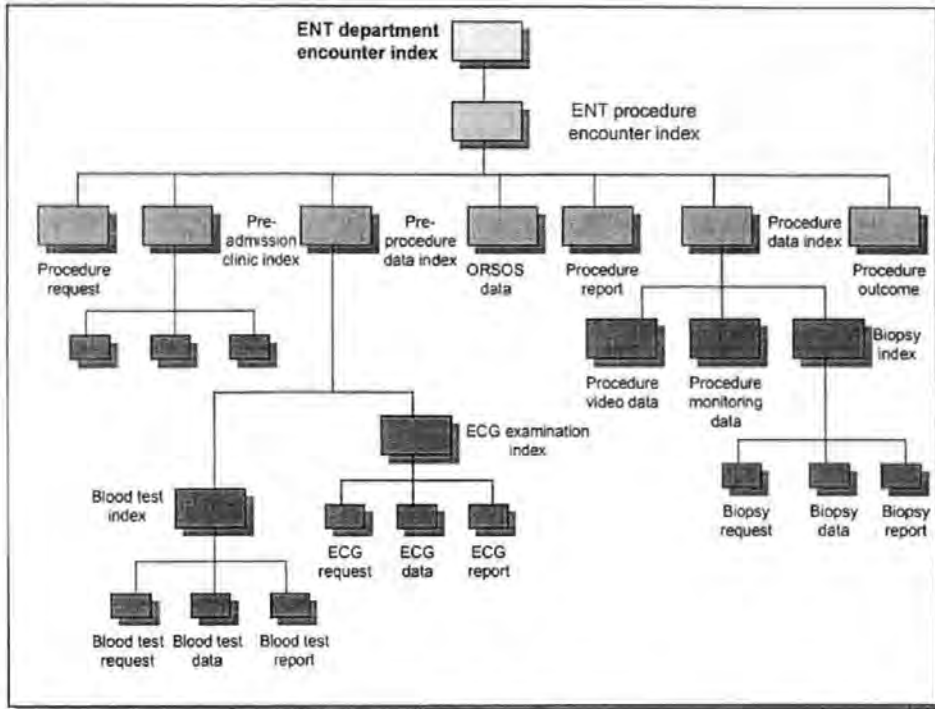
Figure 7.5 – Overview of a procedure encounter structure

The demonstration case (shown by POSEIDON) could actually end after the Biopsy procedure encounter has been completed, as the patient's care to this point is sufficient to demonstrate the majority of the system's operations. However, to demonstrate how care can be co-ordinated between departments, and is conducted in other departments, the care the patient would receive within the Speech Therapy department is discussed. Table 7.9 shows the use of POSEIDON during care provision within the Speech Therapy department once the referral request (detailed earlier), has been made.

Care provision actions	Role of POSEIDON	Key features / benefits shown
Speech Therapist accesses, responds to the request	POSEIDON flags and shows the ENT request, records searched for relevant information, appropriate appointment given. Required Speech Therapy consultation encounter framework structure created as appointment given	• Full departmental / encounter records - utilised to furnish information (including time scales regarding other care), so that Speech Therapy can effectively co-ordinate care provision • Multimedia data generated - enables full appreciation of problems to be gained • Full encounter records - enabled as Speech Therapy referral request shown as outcome of ENT encounter, and referral data item of Speech therapy encounter
Patient arrives, details checked and corrected	PI and PHC sections of record examined, any incorrect data altered using data manipulation pages	• Record sectioning - enables correct and efficient administration of Patient • Staff resources - utilised efficiently and effectively
Records examined to assess treatment of Patient thus far	Records searched and appropriate department and encounter records studied	• Full encounter / departmental records - enable all relevant details to be readily viewed • Multimedia - availability of multimedia data as integral part of records enables full understanding of problems to be gained • Flexibility – framework structures present are tailored to support the precise operations of the Speech Therapy department
Speech Therapist performs a variety of clinical tests / assessments within the department	Options on the *Speech Therapy consultation notes data entry page* utilised to enable recording of required departmental tests / assessments. Required framework structure components utilised to support data entry / display of data. A number of data entry methods available for the entry of audio, graphical, numerical and text data given by the tests / assessments	• Systems support - utilised for the support of multimedia data given by other HCE systems • Multimedia - range of multimedia data generated and recorded within Speech Therapy • Data entry and display pages - utilised for the entry and presentation of the data generated • Index pages - utilised to present all the data given during the encounter in a structured form
Speech Therapist determines outcome of encounter	Option on *Speech Therapy consultation notes data entry page* used to request follow-up Speech Therapy encounter as outcome	• Full encounter records - follow-up request seen as outcome of one encounter and referral data item of next, thus both are composite and comprehensive • Clinical time saved / better Patient administration - 80% of request details pre-entered • Electronic request cannot be overlooked or lost

Table 7.9 - POSEIDON utilisation by Speech Therapy

POSEIDON is utilised by the Speech Therapist in a similar way as by the ENT Consultant. The Speech Therapist is able to enter consultation notes, and request clinical tests from other departments, generate multimedia data via departmental clinical tests, and define consultation outcomes (such as discharge, further appointment and referral). This is done using the appropriate menu options on the *Speech Therapy consultation notes data entry page* (which is analogous to the *ENT consultation notes data entry page*). Figure 7.6 illustrates the structure of the data generated within the Speech Therapy referral consultation and shows how the framework structure of the MEHCR enables any care provision required to be given and recorded.
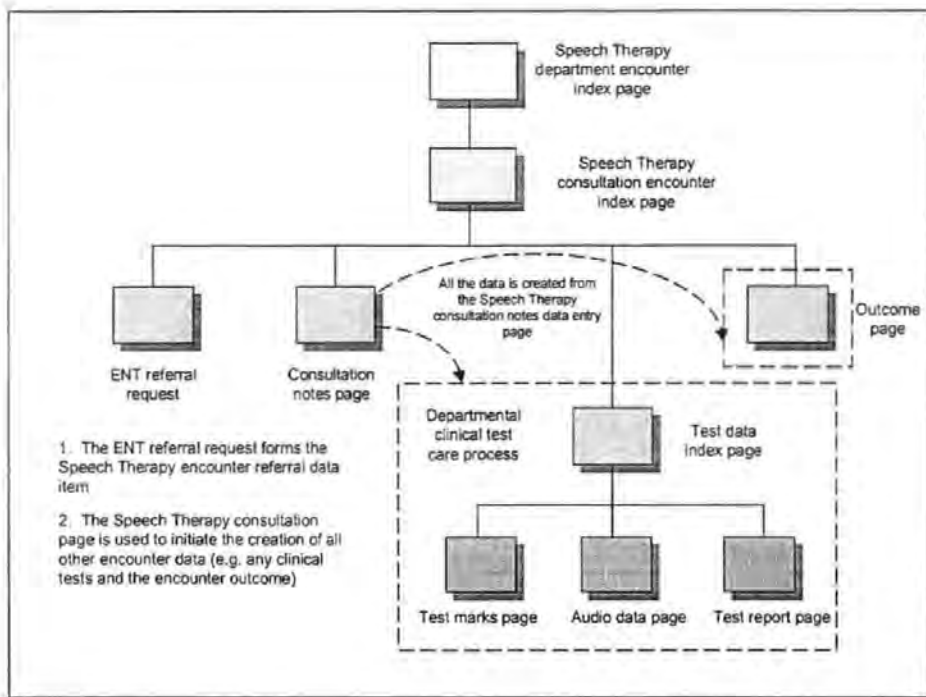
Figure 7.6 – Speech Therapy consultation

By following the care provision given to the patient and the use of POSEIDON throughout, it can be seen that it uniquely enables all aspects of care provision to be delivered (even when numerous disparate systems and departments are involved), working practices supported, and the facilitation of the creation, maintenance and utilisation of composite and comprehensive departmental and encounter multimedia care provision records. As such, it can be demonstrated that the design defined for the MEHCR will benefit health care by increasing the efficiency and quality of care provision.

7.4 POSEIDON limitations

POSEIDON is exactly what it claims to be, a demonstration system which shows conceptual design elements of the project in the form of a number of key features. As such it has numerous shortcomings when compared to what would be required in a full system. These limitations are summarised as follows:

- only a single patient record and case treatment (within a limited number of departments) are shown, which precludes POSEIDON from illustrating the MEHCR's full capabilities with respect to composite and comprehensive care provision for all care needs;

- a limited number of hospital departments are operational / can actually be demonstrated. This prevents the MEHCR's ability to precisely tailor its operations and capabilities to the needs of each department (throughout the HCE) from being shown fully;

- data entry methods implemented are limited (mainly to text and the appending of multimedia data files), whereas the ability to implement speech to text, touch screens and graphics tablet data entry would have been desirable, to illustrate more fully the variety of data entry methods supported by the MEHCR;

- only a few of the more advanced features defined in the conceptual ideas are present (e.g. graphical aids and iconised information). However, the ability to generate the EHDS's, readily import relevant information from other sources, and show a shared clinical workspace, would have been desirable, as its would enable the comprehensive nature of the MEHCR operations to be seen;

- access to other services and systems is only simulated (e.g. to the PAS and Internet), whereas to ability to switch between different services and systems, import data and link to it, would have demonstrated systems inter-operability and how the records could be made truly comprehensive.

However, having stated POSEIDON's shortcomings, it was felt that it had been very successful in achieving its aim of showing some of the MEHCR's features, and enabling an evaluation of the conceptual design. The actual results of the evaluation itself can be seen in the next chapter.

7.5 Conclusions

This chapter has sought to outline the purpose of the demonstration system, the demonstration case, the key features shown, how it is utilised in care provision, and the benefits facilitated. The next chapter discusses the actual evaluation of POSEIDON and the further development of the system.

Chapter 8

POSEIDON evaluation

Introduction

This chapter discusses two different ways in which POSEIDON, and hence the conceptual ideas defined, were evaluated (i.e. by HCE staff and EHCR professionals). It looks at the aims of both of the evaluation processes and the methods utilised by them. It reviews the results gained, and some of the most pertinent criticisms and praises given concerning POSEIDON, the key features it illustrates and the full conceptual ideas defined. The chapter also alludes to areas within both POSEIDON and the conceptual ideas which require further investigation and development. Finally, the evaluation processes as a whole are commented upon.

8.1 POSEIDON evaluation strategy

POSEIDON was designed to show the provision of care throughout a complex and clinically accurate demonstration case, so that the majority of the MEHCR's key design features (detailed in chapter seven), could be shown and evaluated in a realistic manner. It was also hoped that demonstrating POSEIDON would act as a catalyst for the discussion and assessment of other parts of the conceptual design (defined in chapter five), and their perceived benefits to health care (defined in chapter six).

Two separate evaluation processes were conducted, involving the following participants:

- end users and HCE IT staff;
- EHCR systems professionals.

By choosing these two groups it was felt that both the practicality and research value of the ideas defined could be assessed by a range of participants possessing appropriate expertise.

A structured evaluation was conducted with the first participant group, so that the structure, utilisation, capabilities and benefits of the MEHCR could be quantified. Meanwhile, the second participant group had a less structured and more discursive evaluation which, spurred by the use of POSEIDON, aimed to assess more fully the conceptual ideas defined, and subsequently comment upon their value with respect to

health care's future development. Thus it was felt that, in total, the evaluations would be as comprehensive as possible within the bounds of the project, in that collectively they:

- include the majority of staff roles identified, health care IT specialists and researchers;

- enable an assessment of the conceptual design.

8.2 End user and IT staff evaluation

A number of research methods were considered for utilisation in the first participant group evaluation process. These ranged from conducting highly structured system demonstrations and interviews, to unsupervised or unstructured evaluations. The former method may give biased results, reflecting the way in which the evaluation process is designed and conducted. The other method, however, may fail to yield results of any use or benefit, as the participants may explore POSEIDON in an unstructured manner and fail to evaluate the key features shown.

As a consequence, a variety of evaluation methods compromising between the two extremes were considered, including the following:

- structured training, followed by unstructured utilisation and evaluation sessions;

- supervised free-ranging utilisation sessions;

- supervised partial utilisation in conjunction with partial demonstration sessions (participants utilise the system to perform their usual duties).

However, time constraints for the participants, and the availability of HCE resources meant that the evaluation method selected was that of POSEIDON being illustrated (via the provision of care around the demonstration patient case), and evaluated fully (in the form of a structured questionnaire detailed in the next section), at the end of the demonstration session. It should be noted that in any evaluation only certain topics can be covered (here they were those included by the questions and raised during discussions). However, every effort was made to cover as many facets of POSEIDON's operations and the conceptual design as possible.

The participants included Secretaries, Nurses, Consultants, System managers and IT specialists, and the evaluation sessions occurred mainly on a one-to-one basis, in a private office, ensuring confidentiality and privacy. During the sessions, participants spent one to two hours asking pertinent questions, discussing with clarity the features shown, commenting on how other care provision scenarios might be supported, discussing POSEIDON's use and capabilities during care provision, and its potential benefits to health care.

8.2.1 Evaluation questionnaire

At the beginning of each evaluation session, the following was recorded: participant name; occupation; department; time and date. The questionnaire had four main sections as follows:

- structure - evaluating record sectioning, flexibility (i.e. tailoring of framework structures, and thus MEHCR operations, to departmental needs), record's hierarchical form (supported by the use of index pages), the maintenance of departmental control, and the composite and comprehensive nature of both departmental and encounter records;

- presentation, functionality and utilisation - evaluating the system's interface, system page concept, enabling of inter-department communications (e.g. requests) and ease of use;

- content - evaluating the records data content and its multimedia nature;

- benefits - evaluating the benefits given to care provision.

Each section consisted of a number of questions having Yes / No responses, and a blank area for the recording of relevant comments. The questions in each of the sections were designed to elicit direct answers (recorded as the evaluation session progressed), so that tangible aspects of POSEIDON could be directly evaluated, and

enable the initiation of discussions concerning the key features shown, and the conceptual designs.

Throughout the evaluations participants were not led, so that consistent and accurate evaluation results could be obtained. If the participants could not give a direct answer, then they were not pushed, their views were noted on the questionnaire, and their answers recorded as undecided. The other comments arising as questions were asked, discussed and recorded at the end of each section, as were the relevant views concerning the key features shown and the conceptual design.

A copy of the actual evaluation questionnaire that was used can be seen in Appendix D. The results have been tabulated, and are presented in Tables 8.1, 8.2, 8.3, and 8.4. To aid understanding of the results, the associated questions (accompanied, where appropriate, by an explanation of their purpose) are given before each table, and the results gained are analysed in section 8.2.2.

Section 1 - system structure

1. Do you like the main organisational structure of the patient record, i.e. the record being composed of 4 main sections (Patient Details, Private Health Care, Medical Histories and Hospital Departments)?

Here the segmentation of the record into four main parts to support care provision operations was examined.

2. Within the Hospital Department sections do you like the use of index pages throughout the record, to structure the patient data (e.g. departmental encounters index pages, consultation and procedural encounter index pages, process index pages etc. in accordance with departmental operations)?

Here the hierarchical structure or form of the MEHCR was examined to determine if it supported the provision and review of care (e.g. did the organisation of encounters (being comprised of care processes and sub-processes tailored to departmental needs) within departments effectively aid care provision).

3. Do you like the composite presentation of related departmental data (e.g. Radiology data presented within the Radiology department records and within the records of the requesting clinical department)?

Here the conceptual design's support of the departmental and encounter based nature of care provision was analysed.

4. Do you like the way in which the record structure ensures and maintains departmental control of departmental operations (e.g. booking of appointments etc.)?

Here the way in which the record enabled departments to accept / reject and schedule their work was examined.

Section 1	Answers		
Question No.	Yes	No	Undecided
1	13	0	0
2	13	0	0
3	13	0	0
4	13	0	0

Table 8.1 - Tabulated results of evaluation questionnaire section 1

Section 2 - presentation, functionality and utilisation

1. Do you like the use of menus to navigate, control and operate the system?

2. Do like the use of colours?

3. Do you like the use of buttons and labels on the index pages?

4. Do you like the use (emulation) of pages to present the data?

Here the grouping of information on screen was being examined.

5. Is the data presented in an easily comprehensible, logical manner?

Here the degree to which the record presented data intuitively was defined.

6. Do you like the maintenance (where appropriate) of the existing formats for the requesting and presenting of administrative and clinical data (e.g. X-ray and Haematology requests)?

Here the use of the existing data set forms as appropriate was examined.

7. Do you feel that the proposed system could / would integrate into the clinical workplace with some re-engineering of working practices?

Here the ease of use and the ability to support the way in which care provision occurs was examined.

Section 2	Answers		
Question No.	Yes	No	Undecided
1	13	0	0
2	13	0	0
3	13	0	0
4	12	0	1
5	13	0	0
6	13	0	0
7	13	0	0

Table 8.2 - Tabulated results of evaluation questionnaire section 2

Section 3 - content

1. Does the system contain all the required non-clinical, administrative and personal patient data necessary?

Here within the demonstration the lack of any data items was examined.

2. Does the system contain additional administrative, personal data which is of use (all previous GP's, addresses, medical conditions, procedures etc.)?

Here the need for and use of the additional data recorded was analysed.

3. Does the system contain all the necessary clinical data (e.g. reports etc.)?

Here the system was examined to determine if any data required for clinical use was absent.

4. Does the system contain additional multimedia clinical data which is of use (e.g. ECG results, Biopsy images, X-ray images, clinical requests)?

Here the value of having and being able to utilise multimedia data was assessed.

5. Does the system contain redundant data?

Here the unnecessary presence of data was defined (e.g. the recording of all referral data items means that patient GP details are held as part of the letters added to the patient record. However, GP details are also held within the PI section, thus this could be thought of a duplication of data).

Section 3	Answers		
Question No.	Yes	No	Undecided
1	12	1	0
2	11	1	1
3	13	0	0
4	12	0	1
5	4	0	9

Table 8.3 - Tabulated results of evaluation questionnaire section 3

Section 4 - benefits

1. Will the system make the administrative tasks supported easier to perform (e.g. booking appointments, admission to the wards, updating of patient details etc.)?

2. Will the system make the clinical functions supported easier to perform (e.g. requesting of clinical tests, referring of patients etc.)?

3. Do you think that the system will save time (maximising the efficiency of the supported processes)?

4. Does the system communicate the clinical and administrative patient information effectively?

5. Does the use of multimedia data aid the communication, review, and evaluation of clinical data?

6. Does the recording and maintenance of the clinical and administrative request, actual patient data, report and data updates produce a more comprehensive and composite record (is all recording necessary)?

7. Will the proposed ubiquitous availability of the system and its composite nature aid the provision of clinical care (will the system make the delivery and support of patient care easier)?

8. Will the system help reduce the number of mistakes made with respect to the administration and use of the patient data and the patient records (e.g. decrease mistakes in filling in details, always give current details etc.)?

Section 4	Answers		
Question No.	Yes	No	Undecided
1	13	0	0
2	9	0	4
3	13	0	0
4	12	0	1
5	13	0	0
6	11	0	2
7	11	0	2
8	13	0	0

Table 8.4 - Tabulated results of evaluation questionnaire section 4

8.2.2 Evaluation results analysis

The information gained from the evaluation process (in the form of both the direct assessments made and the relevant comments recorded) were carefully analysed. The evaluation results are discussed in the next four sections.

8.2.2.1 Section one

This section evaluated POSEIDON's sectioning, structures, maintenance of departmental control, and its facilitation of composite and comprehensive departmental and encounter records. The participants liked the sectioning of the record into four main parts, and the constituent sub-sections. It was felt that this effectively partitioned distinct parts of care provision and would greatly aid both patient administration and the review of previous summary medical histories.

The presence of full multimedia departmental and encounter records, without any duplication of data, was thought to be of great value. Equally, the ability to instantly be aware of, and view, every item of data (of any media) either generated within the department, or as part of an encounter managed by the department was highly commended. It was felt that, collectively, these MEHCR capabilities would considerably ease / eradicate problems associated with the following, and increase the efficiency and quality of care provision:

- obtaining of existing patient information from the records as the MEHCR enables all data, especially multimedia data, to be recorded, prevents data being removed and enables the record to be effectively searched. Thus, clinical decisions are not made in ignorance of data;

- tracking of patient progress, as the MEHCR's ability to instantly show the absence / presence of patient data and give narrative summary reports (e.g. examination performed, report generated,

sign off awaited), would negate the need for progress chasing phone calls, and the posting / receipt and appending of data to the records.

The ability to retain departmental workload control was well received, as it was felt that to ensure the correct and efficient provision of care, departments need the freedom to effectively manage their operations.

Also praised was the automatic generation of some appointments (e.g. pre-procedure appointments) within the required department sections. This is because the functionality complements the existing care provision process, in which loose general agreements / arrangement exist. For example, at present ECG might permit ENT patients requiring ECG examinations before surgery to attend the department on a Tuesday morning. At present, this means that ECG are unaware of how many and which patients will attend. However, within the MEHCR, as procedure appointments are given, ECG appointments (if required) are automatically requested and accepted (in accordance with the inter-department agreement) for a Tuesday morning two weeks prior to the procedure date. Thus, now ECG know how many and which patients are going to arrive on the Tuesday morning and so can provide suitable resources. Equally, their full patient records can be reviewed for relevant data. It was felt that this would greatly aid the management of departmental resources and facilitate better patient care.

Another feature of the MEHCR commended was the ability to tailor structures to departmental operations. Participants praised the systems ability to define encounter structures (e.g. Speech Therapy and ENT consultations) to reflect the precise operations of various departments, whilst retaining a basic coherent feel to consultation encounters. It was felt that this consistency between departments for the same types of operations would aid its clinical use. Equally, the different Radiology departmental encounter structure given was enthused over as it accurately reflected the specialist operations of the department, but in a way which enabled its easy review when examined as a care process within another encounter (i.e. the ENT consultation encounter).

The hierarchical structure of the record received considerable praised. Participants expressed a liking for the way in which data could be located and generated (via the selection of sections, sub-sections etc. in the PI, MH and PHC sections, and departments, encounters and care processes within the HD sub-section sections). It was felt that the structure given was intuitive, enabling different items of data to be generated and presented in a coherent manner.

8.2.2.2 Section two

This section evaluated the system page concept, the interface designs, ease of use and inter-department communications. The system page concept was widely praised as a way of enabling the MEHCR's effective utilisation. Its use of the different types of system pages throughout the MEHCR for different purposes was commended. It separated different aspects of care provision (e.g. the creation and display,

manipulation / updating of existing data sets, and the structuring of the hierarchy via index pages).

Initially, one participant expressed concerns about the need to go between system pages to obtain specific items of data. For example, in the MH sub-sections each page contains a maximum number of summary data sets in chronological order. The user views the information via Next, Back, First and Last page options, to find appropriate data. The participant stated a preference to scroll the data sets on one page. It was explained that this data display option along with others (defined as follows) could easily be accommodated by the MEHCR's system page concept, and the participant's concerns were satisfied:

- within the medication sub-section, medications taken could be displayed by listing the names of the medication and having an associated icon next to it on screen. As the user double clicks on the icon the summary details are displayed;

- within an encounter any data page being viewed could have a small-elongated window to the side. In the window all other encounter data could be iconised or indexed in an "outlook style" similar to the Oswestry system (discussed in chapter 3).

Throughout the evaluation the way, in which the system pages provide a workspace area for the entry of data was praised. Equally, the way in which certain pages (e.g. the consultation notes data entry page) enable the encounters to be controlled was

highly commended as it reflected the nature of care provision, when one clinician takes responsibility for directing care.

The interface designs, and the system's ease of use, were all well received by all, with the use of a variety of common Windows controls offering continuity between the operation of the MEHCR and some other HCE systems currently utilised being praised. The designs were felt to be intuitive and complement the MEHCR's structure and use. Menus and their layered options were seen as a good way to enable very specific aspects of care to be offered (without putting the burden on the user to specify operations), as they offer considerable scope for specialisation. It was also felt that their use would enable the utilisation of the system to remain composite as the menu options could be extended to accommodate the support of further health care developments.

The interface was also commended for enabling the seamless support and integration of the operations of existing systems (e.g. PAS) so that a consistent mode of operation is given throughout the MEHCR. It was felt that this capability would substantially decrease the practice of "systems avoidance". This involves staff asking others to utilise systems (which they do not use on a regular basis) for them. By decreasing this, the care provision efficiency could be increased as staff resources are more effectively utilised and the risk of errors occurring as information is sought and passed between staff is minimised.

The evaluation of POSEIDON's interface designs also enabled their flexibility to be assessed. Obviously, with POSEIDON the flexibility of the full MEHCR can only be simulated with respect to the offering of numerous multimedia data entry methods, and the tailoring of departmental operations etc. However, a number of participants suggested that the flexible nature of the interfaces would be useful so that personalised settings within the MEHCR (for larger menus and text, different colours, preferred data entry methods for specific tasks etc.), could be given, as it was felt that these touches would aid ease of use.

The inter-department communications of POSEIDON were extremely popular with the participants, as they saw immediate and considerable benefits for the efficiency of care provision and the support of their duties. The pre-entry of data alone was felt to be a huge benefit for health care in terms of time savings, and the maintenance of existing formats for these departmental exchanges was commended as it was felt that the correct information required was present and in an easy to utilise from.

8.2.2.3 Section three

Section three evaluated the information content of POSEIDON and its multimedia nature. Generally, the information content of the system was commended. However, some participants did identify items of data whose presence would be useful. These included full details of the patient's Dentist and employers, as this information could be utilised in patient administration (e.g. private treatments are often funded through employers health insurance schemes), thus, if these details were present, then the

administration of some of the patient's private treatments would be made easier. After some discussion of the conceptual ideas defined and their capabilities with respect to expansion, it was felt that the required information could be accommodated by extending the PI section to include two further sub-sections, Dentist's details and Employer's details, utilised in the same way as the GP details sub-section.

Obviously, a number of these sorts of findings would arise if more departments became involved in the research and more participants witnessed POSEIDON's operation (this highlighted the need for more extensive research to be conducted throughout all HCE departments to identify further requirements). However, it was felt that the conceptual ideas defined were capable of accommodating the additional needs identified by the participants.

One participant identified some data redundancy within the system. For example, it was felt that as all GP letters (containing GP details such as address) were held in the system, then it was not necessary to maintain complete records of all GP details. However, this proved to be a contentious point with the Secretarial and Administrative staff (i.e. those who tend to use this data) favouring its retention (as at present within POSEIDON), as this made its location and use easier. Equally, it was felt that if the GP address details were removed, and GP referrals (which form part of the record) accepted via other means of communication (e.g. e-mail), data such as GP address may be lost

The importance of the comprehensive coding of all data was seized upon by the participants. POSEIDON does not actually support the coding of data and, as stated in chapter three, at present there is no coding system capable of capturing all record data. However, the ability to transparently support specialist-coding systems (as they develop) beneath the MEHCR (as given by the conceptual designs) would enable comprehensive clinical coding to occur. This solution was discussed and satisfied the concerns of the participants.

The multimedia nature of POSEIDON and its benefits to health care were well received. This was of particular interest because in the initial system's requirements capture process it was felt by some staff that the presence of multimedia data would have limited benefits to health care, often being confined to patients with complex and specialist problems. However, the enthusiasm for multimedia records on seeing POSEIDON was very pleasing. The participants commented upon the numerous benefits that the recording and use of multimedia data would facilitate with respect to the following:

- comparative data review - image, video, audio and graphical data generated over a variety of time scales can be compared and the patient's progress objectively assessed;

- patient understanding - the use of multimedia data to aid the explanation of problems and proposed treatments to patients;

- clinical understanding - the use of multimedia data to enable clinicians to review data and gain a full appreciation of problems (negating the

need to rely completely on reports, which may have been written by others, when reviewing information);

- clinical training - the use of multimedia data in the continued training of clinicians of all types.

8.2.2.4 Section four

The participants agreed that the use of the MEHCR (as illustrated by POSEIDON) would provide numerous benefits enabling increases in the quality an efficiency of care provision, as follows:

- electronic communications – pre-entry of data (decreasing data entry tasks and the possibility of errors occurring), increased speed of communications, and increased legibility (text is type written rather that hand written);

- more patient data – recording of all patient data, in the most appropriate media (e.g. video etc.) would aid clinical care as all patient data is available, in a media imparting the greatest understanding;

- availability of patient data – the greatly increased availability of all patient data would provide greater efficiencies as resources are not deployed in the obtaining and transport of patient data;

- resource management – resources could be managed better as more information (e.g. such as the number of patients attending an ECG clinic) is available.

8.2.3 Evaluation conclusions

The evaluation was successful, enabling key features of POSEIDON to be quantitatively assessed, and discussions concerning the entire conceptual design to occur. The actual results gained were very pleasing. A summary of the comments shows that the MEHCR defined offered a means of facilitating all aspects of care provision, whilst enabling its seamless recording, in a way which complemented the essential elements of the care provision process. The MEHCR's electronic communications were well received as a way of making immediate efficiencies whilst supporting the need for departmental controls.

The way in which the MEHCR enabled the generation and maintenance of composite and comprehensive encounter and departmental records received the greatest commendation. The participants defined this as an effective way of satisfying departmental record needs, facilitating effective patient management between departments and enabling the effective structuring of all data related to one encounter in a comprehensible fashion.

Finally, the ability to embrace care advances whilst remaining composite and comprehensive was also well received. At present, as systems are introduced or altered, new processes tend to be introduced or processes altered to enable the system's use within care provision. This puts much of the burden of change on to the staff who must remember changes to practices or perform new ones. The MEHCR, however, was seen as a means of breaking the cycle of systems introduction /

alteration disruption as processes are streamlined, integrated and automated as far as possible.

8.3 EHCR systems professionals evaluation

The second evaluation process involved demonstrating POSEIDON to a small number of NHS health care professionals (five) involved in the modelling and development of health care and health care systems, and the use of multimedia in health care. The evaluation consisted of POSEIDON being demonstrated (as in the previous evaluation process via the care of the demonstration patient case). However, here, as POSEIDON was shown, discussions ensued covering all aspects of the conceptual designs, along with their relevance to other ECHR work, and to various health care developments.

8.3.1 Evaluation results

Throughout the evaluation the MEHCR's support of electronic communications received the same praise as in the previous evaluation, being seen as a means of immediately increasing the efficiency of care provision. Equally, the benefits to care provision given by both the retention of departmental control and the increased availability of more data were commended.

The way in which the MEHCR structured care provision was commented on. The participants were very interested in the way in which the different types of encounters were defined, and how the procedure and consultants were comprised of care

processes of different types. Equally, the way in which one type of care processes (i.e. clinical test care process) formed one type of encounter (i.e. departmental encounter), and was then seen as a care process of another encounter (procedure / consultation) was discussed at length. It was felt the this way of defining care provision and relating departmental data was a novel and effective way of describing care provision.

Equally, the structural form of the MEHCR given to support the way in which care provision was defined was highly praised. The ability to enable both the provision and recording of care through a system tailored to departmental care provision operations was commended and seen as a means of increasing the efficiency of care provision. Also, the creation and maintenance of both composite and comprehensive departmental and encounter records, without the duplication of data, was well received. This capability was seen as a way of satisfying the desire and need for departments to keep records of all care directly provided, and of that performed on their behalf as part of an encounter that they manage. It was felt that, by ending the creating and maintenance of departmental records the MEHCR given offered a means improving the efficiency and quality of care by decreasing administrative overheads and increasing data availability.

The framework structures of the MEHCR (given by structural descriptions), were commended as a way of achieving the form of the MEHCR. Equally, the ability to make changes to the framework structures to accommodate developments was praised. This was seen as an essential element to the evolution of electronic records,

as at present the fear of implementing a MEHCR and then finding that ten years later it is no longer composite and comprehensive could be removed.

Also commented upon was the MEHCR's sectioning, system page concept and systems support. The sectioning of the record was felt to be a good way to separate the record's different purposes with respect to patient administration and care provision. The system page concept was felt to offer a consistent and effective way to permit the MEHCR's utilisation.

As the discussions progressed, the conceptual ideas defined were found to be capable of responding to and supporting the vast majority of future health care scenario requirements given by the participants. For example, the issue of clinical coding was raised again and discussed. Fortunately, the capabilities of the conceptual ideas were seen (with respect to transparently supporting specialist systems), as an effective way of efficiently utilising existing and future coding developments, to enable the comprehensive clinical coding of all patient data.

Equally, extensions to the MEHCR to facilitate the recording and presentation of all patient data, including technical systems data (such as that detailing the exact technical nature of MRI scans (e.g. scan orientation etc.)), was discussed and the conceptual ideas found to accommodate this requirement. For example, the framework structures of the MRI clinical care process could be extended (by altering the descriptions of the framework structures), to give an additional component to

support the technical system data, which could be recorded and presented by additional system pages as appropriate.

The clinical coding support and MRI scan expansion scenarios are just two examples of those posed, and fully accommodated by the conceptual designs as defined. However, some possible improvements to the conceptual ideas were identified, such as the need to provide for the possibility of more than one instance of a particular clinical test being performed during an encounter. For example, a second additional X-ray examination of a patient's neck might be required to show fully a particular patient problem. Equally, more than one item of examination / test data generated as part of one test or examination (e.g. more than one nasal endoscopy examination might be required as perhaps two very different views (two separate videos) might be required to illustrate fully the patient's condition). The conceptual designs defined could be enable these requirements to be met by either:

- introducing a further framework structure layer to support more than one item of patient data (e.g. two separate video recordings);
- introducing a further framework structure layer to support two instances of the clinical test care process (e.g. when two separate X-ray examinations prove to be required once the examination commences).

In this way the conceptual design enables the exact clinical care required by the patient to be given and supported and given.

A further discussion point focused on the need to find a better way of appending multimedia data files to POSEIDON. In POSEIDON, file names and locations are typed in, or directory listing browsed for the presentation and appending of data held by other HCE systems. This was felt to be open to mistakes with respect to the viewing / appending of the correct file. Thus, the participants felt that a highly automated process in which appropriate files are automatically obtained (from source systems), and presented within the MEHCR was felt to be required. This automation would be given as in a full implementation within the design environment the SV's of any two systems (e.g. MRI and the MEHCR) involved in any exchange of data are defined so that both systems are aware of the data exchanges required. So, when data is generated on a source system (such as MRI) its presence could trigger the execution of code so that when the appropriate part of the patient's MEHCR is accessed (e.g. the Radiology section) a message is seen to indicate the presence of data for appending to the record. The appropriate Radiology encounter is then presented to the user. On accessing this the required data entry page (MRI scan data entry page) is given. When the page is accessed the data to be appended is automatically presented, after checks (such as the matching of patient number, department, encounter and care process references attached to the data) have been completed. Thus, the process of appending or linking data to the MEHCR from other systems is automated to a large extent. This proposal satisfied the concerns raised.

8.3.2 Evaluation conclusions

This evaluation process was again felt to be very successful. POSEIDON was seen as a valuable demonstration tool, offering a realistic initial embodiment of some of the key features of the conceptual designs. The conceptual designs, in conjunction with the design environment, were seen as a novel way to facilitate and record comprehensive and composite multimedia care provision now (irrespective of the implementation approach), and as health care develops over time.

The fact that the conceptual ideas were able to cope with all the future health care scenarios posed (subject to minor extensions to a few of the MEHCR's component framework structures), was most gratifying. It endorsed the validity and the comprehensive nature of the ideas defined, demonstrating that the MEHCR's inherent capabilities with respect to flexibility, expansion, systems support and interface designs (in conjunction with the two different types of views defined), would offer a way to achieve a composite and comprehensive record which remains so over time.

In addition, the development approach as a whole was commended, with its patient orientated nature aiding care provision, its support and enhancement of existing systems aiding working practices, and its inherent flexibility and expansionist capabilities embracing the ever changing nature of health care.

8.4 Evaluation review

As eluded to earlier, it would have been desirable to have conducted further evaluation sessions with the first group of participants, where they actually used POSEIDON themselves and were free to explore different aspects of its operation. Ideally, a further two evaluation sessions would take place, one would involve participants performing their usual duties with POSEIDON, while the second would allow the participants to explore the entire system. In this way, POSEIDON could be progressively refined as utilisation problems are identified and resolved. Unfortunately, the time constraints of the project did not permit this further work to be performed, but it would form a part of any further development of the system, as would the extension of the system to enable a greater range of activities to be performed, rather than just those simulated within the demonstration case. However, having said this the initial evaluations were felt to be appropriate and valid.

Obviously, POSEIDON is only the first practical realisation of the conceptual designs defined in chapter five, and numerous features envisaged (such as those for the coding of data, the use of a variety of data entry methods and the creation of EHDS's), were not implemented. However, POSEIDON as it stands was very well received, and provides a practical demonstration of how the requirements of a MEHCR could be met.

8.5 Conclusions

This chapter has sought to illustrate how POSEIDON, and the conceptual design defined, was demonstrated and evaluated during two different evaluation processes. It has discussed the findings of the sessions and, thus, the value of the design formulated. The next and final chapter moves on to review the overall achievements of the research programme and look towards the further refinement and embodiment of the conceptual designs defined.

Chapter 9

Conclusions

Introduction

This chapter discusses the achievement of the research project, examining the research performed, the conceptual design defined, its embodiment and evaluation. The limitations of the project are also discussed, along with appropriate areas of further work. Finally, the chapter concludes by examining the prospects for further MEHCR developments and how the research project has illustrated one way in which they can be achieved.

Introduction

9.1   Research project achievements

The work undertaken as part of the research project aimed (as defined in chapter one) to give a composite and comprehensive multimedia electronic health care record (MEHCR), capable of the following:

- generation / recording / presentation of all patient data (including multimedia data) as care is provided;

- support of patient care provision (and its constituent activities), care management and care administration;

- accommodation of future care provision advances whilst remaining composite and comprehensive.

To achieve the aim defined, a comprehensive analysis of care provision was performed.   This identified both the problems associated with the use of paper-based records and the requirements that a multimedia EHCR must satisfy.   From the analysis, a high level representation of care provision was determined.   This defined care provision as being comprised of different types of encounters, made up of various types of care processes, which separated logical aspects of care.

To support the nature of care provision, and satisfy the requirements identified, a "conceptual design" was defined.   This defined a MEHCR framework through which multimedia patient care could be delivered, and seamlessly recorded, in accordance

with patient needs and optimised HCE operations. Thus, the MEHCR given enabled the following:

- efficient provision of all patient care in accordance with patient needs;

- care provision in accordance with / tailored to departmental operations;

- seamless recording of all patient data (of any media) as care is given;

- administration and management of patient care within and between departments and other clinical bodies (e.g. GPs);

- efficient utilisation of staff resources during care;

- expansion or alteration of operations to accommodate changes in care provision;

- full departmental and encounter records without the duplication of data;

- effective association of related patient data without its duplication.

Equally, the design environment defined provides a means of achieving both the MEHCR's initial implementation (regardless of the implementation approach adopted) and retaining its composite and comprehensive nature as care provision advances (in the form of new systems and working practices).

To assess the conceptual design a prototype implementation of the MEHCR, known as POSEIDON, was developed. POSEIDON acted as a practical proof-of-concept demonstration system, enabling the conceptual design to be evaluated by both end users and EHCR professionals.

An examination of the project's achievements shows that the work conducted and the designs defined did enable the original aims to be achieved. Thus, the MEHCR given supports the provision of all aspects of patient administration, management and care and the seamless recording of all patient data (of any media) in such a way as to enable the production and maintenance of comprehensive and composite multimedia patient records. Equally, the research has given rise to a number of papers presented at referred international conferences, receiving favourable comments from numerous delegates. As such, it is considered that the research has made a valuable contribution to the MEHCR field.

9.2 Limitations of research project

The research project was limited with respect to the human resources, thus, in some respects the research itself was limited. For example, it was not possible to include all HCE departments in the research, hence, the more contained research base was defined. Despite every effort being made to include departments having diverse and representative operations within the research base, it is inevitable that, as some departments were not included, some requirements were not identified. Equally,

being limited to one Trust meant that requirements arising from different ways of operating were not seen.

The research was also limited to some extent by the availability of HCE resources. All the HCE staff asked to help in the research agreed without hesitation, with many of those involved repeatedly giving considerable amounts of their own time after and before work and during lunch breaks. Ultimately, however, the research had to be conducted around both the availability of staff and other HCE resources. For example, staff would be on courses for a number of weeks, called away when urgently required elsewhere, or the resources put aside for the research (e.g. a private room in which to conduct interviews) required for another purpose. This limited the research to a small extent in that some participants were unable to be involved throughout. For example, having participated in the initial research staff would be unable to take part in the checking of the models defined.

The project's limited technical resources also imposed limitations on the on the research with respect to the demonstration system. For example, it was not possible to implement a variety of data entry methods (such as speech to text, graphics tablet, touch screen etc.). However, having stated that there were limitations, the work undertaken was felt to be comprehensive within its bounds.

9.3   Further work

When considering further work that the project could give rise to, a number of areas immediately come to mind, as follows, to overcome a number of the project's limitations discussed previously:

- extension of the research base to cover all HCE departments;

- extension of the research to other HCEs;

- further development of the demonstration system;

- further and different types of evaluations.

In addition to these areas it would be of interest to develop a small number of prototypes networked between departments and integrated with departmental systems. These could then support various simple patient care scenarios (e.g. consultations when patients are referred to another department, such as Radiology, for a clinical test care process, and then discharged). The prototypes could be used alongside the existing paper-based records and manual processes. This would enable some of the benefits with respect to electronic communications, greater availability of data etc. to be assessed and quantified. In addition to this, the research could also be utilised to permit an assessment of the usability of the system from the clinician perspective, and how the presence / use of the system impacts upon the patient encounter.

During the first evaluation sessions the participants suggested numerous situations where multimedia might be of use. These ranged from simply being able to recall

patient cases better via the availability of a picture of the patient, to patient education and clinician training. Thus, another possible area of work would entail further investigations into the potential for the use of multimedia data throughout care provision to permit further improvements in care quality and efficiency in the future.

Further investigations into the entry of multimedia would also form a logical extension to the research undertaken. The limitations of the project meant that only rudimentary data entry methods were implemented to show the principle of entering data through the MEHCR's data entry pages. However, further work to identify effective data entry methods for different types of activities (e.g. generation of clinical request, entry of consultation notes, annotation of images and video etc.) would be of great value. Finally, on a similar theme, it might be of interest to investigate further data entry methods suitable for problematic environments such as theatre.

These areas for further investigation represent only a small number of those necessary to progress EHCRs, especially those EHCRs having multimedia capabilities. As such, this situation demonstrates that, despite resources being deployed towards the development of EHCRs (especially in the last decade), there are still numerous developments (e.g. with respect to data entry, terminologies, health care communications, record data content, security etc.) which must occur if EHCRs are to be realised.

9.4 Future of multimedia electronic health care records

A review of research currently being conducted with respect to care provision shows that within numerous fields (e.g. records security, clinician training, surgical planning, diagnostic methods etc.), a variety of advances are being made. By examining some of these advances, especially those concerned with aiding the provision of patient care as follows, it can be seen that multimedia data is common;

- virtual reality system for the assessment and rehabilitation of cognitive functions for patients having brain injuries (Riva, 1999);

- virtual colonoscopy where CT images are fused with rendered 3D images (Halligan & Fenlon, 1999).

As these advances become deployed within care provision more multimedia data will be utilised, and the case for EHCRs having full multimedia capabilities is made stronger. In fact, even now, the use of multimedia data in the form of digital imaging, patient photography and video taping is increasing (Carpenter, 1999) and adding weight to the need for their development.

It has been said that now is the time to being looking seriously at EHCRs and address the issues which need to be tackled. Equally, it has been stated that nobody appears to have the answer as to how developments should occur (Ash & Johnson, 1999). However, the impetus does currently exist to progress EHCRs. For example, in the UK Information for Health states that all HCEs should achieve level three of the six

level model by 2005. Equally, the inevitability of technology playing a greater role in care provision as EHCRs develop is witnessed by the introduction of IT proficiency to some medical school curricula (Penn, 1999). However, having said this there are at present no EHCRs enabling the support of care provision and the recording of all multimedia patient data.

In response to this situation, this project has defined a way in which comprehensive and composite multimedia patient records can be given whilst care provision occurs and is facilitated now and in the future. It has shown how the departmental and specialised nature of care provision can be supported. Equally, it has demonstrated how fundamental static aspects of care provision can be accommodated whilst others can be re-engineered. As such it illustrates that multimedia EHCR solutions can be defined, and that such a system provides numerous benefits to care provision.

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Appendix A

Definition of Job and Duties with respect to the patient records and computerised systems

Interview question set

1	Definition of job and duties
1	What is your name?
2	What is your official Job Title?
3	Could you please give a quick overview of your job (what does it entail etc.)
4	Do you have contacts with other hospitals or hospital departments?
5	Define the forms the contacts take (phone, fax, e-mail etc.)

2	Dealings with patients
1a	Do you have any direct dealings with patients? *(if no go to next section)*
1b	What is the nature of this contact (discuss)?

3	Patient referrals and appointments
1a	Are you involved in the patient referral process?
1b	In what way are you involved in the referral process? *(describe)*
1c	Are computerised systems (centralised or departmental) used or referenced when referral appointments with other departments are made?
2a	Are you involved in the patient appointment process?
2b	In what way are you involved in the appointment process? *(describe)*
2c	Are computerised systems (centralised or departmental) used or referenced when departmental appointments are made?

4	Patient records (paper records)
1	Do you have contact with the patient records? *(if no go to next section)*
2a	Do you have access to the contents of the patient records?
2b	Are you required to go through any security checks or procedures to gain access to the patient records?
3	What data / information about the patient to your knowledge is held within the patient record?
4	Do you find that you usually access only a small amount of data about a patient within the patient record, or do you examine the entire record? *(do you only examine selected departmental record sections as appropriate)*
5a	Are you involved in the appending or deletion of data items to the patient records?
5b	What are the procedures involved for the appending or deletion of data to or from the records?
5c	How much time and effort is involved in the appending of data to the records?
6a	Are you involved in the movement of the patient records within the department?
6b	Are there any notification, request ,or receipt procedures you must follow when the records are transported / moved within the department?
7	Are you involved in the movement of the patient records between the hospital departments?
7a	Are there any notification, request ,or receipt procedures you must follow when the records are transported / moved between the departments?

4	Patient records (paper records)
8a	Are you involved in the movement of the patient records between the hospital department and the patient record stores?
8b	Are there any notification, request ,or receipt procedures you must follow when the records are transported / moved between the department and the hospital record stores?
9a	Are you involved in the movement of the patient records between the department and other hospitals?
9b	Are there any notification, request, or receipt procedures you must follow when the records are transported / moved between the hospitals?
10	How is the patient and the patient record explicitly referenced e.g. patient hospital identification number, patient name etc.?
11	How is the data within the record organised, i.e. chronologically, on a departmental basis, according to data types or a combination of the previous?
12	What types of data are held within the hard copy patient records at present, e.g. text, graphics, images etc.?
13	Who owns the data held within the patient record? *(discuss)*
14	Does your department have separate a departmental patient records, or are the records held within the main patient record?
15	Do the individual departments and patient records contain hard copies of data held on any central or departmental computer systems? *(if so then what)*
16	Are there any other instances/circumstances that come to mind when instances of data duplication are apparent between the hard copy records and computerised records?

4	Patient records (paper records)
17	Are there any instances where data duplication takes place between departments? *(e.g. the duplication of referral data)*
18	Are there any other official or non official practices/instances where data duplication occurs?
19	How easy are the hard copy patient records to use? *(does it take time and effort to search the records for the necessary data)*
20a 20b	Do you append patient data to the hard copy patient records? How much time and effort is involved in appending the generated patient data to the hard copy record?
21	What, if any, duplicate patient data is held within several different departments record sections?

5	Patient data
1	Do you have contact with separate items of patient data, e.g. test results, x-rays, text notes etc., which are not yet contained within the patient record? *(if no go to next section)*
2	Are you required to go through any security checks or procedures to gain access to the separate data items?
3a	Are you involved in the movement or transfer of the separate patient data items within the department?
3b	Are there any notification, request ,or receipt procedures you must follow when the data items are transferred or moved within the department?
4a	Are you involved in the movement of patient data items between the hospital departments?
4b	Are there any notification, request ,or receipt procedures you must follow when the data items are transferred or moved between the hospital departments?
5a	Are you involved in the movement of data items between the department and other hospitals?
5b	Are there any notification, request ,or receipt procedures you must follow when the data items are transferred or moved between the department and other hospitals?

6	Patient data generation, processing and interpretation
1a	Are you involved in the generation of any patient data?
1b	How do you collect the patient data?
1c	Are any computerised systems involved in the data collection?
1d	In what format is the data collected?
2	Are you involved in the processing of any patient data?
2b	How do you process the patient data?
2c	Are any computerised systems involved in the data processing?
2d	In what format is the processed collected?
3a	Are you involved in the interpretation of any patient data?
3b	How do you interpret the patient data?
3c	Are any computerised systems involved in the data interpretation?
3d	In what format is the interpreted or presented collected?

7	Use of PAS
1	Do you use the PAS system? *(if no go to next section)*
2	What security procedures or checks are in place for accessing the system?
3	How do you reference the patient on the PAS system?
4	What data is held on PAS?
5	How much of the data held on PAS do you view?
6	Can you access other departments records through PAS?
7	What do use PAS for (referral of patients, scheduling of examinations, tracing of patients etc.)?
8	How easy is PAS to use?
9a	Do you append data to PAS?
9b	When appending data to PAS are there any security checks or procedures in place?
9c	How much time and effort does it take to append data to PAS?
10a	Do you delete or amend data on the PAS system?
10b	When deleting or amending data to PAS are there any security checks or procedures in place?
10c	How much time and effort does it take to delete data from or amend to PAS?
11	Is the data held on PAS duplicated within the patient records?
12	How easy is it to search the PAS system for data?
13	Do you know of any other functions which PAS performs - e.g. audit and managerial functions?

8	Non-clinical departmental systems
1a	Do you have a specialised non clinical computerised departmental system?? *(if no go to next section)*
1b	Do you use the system?
1c	If you do not use the system why not?
2	What is the system called and how old is it?
3	What are the systems functions - auditing, management, scheduling of patients, staff etc.?
4a	Do you have access to the system?
4b	What security procedures or checks are required for access to the system?
5	What data does the system hold or contain and in what format?
6	What data does the system generate and in what format?
7	Is the data held duplicated within other systems/records?
8	Is the system linked to PAS?
9	What terminal types does the system use?

9	Departmental clinical systems
1a	Do you have a specialised clinical computerised departmental system? *(if no go to next section)*
1b	If so do you use the system?
1c	If you do not use the system why not?
2	What is the system called and how old is it?
3	What are the systems clinical functions, data generation, analysis or interpretation?
4a	Do you have access to the system?
4b	What security procedures or checks are required for access to the system?
5	What data does the system hold / contain and in what format?
6	What data does the system generate and in what format?
7	Is the data held duplicated within other systems/records?
8	Is the system linked to PAS?
9	What terminal types does the system use?

10	Computerised systems (general)
1	Do you use any computer systems? *(if no go to next section)*
2a	Are there guidelines for the organisation and appending of data to the computerised systems or records which you use?
2b	What are the guidelines?
3a	Do you use more than one system on a regular basis?
3b	Are you happy using more than one system or would you be happier using a single system?
4a	Do you produce any digital data?
4b	In what format do you produce data?
4c	What packages do you use to produce and process the data?
5	How comprehensive and easy to use are the systems?
6	How relevant is the data held on the systems?
7	Do you ever have to take hard copies of some of the data on the computerised systems?

11	Future systems development
1	Do you understand the phrase "Multimedia Health Care Records System"?
2	Do you feel the ability to view one comprehensive records system would be useful in improving clinical care?
3	Do you perceive any immediate advantages or disadvantages of such a system?
4a	How do you feel about using computerised systems in general, are you quite comfortable with such systems and technology?
4b	How happy would you feel about having specialised and general training to prepare to use the system?
4c	Would you feel comfortable having computerised on line help or prefer human there to help (on telephone) etc. or combination of the two?
4d	How would you prefer the help to be given text, audio etc. ask them to think about it?
5	What forms of data presentation are used at present (audio, graphics, video)?
6	Do you feel there would be benefits to holding or representing certain types of data in different media, e.g. audio, video and graphics rather than text - would it aid comprehension and clarity?
7	How could the records be better organised or structured to make them easier to use?
8	Are there any prerequisites for the order / presentation / structure of the data held within the records, e.g. surgical notes in red, chronological order of notes, departmental separation of data within record?

11	Future systems development
9	Are there any system features which you require from the system or would find useful, e.g. data searches, sort by... date/type/size/department/consultant, order by.., show all, find ..., search files, seek files.... etc.?
10	Would you be prepared to carry a smart card or a physical key for security?
11	Would you be prepared / able to remember an ID number and password?
12	Would you be prepared to change the password on a regular basis?
13	How do you foresee the system affecting your existing working practices?
14	Would you be prepared to advise on the design of a multimedia system with respect to its ease of use, presentation, structure etc. so that the best possible end result can be obtained?
15	Would you be prepared to change some of your present working practices as long as they were not detrimental to patient care or increased your work load?
16	What would the general prerequisites of a comprehensive multimedia records system be? *(suggest ease of use, security of data, ease of authenticated access, ease of multimedia data production, ease of appending of data etc.)*

11	Future systems development
17	Would it be beneficial to have strict guidelines / procedural rules for the use of the entire proposed system (for the entry of data, the use of the system, the structure of the system, access to the system and security of the system), or do you feel that in the health care environment it would be better to have a more flexible approach to the use of the system?
18	How do you feel about the efficiency and design of current procedures / working practices - are there any areas in particular which you feel could benefit from a restructuring of their operations - discuss?
19	Do you feel that given the tools and better working practices that you could maximise your efficiency and that this would result in an increase in the quality of the services and care which you can provide, or are you happy with the present system?

Appendix B

Patient centric models

Overview

Appendix B contains several Patient Centric Models (PCM) which collectively show a number of aspects of care provision associated with a patient consultation. The models are defined so that a patient can be followed through the care system from the GP referral, through the HCE consultation, as further clinical information is gathered from other HCE departments and through a number of possible consultation outcomes (e.g. discharge).

The models included in the Appendix do not cover every possible route the patient might take as care provision occurs because many of the routes are similar. For example, the route taken when a patient is seen by another HCE department so that clinical data can be obtained is often the same or very similar which ever department they go to. Thus, the models present are those which show aspects of care or care routes which are fundamentally different such as a patient being discharged after a consultation and a patient being referred to another HCE department for treatment. The particular PCMs included in the appendix and the occurrences they show are as follows:

- GP referral – patient referred to HCE department (B1);

- Patient appointment – request for patient referral received and appointment is given (B2);

- Patient consultation – occurrences forming the patient consultation (B3);

- Consultation care actions (further data required via OP) – further information (such as that gained from a clinical test) required as part of

consultation and obtained via Out Patients collecting sample data and its analysis being performed by another department (e.g. clinical chemistry) (B4);

- Consultation care actions (further data required) - further information (such as that gained from a clinical test) required as part of consultation and obtained when tests and their analysis are performed directly by another HCE department (B5);

- Consultation care actions (outcome: discharge) – patient discharged as result of consultation (B6);

- Consultation care actions (outcome: drugs dispensed and discharge) – patient receives medication and is them discharged as result of consultation (B7);

- Consultation care actions (outcome: drugs dispensed and further appointment given) – patient receives medication and another consultation appointment as outcome of consultation (B8);

- Consultation care actions (outcome: referral to another HCE department) – patient referred to another HCE for care (B9);

- Consultation care actions (outcome: OP treatment) – patient goes on from consultation to receive treatment of some king from the Out Patient department (B10).

B1 GP referral

Patient in good health → Patient undergoes detrimental physical / psychological change

No ↑ (from Patient undergoes detrimental physical / psychological change)

Yes → Patient feels unwell → Patient evaluates extent of ill feeling

No → Patient evaluates extent of ill feeling

Patient evaluates extent of ill feeling → Patient wants to see GP

Patient wants to see GP → No → Patient recovers → Yes → Patient in good health

No → Patient wants to see GP

Yes → Patient contacts GP surgery → Appropriate appointment made

Appropriate appointment made → Patient GP records located

Patient GP records located → No → Appointment cancelled

Patient GP records located → Appointment kept

Appointment kept → Yes → Patient arrives for appointment

No → Patient GP records located

Patient arrives for appointment → GP sees patient with any paper based GP records and access to any computerised system

GP sees patient with any paper based GP records and access to any computerised system → Patient examined and consulted with

Patient examined and consulted with → Course of action decided upon

Course of action decided upon → Patient GP records and any systems updated as required

Course of action decided upon → GP perceives requirement for further data outside GP capabilities

GP perceives requirement for further data outside GP capabilities → No → GP treatment options

GP perceives requirement for further data outside GP capabilities → Yes → Referral options

GP treatment options:
- Follow up appointment only
- Drug treatment and follow up appointment
- Drug treatment
- Discharge

Referral options:
- HCE clinical services required
- None HCE referral
- HCE consultation referral → Go to B2

B2 Patient appointment

As a result of patient seeing GP, the GP feels that a referral for the patient to see a consultant at a HCE is required

→ GP updates GP records and any systems as appropriate to show patient referral has been

Letter of referral sent from GP to HCE

→ Letter contains basic patient details and problem details

GP letter of referral addressed to named consultant

Yes ← | → No → Letter addressed to the department

Consultant's secretary sorts the letter

Secretary in department sorts letter for an appropriate consultant

Named consultant evaluates the GP's referral letter

Consultant evaluates the GP's referral letter

Decision made as to urgency of appointment

Decision made as to urgency of the appointment and which consultant should see patient

GP letter with required actions passed to receptionist

Receptionist enters appropriate details on to PAS to determine if patient has existing HCE record

```
                    │
                    ▼
┌─────────────────────┐        ┌─────────────────────────────┐
│ Patient is on PAS   │  ┌─────┐│ Receptionist checks existing PAS │
│ and has HCE         │─▶│ Yes │▶│ data with data in GP letter.  PAS is │
│ record              │  └─────┘│ undated if required with more │
└─────────────────────┘        │ current patient information   │
         │                     └─────────────────────────────┘
         ▼                                  │
     ┌───────┐                              ▼
     │  No   │        ┌──────────────┐  ┌──────────────┐  ┌──────────────┐
     └───────┘        │ PAS searched │  │ PAS offers a │  │ Most         │
         │            │ for possible │  │ number of    │  │ appropriate  │
         ▼            │ appropriate  │─▶│ possible     │─▶│ appointment  │
┌─────────────────┐   │ appointments │  │ appointments │  │ selected for │
│ Receptionist    │   └──────────────┘  └──────────────┘  │ patient      │
│ creates new     │──────────▶                            └──────────────┘
│ patient on the  │                                              │
│ PAS             │                                              ▼
└─────────────────┘   ┌──────────────┐  ┌──────────────┐  ┌──────────────┐
                      │ Appointment  │  │ Patient now  │  │ Receptionist │
┌─────────────────────┐│ letter       │  │ on the PAS   │  │ confirms     │
│ Record front sheet, ││ generated on │◀─│ appointment  │◀─│ patient      │
│ labels sheet, NHS   │◀│ PAS and sent │  │ pending list │  │ details with │
│ number etc.         ││ to the       │  └──────────────┘  │ the          │
│ generated by PAS    ││ Patient      │                    │ appointment  │
└─────────────────────┘└──────────────┘                    │ on PAS       │
         │                    │                            └──────────────┘
         ▼                    ▼
┌─────────────────────┐┌──────────────────┐       ┌──────────────────┐
│ Receptionist creates││ Patient has HCE   │ ┌────┐│ Patient records  │
│ new patient record  ││ record            │ │Yes ││ recalled from    │
│ folder (front sheet,││ (i.e. patient has │▶│    ││ current location │
│ labels, ENT         ││ attended /        │ └────┘│ in HCE to        │
│ section,            ││ been referred to  │       │ department       │
│ continuation sheets ││ HCE before        │       └──────────────────┘
│ and GP's referral   ││                   │                │
│ letter)             │└──────────────────┘                ▼
└─────────────────────┘         │              ┌──────────────────┐
         │                  ┌───────┐          │ Records traced   │
         ▼                  │  No   │          │ from location to │
┌─────────────────────┐     └───────┘          │ the department   │
│ New patient records │         │              │ (on PAS)         │
│ traced to the       │         ▼              └──────────────────┘
│ department on PAS   │  ┌──────────────┐               │
└─────────────────────┘  │ Patient      │               ▼
         │               │ records      │     ┌──────────────────┐
         │               │ completed and│◀────│ Referral letter  │
         │               │ present in   │     │ from GP with     │
         │               │ the          │     │ consultant's     │
         └──────────────▶│ department   │     │ details added to │
                         └──────────────┘◀────│ it is appended   │
                                │             │ to the patient   │
                                ▼             │ records          │
                         ┌──────────────┐     └──────────────────┘
                         │ Urgent       │
                         │ consultation │
                         │ appointment  │
                         └──────────────┘
                                │
                                ▼
```

```
                                    Yes          No
```

Patient records returned to Medical Records department or any other requesting department

New appointment date added to bottom of GP letter in Notes, as well as any DNA data

Patient records held in the ENT department

Short time before the appointment date (1 week), the patient records are recalled to the department: traced to the department on the PAS

Patient records updated as to the new appointment

Letter sent to the GP

GP informed that the patient does not want further appointment

Patient records arrive at the ENT department for the appointment

Another appointment made by receptionist on PAS and letter generated

Yes   No

Letter sent to the patient with new appointment details

Yes   No

Patient wants another appointment

Patient records in the ENT department ready for Patients appointment

Suspected complaint of a serious nature, receptionist checks patient records

Yes

Appointment given cancelled

No

Nurse checks patient records before clinic, in case any special patient treatment requirements are recognised

Patient arrives for the appointment

Yes   No

Appointment date arrives

Patient records and patient shown into consultation room

Patient maintains the given appointment

Appointment removed from the existing pending list on PAS

Consultant sees patient and has patient records as desired for the appointment

Go to B3

B3 Patient consultation

Receptionist checks patient's address and details with those in records and on PAS → Records and PAS data updated if required and records passed to nurse → Records placed in clinic order and kept on table outside consulting room → Nurse checks through and reads records before patient goes in (consultant informed if anything in records felt to be relevant)

Patient arrives for appointment at clinic as desired → Patient details checked at reception on arrival → Patient waits to see consultant → Patient and records taken into consultant's room

Nurse may leave or stay (generally nurse remains outside consulting room with door open)

Data recorded in the patient records according to the consultants usual style ← Patient volunteers information and the consultant makes appropriate notes on continuation sheets in ENT section of the patient records ← Patient interviewed by consultant ← Consultant views records, especially letter of referral

Patient may be examined by the consultant → Consultant records any further appropriate data on continuation sheets in ENT section → Consultant discusses views and findings with patient → Course of action agreed between Patient and Consultant

Nurse records outcome / progress on the clinic sheet and directs patient as required ← Nurse asks patient about progress / outcome and actions required. Equally, checks patient understands what is to happen to them ← Patient leaves room having been informed of action to be taken ← Consultant updates records on ENT continuation sheets as required

All patients should inform the reception desk as to all consultation outcomes / progress / further actions required so the appropriate data can be recorded and if necessary actions initiated

Numerous possible care actions may be required

Records remain in the consulting room until the end of the clinic

Go to B4 – B5

Consultation outcomes

Further care from other departments as part of ENT consultation

Go to B6 – B10

B4 Consultation care actions (further care: required from another department via OP as part of current consultation)

The consultation care actions necessary are that another HCE department is required to provide care in some form (e.g. a clinical test) as part of the ENT consultation, and that the care is provided via OP → Consultant informs patient that further data is required as part of the current consultation and that this will be generated via OP → Consultant selects the appropriate clinical test request form

Nurse records patient name and details, clinical tests requested, date, and requesting Consultant in the "Investigation Book" ← Nurse notes outcome on clinic sheet and enters test requests made in the "Investigation Book" ← Consultant enters clinical test required on the clinical test request form ← Consultant fills out some test request form details

Patient informs reception as to need for further data ← Nurse completes clinical test request form and directs patient as required ← Nurse asks patient what is to happen to them as they leave the room ← Consultant gives request form to patient and patient leaves the room

Consultant updates the patient records as required and notes tests requested

Reception note this and direct the patient to the appropraite department (OP) → Patient directed to Out Patients department where the clinical test samples will be taken

Consultant dictates any required instructions to the secretary

Reception at OP organise the performing of the patients sample abstraction ← Patient goes to the OP with clinical test request form

Sample label data entered by the Clinician abstracting sample

Patient records placed on one side in then consulting room until the end of the clinic

Sample fully labelled as appropriate (patient name, hospital number, analysis required, etc.) and placed in a test request sample packet with the sample request form → Details on request form and sample checked before sample packet placed in mail → Sample packet placed in the internal mail system and taken by the porters to the appropriate clinical services department

```
                                            ↓                              ↓
┌──────────────┐  ┌──────────────┐  ┌──────────────────┐  ┌──────────────┐
│ Details      │  │ Test         │  │ Appropriate      │  │ Secretary    │
│ checked      │←─│ requested    │←─│ clinical services│  │ collects all │
│ as required  │  │ performed as │  │ department       │  │ patient      │
│ throughout   │  │ desired and  │  │ receives the     │  │ records at   │
│ tests and    │  │ results      │  │ patient's test   │  │ the end of   │
│ analysis     │  │ required     │  │ sample and       │  │ the clinic   │
│ procedures   │  │ obtained     │  │ request form     │  │ and takes    │
└──────────────┘  └──────────────┘  │ together in the  │  │ appropriate  │
                                     │ test request     │  │ action in    │
┌──────────────┐  ┌──────────────┐  │ sample packet    │  │ accordance   │
│ Report sent  │  │ Test report  │  └──────────────────┘  │ with the     │
│ in the       │  │ generated -  │                        │ dictated     │
│ internal     │  │ results      │  ┌──────────────────┐  │ dictaphone   │
│ mail system  │←─│ checked -    │  │ Results may be   │  │ details      │
│ to the ENT   │  │ test results │  │ seen before all  │  └──────────────┘
│ department   │  │ authenticated│  │ outstanding      │
└──────────────┘  │ - and report │  │ results are back │
                  │ sent to the  │  │ if Patient is    │
                  │ requesting   │  │ urgent !         │
                  │ consultant   │  └──────────────────┘
                  └──────────────┘
┌──────────────┐  ┌──────────────┐  ┌──────────────────┐  ┌──────────────┐
│ ENT          │  │ ENT          │  │ Test results     │  │ Patient      │
│ reception    │  │ reception log│  │ passed to the    │  │ records held │
│ receive the  │─→│ receipt of   │─→│ consultant's     │  │ by secretary │
│ test results │  │ the test     │  │ secretary        │  │ until all    │
│ in the mail  │  │ result in the│  └──────────────────┘  │ test results │
└──────────────┘  │ "Investigation│                       │ are returned │
                  │ Book"        │                        └──────────────┘
                  └──────────────┘
                         ↓
                  ┌──────────────┐  ┌──────────────┐    ┌─────┐
┌──────────────┐  │ Notes /      │  │ Other patient│    │ Yes │
│ Patient      │  │ "Investigation│ │ clinical test│───→└─────┘
│ records      │  │ Book" checked│→ │ results      │
│ returned to  │  │ to see if any│  │ outstanding  │   ┌──────────────┐
│ the reception│  │ other test   │  └──────────────┘   │ Patient      │
│ and traced   │  │ results are  │         │           │ records and  │
│ out, on PAS, │  │ outstanding  │      ┌─────┐         │ all          │
│ to the       │  └──────────────┘      │ No  │────────→│ investigation│
│ medical      │                        └─────┘         │ results given│
│ records      │                                        │ to the       │
│ department   │                                        │ consultant   │
└──────────────┘                                        │ to asses     │
                  ┌──────────────┐                      └──────────────┘
┌──────────────┐  │ Secretary    │  ┌──────────┐  ┌──────────────┐
│ Copy of GP   │  │ collects     │  │ Dictates │  │ Consultant   │
│ letter       │  │ records with │  │ required │  │ determines   │
│ appended to  │←─│ test results │←─│ action on│←─│ action       │
│ patient ENT  │  │ appended in  │  │ dictaphone│ │ required for │
│ records      │  │ "Clinical    │  └──────────┘  │ the Patient  │
│ section      │  │ Investigation│                └──────────────┘
└──────────────┘  │ Section" and │
                  │ tapes from   │
┌──────────────┐  │ consultant   │
│ Consultant   │  │ and generates│
│ checks and   │  │ required data│  ┌──────────────────┐
│ signs the    │  └──────────────┘  │ Further          │
│ letters      │                    │ consultation     │
└──────────────┘                    │ appointment      │
                                     │ required         │
┌──────────┐ ┌──────────┐ ┌────────┐ └──────────────────┘
│ Letter to│ │ Letter to│ │ Patient│          ↑
│ GP       │ │ patient  │ │ discharged       │
│ generated│ │ generated│ └────────┘
└──────────┘ └──────────┘
                          ┌─────┐  ┌─────┐
                          │ Yes │  │ No  │
                          └─────┘  └─────┘
                                        ↓
```

```
                                          │
                                          ▼
                              ┌──────────────────────┐        ┌──────────────────────┐
                              │    Further ENT       │        │    Informative       │
                              │    consultation      │        │   letter for the     │
                              │ appointment required │        │     GP may be        │
┌──────────────────┐         └──────────────────────┘        │  required, if so     │
│   Referral to    │                    │                    │   appended to        │
│  another HCE     │       ┌──────┐     ▼       ┌──────┐      │    records           │
│  consultant or   │◄──────│  No  │◄────────────│ Yes  │      └──────────────────────┘
│   department     │       └──────┘             └──────┘                 ▲
└──────────────────┘                              │                      │
                                                  ▼                      │
                                     ┌──────────────────────┐   ┌──────────────────────┐
                                     │  Secretary makes     │   │      Letter          │
                                     │   appropriate        │──►│  generated for       │
                                     │  appointment on      │   │  patient on PAS      │
                                     │      PAS             │   └──────────────────────┘
                                     └──────────────────────┘             │
                                                  │                       ▼
                                                  ▼           ┌──────────────────────┐
                                     ┌──────────────────────┐ │   Letter sent to     │
                                     │ Records returned to  │ │  the patient as      │
                                     │ reception - may be   │ │    required          │
                                     │ held or returned to  │ └──────────────────────┘
                                     │ medical records and  │
                                     │ traced out on PAS,   │
                                     │ depending on         │
                                     │ urgency of the       │
                                     │ appointment          │
                                     └──────────────────────┘
```

B5 Consultation care actions
(further care: required from another HCE department)

```
As part of the                Consultant informs          Consultant
consultation further care     patients of need for        selects the
is required from another  →   further care (in the    →   appropriate X-
HCE department (e.g.          form of an X-ray to         ray request
X-ray from Radiology)         provide more                form
                              information)
```

```
Nurse notes required                                                    X-ray request
investigation details in the    Nurse records      Consultant enters    form is
"Investigations Book", i.e.  ← request on clinic  ← X-ray examination  ← completed
Patient name, test requested   sheet               required and signs   partially by
and requesting consultant                          request form         consultant
```

```
Nurse completes        Nurse asks patient      Patient leaves the      Request
request form details ← about progress of    ← consulting room      ←  form given
                       consultation and                               to patient
                       what the consultant
                       has told them
```

```
Completed request form        Patient goes to the         Reception record the care
returned to the patient       reception to report what    actions defined (i.e. that
and patient is directed to →  has happened in the      →  patient is sent for X-ray)
reception                     consultation
```

```
                    Same day X-ray
     Yes         ←  wet- film         →   No    →   Consultant updates
                    appointment                     patient records as to
                                                    consultation
                                                    progress (i.e. X-ray
                                                    request)
```

```
Consultant records                 X-ray request taken
details in patient                 from patient and sent to
records and waits for              radiology internally        Consultants dictates
X-ray to come back                                             required actions to
                                                               the secretary on
                                                               dictaphone
```

```
Records placed on side in          Radiology give patient
the consulting room until          appropriate appointment
the results are returned           and inform patient by
                                   letter
```

```
┌─────────────────────┐                              ┌──────────────────────┐                    ┌─────────────────────┐
│  Patient arrives at │                              │                      │                    │   Consultant puts   │
│ Radiology for X-ray │◄──────────────┐              │                      │                    │  records on one side│
│  as requested on the│               │              │                      │                    │  until end of clinic│
│     request form    │               │              │                      │                    │                     │
└─────────────────────┘               │              │                      │                    └─────────────────────┘
           │                          │              │                      │                               │
           ▼                          │              │                      │                               ▼
┌─────────────────────┐     ┌─────────────────────┐  │   ┌─────────────────┐              ┌──────────────────────┐
│ Wet-film X-ray      │     │ Patient returns with│  │   │ "Investigations │              │ Secretary collects   │
│ performed - X-      │     │ film and is seen by │  │   │ book" entry     │              │ records and tapes at │
│ ray returned to     │────►│ consultant who      │  │   │ confirmed as    │              │ end of clinic        │
│ the Consultant      │     │ assesses the film   │  │   │ finished        │              └──────────────────────┘
│ without being       │     └─────────────────────┘  │   └─────────────────┘                         │
│ reported on         │                │             │                                               ▼
└─────────────────────┘                ▼             │                                  ┌──────────────────────┐
                              ┌─────────────────────┐│                                  │ Appropriate data     │
                              │ Consultant receives ││                                  │ added to patient     │
                              │ the X-rays          ││                                  │ records              │
                              └─────────────────────┘│                                  └──────────────────────┘
                                       │             │                                             │
                                       ▼             │                                             ▼
┌─────────────────────┐     ┌─────────────────────┐ │                                  ┌──────────────────────┐
│ Patient records     │     │ Patient records     │ │                                  │ Records retained in  │
│ updated as to       │◄────│ retrieved, X-rays    │◄┘                                  │ department for arrival│
│ action required     │     │ viewed, and          │◄──────────────────────────────────│ of X-ray results     │
└─────────────────────┘     │ decision made as to  │                                   └──────────────────────┘
           │                │ appropriate action   │
           ▼                └─────────────────────┘
┌─────────────────────┐
│ Consultant          │               ┌─────────────────────┐
│ dictates outcome    │               │ Consultation may now│
│ to dictaphone       │               │ have an outcome (e.g.│
└─────────────────────┘               │ discharge)          │
           │                          └─────────────────────┘
           ▼                                     ▲
┌─────────────────────┐  ┌─────────────┐  ┌─────────────────────┐
│ Secretary collects  │  │ Secretary   │  │ Number of possible  │
│ the notes and the   │  │ generates   │  │ care actions are    │
│ dictaphone tapes    │─►│ required    │─►│ required depending  │
│ at the end of the   │  │ data        │  │ on the patient data │
│ clinic session      │  └─────────────┘  │ gained              │
└─────────────────────┘                   └─────────────────────┘
                                                     │
                                                     ▼
                              ┌──────────────────────────────────────┐
                              │ Further data may be required as part  │
                              │ of the consultation such as another   │
                              │ clinical test from another HCE         │
                              │ department (e.g. ECG)                  │
                              └──────────────────────────────────────┘
```

B6 Consultation care actions (outcome: discharge)

```
┌─────────────────┐    ┌─────────────────┐    ┌─────────────────┐    ┌─────────────────────┐
│ Further care    │    │ No treatment,   │    │ Patient informed│    │ Patient leaves the  │
│ actions         │    │ or further      │    │ by the consultant│   │ consulting room and │
│ required. Outcome│─→ │ treatment, felt │─→  │ as to the       │─→  │ informs nurse of    │
│ of consultation is│  │ to be required  │    │ outcome         │    │ outcome at door     │
│ discharge       │    │                 │    │                 │    │ (nurse notes        │
│                 │    │                 │    │                 │    │ discharge on clinic │
│                 │    │                 │    │                 │    │ sheet)              │
└─────────────────┘    └─────────────────┘    └─────────────────┘    └─────────────────────┘
```

- Further care actions required. Outcome of consultation is discharge
- No treatment, or further treatment, felt to be required
- Patient informed by the consultant as to the outcome
- Patient leaves the consulting room and informs nurse of outcome at door (nurse notes discharge on clinic sheet)

- Consultant finishes entering the appropriate notes into the patient records on ENT continuation sheets

- Secretary works through all the different sets of patient records as required with directions on dictaphone
- At end of clinic secretary collects all patient records and Dictaphone tape / s and takes them to his / her office
- Consultant dictates required details of outcome to a dictaphone

- For patients requiring either no treatments or no further treatment
- Secretary types up dictated audio tapes and produces the required data
- Secretary produces the GP's letter
- Patient records placed out of the way with other seen patient records within the consulting room

- *No letters are sent to the patients unless they are In-Patients, when they will get a Discharge letter*
- Secretary puts copy of GP letter in ENT records
- Consultant checks details in letter and signs it
- Patient goes to reception desk and informs them of the discharge outcome

- Patient records returned to Medical Records - traced out on PAS
- Completed patient records passed by secretary to reception
- Secretary sends letter to the GP
- Patient discharged

- Reception check discharge data in records with discharge outcome given by patient and noted on clinic sheet
- Reception notes outcome of consultation on the clinic sheet

B6 Consultation care actions (outcome: discharge)

```
┌──────────────────┐   ┌──────────────┐   ┌──────────────┐   ┌────────────────────────┐
│ Further care     │   │ No treatment,│   │ Patient      │   │ Patient leaves the     │
│ actions required.│──▶│ or further   │──▶│ informed     │──▶│ consulting room and    │
│ Outcome of       │   │ treatment,   │   │ by the       │   │ informs nurse of       │
│ consultation is  │   │ felt to be   │   │ consultant   │   │ outcome at door (nurse │
│ discharge        │   │ required     │   │ as to the    │   │ notes discharge on     │
│                  │   │              │   │ outcome      │   │ clinic sheet)          │
└──────────────────┘   └──────────────┘   └──────────────┘   └────────────────────────┘
```

Further care actions required. Outcome of consultation is discharge → **No treatment, or further treatment, felt to be required** → **Patient informed by the consultant as to the outcome** → **Patient leaves the consulting room and informs nurse of outcome at door (nurse notes discharge on clinic sheet)**

Consultant finishes entering the appropriate notes into the patient records on ENT continuation sheets

Consultant dictates required details of outcome to a dictaphone

At end of clinic secretary collects all patient records and Dictaphone tape / s and takes them to his / her office

Secretary works through all the different sets of patient records as required with directions on dictaphone

For patients requiring either no treatments or no further treatment

Secretary types up dictated audio tapes and produces the required data

Secretary produces the GP's letter

Patient records placed out of the way with other seen patient records within the consulting room

No letters are sent to the patients unless they are In-Patients, when they will get a Discharge letter

Secretary puts copy of GP letter in ENT records

Consultant checks details in letter and signs it

Patient goes to reception desk and informs them of the discharge outcome

Patient records returned to Medical Records - traced out on PAS

Completed patient records passed by secretary to reception

Secretary sends letter to the GP

Patient discharged

Reception check discharge data in records with discharge outcome given by patient and noted on clinic sheet

Reception notes outcome of consultation on the clinic sheet

B7 Consultation care actions
(outcome: pharmacy and discharge)

```
┌─────────────────────┐     ┌──────────────────┐     ┌──────────────────────┐
│ Possible consultation│    │ Patient informed by│   │ Consultant writes the│
│ care actions. Outcome│    │ the consultant as to│  │ prescription on HCE  │
│ of consultation is that│→ │ the consultation  │ → │ pharmacy prescription│
│ patient requires    │     │ outcome          │    │ forms - signs it and hands it│
│ medication from     │     └──────────────────┘    │ to the Patient       │
│ pharmacy and can be │                              └──────────────────────┘
│ discharged          │
└─────────────────────┘
```

Possible consultation care actions. Outcome of consultation is that patient requires medication from pharmacy and can be discharged → Patient informed by the consultant as to the consultation outcome → Consultant writes the prescription on HCE pharmacy prescription forms - signs it and hands it to the Patient

Patient leaves the consulting room with the prescription and goes to the reception where outcome is recorded. Patient goes to the HCE pharmacy for the prescription ← Nurse checks outcome as patient leaves the room and notes outcome on clinic sheet. Patient directed as required ← Patient leaves consulting room with the HCE pharmacy prescription

Secretary works through all the different sets of patient records as required with directions on dictaphone ← At end of clinic secretary collects all patient records and dictaphone tape / s and takes them to his / her office ← Consultant dictates required details of outcome to dictaphone ← Consultant finishes entering the appropriate data into the patient records and notes the prescription given

Patient records placed out of the way with other seen patient records within the consulting room

For patients requiring no further treatment beyond the drugs prescribed → Secretary types up dictated audio tapes and produces the required data → Secretary produces the GP's letter

Consultant checks details in letter and signs it

Patient records returned to medical records - traced out on PAS

Secretary passes notes to the reception and outcome in records checked against reception clinic sheet ← Secretary places copy of GP letter in the patients records (ENT section) ← Signed letter returned to the secretary → Secretary sends letter to the GP

Patient discharged

B8 Consultation care actions
(outcome: pharmacy treatment and further follow-up appointment)

Result of consultation is that patient requires medication and another follow-up appointment in the ENT department	Patient informed by the consultant as to the outcome (i.e. drugs and another appointment required)	Patient told by consultant when to request the follow-up appointment for (patient requests appointment at reception)	Consultant writes the HCE pharmacy prescription as required and records when the patient should be seen again (rough indication recorded by consultant)

Patient goes to the HCE Pharmacy for the prescription	Patient goes to reception to get an appropriate next appointment	Nurse checks outcome as patient leaves, notes outcome on clinic sheet and directs patient as required	Patient leaves the consulting room with the prescription

Secretary works through all the different sets of patient records as required with directions on dictaphone	At end of clinic secretary collects all patient records and dictaphone tape / s and takes them to his / her office	Consultant dictates required details (if any) of outcome to a dictaphone	Consultant finishes entering the appropriate data into the patient records

For patients requiring a further appointment and medication	Secretary types up any dictated audio tapes and produces any required data	Secretary produces letter for the GP	Patient records placed out of the way with other seen patient records within the consulting room

Patient records retained within the department ready for next appointment	Patient records returned to medical records (traced on PAS)	Patient on pending list for next appointment	Consultant checks and signs the GP letter
Yes / No		Secretary posts letter to the GP	Checked letter returned to the secretary
Urgent appointment (next 2-3 weeks)	Reception reference PAS and patient records to check that urgency of next appointment corresponds	Patient records returned to the reception	Secretary appends copy of GP letter to the patient records

B9 Consultation care actions
(outcome: departmental referral)

```
Reception note          Patient directed to          Nurse asks Patient as to outcome, and
outcome on clinic   ◄── the reception desk   ◄──     notes outcome on Clinic Sheet
sheet
```

```
Possible consultation       Patient requires no       Patient informed       Patient leaves the
care actions.               immediate                 of required            consultation room
Outcome is referral to  ──► treatment but        ──► referral and      ──►
another HCE                 referral to another       planned future                    │
department for              HCE department            actions                           ▼
treatment                   for a consultation                               Consultant enters
                            and or treatment                                 data in the patient
                                                                             records as
                                                                             appropriate
```

```
Secretary works          At the end of the        Consultant dictates           │
through all the          clinic the secretary     to Dictaphone                 ▼
different patient    ◄──  collects all the         required action for      Patient records put
records as directed      patient records and      the Patient Referral  ──► to one side until
by the details on        tapes from the                                      the clinic finishes
the dictaphone           consulting room
     │                   and takes them to
     ▼                   his / her office     ◄──────────────────────────────────┘
```

```
For Patients requiring a                                                         Referral
departmental referral        Secretary          Letter to consultant            consultation is
and no immediate ENT    ──►  produces the   ──► or department         ──►        urgent
treatment                    required data       requesting referral                 │
                                 │               produced                            ▼
                                 ▼                                                  Yes
                             Letter for GP       GP letter signed                    │
                             produced       ──►  by the consultant                   ▼
Patient records traced                                                         Referral request
out from ENT to              Department to which patient is        No          letter signed by
referral department          referred is responsible for                      ENT Consultant
on PAS                       giving the patient the                                  │
     ▲                       appointment and writing to the                         ▼
     │                       patient                                           Secretary
Reception sends patient          ▲                                             collects signed
records to appropriate           │              Secretary sends          ◄──  letter from
referral department          Secretary puts copies    letters in mail         consultant
     ▲                       of GP's letter and   ◄──
     │                       referral request letter in
Secretary passes        ◄──  the patients records
patient records to           (ENT section)
reception
```

B10 Consultation care actions
(outcome: Out Patients treatment or procedure)

```
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Consultation may    │     │ Consultant "STAMPS" │     │ Consultant          │
│ result in patient   │────▶│ the ENT continuation│────▶│ enters required     │
│ being referred to   │     │ sheets with the OP  │     │ data into stamp     │
│ the Out Patients    │     │ stamp               │     │ spaces              │
│ department for      │     └─────────────────────┘     └─────────────────────┘
│ treatment           │
└─────────────────────┘
```

```
┌─────────────────────┐     ┌─────────────────────┐     ┌──────────────────────────────┐
│ Nurse asks patient  │◀────│ Patient leaves the  │     │ OP Procedure required,       │
│ what has happened   │     │ consulting room     │     │ requesting consultant, who   │
│ in the consultation │     └─────────────────────┘     │ can perform the procedure,   │
└─────────────────────┘                                 │ urgency of operation, In     │
                                                         │ Patient / Day Case / Plym    │
                                                         │ Day Case Unit, general /     │
                                                         │ local anaesthetic, sort      │
                                                         │ notice telephone number,     │
                                                         │ tests required, and any      │
                                                         │ other comments               │
                                                         └──────────────────────────────┘
```

```
┌─────────────────────┐     ┌─────────────────────┐
│ Outcome of OP       │     │ Consultant dictates │
│ referral recorded   │     │ required actions to │
│ on the clinic sheet │     │ the dictaphone      │
└─────────────────────┘     └─────────────────────┘
```

```
┌───────────────┐  ┌─────────────────────┐  ┌──────────────────────────┐  ┌─────────────────────┐
│ Patient       │  │ Patient notes put   │  │ At the end of the clinic │  │ Secretary reads OP  │
│ directed to   │  │ on one side until   │─▶│ session the secretary    │─▶│ stamp data and      │
│ the reception │  │ the end of the      │  │ collects all the notes   │  │ generates required  │
└───────────────┘  │ clinic session      │  │ and the dictaphone tapes │  │ information         │
                   └─────────────────────┘  └──────────────────────────┘  └─────────────────────┘
```

```
┌───────────────┐  ┌─────────────────┐  ┌─────────────────────┐  ┌─────────────────────┐
│ Reception     │  │ Letter sent to  │◀─│ Letter checked and  │◀─│ Secretary generates │
│ note the      │  │ the GP          │  │ signed by the       │  │ letter to the GP    │
│ consultation  │  └─────────────────┘  │ consultant          │  └─────────────────────┘
│ outcome       │                       └─────────────────────┘
└───────────────┘
```

```
                                        ┌─────────────────────┐
                                        │ Copy of letter      │
                                        │ appended to the     │
                                        │ patients ENT        │
                                        │ record section      │
                                        └─────────────────────┘
```

```
┌─────────────────────┐              ┌─────────────────────┐
│ Patient leaves and  │              │ Urgent Out Patients │
│ waits to hear from  │              │ appointment         │
│ the HCE for the     │              └─────────────────────┘
│ OPPAd Clinic        │
│ appointment         │
└─────────────────────┘
```

```
┌─────────────────────┐     ┌──────┐  ┌──────┐     ┌─────────────────────┐
│ Secretary makes the │     │  No  │  │ Yes  │     │ Secretary passes    │
│ required            │◀────│      │  │      │────▶│ patient records to  │
│ appointments for    │     └──────┘  └──────┘     │ the admissions      │
│ the OutPatient      │                            │ office (traced on   │
│ treatment and the   │                            │ PAS)                │
│ OPPAd Clinic on PAS │                            └─────────────────────┘
└─────────────────────┘
```

Secretary generates the required 2 letters to the patient, one with details of the out patient appointment, and the other with the OPPAd clinic appointment on PAS

Appointment made on PAS for the out patient treatment and the OPPAd clinic

Admissions Officer checks notes and makes the required appointment

Admissions officer generates 2 letters of appointment to the Patient one with Out Patient appointment and one with the OPPAd Clinic appointment on PAS

Admissions officer puts the patient on the waiting list

Secretary returns the patients records to the admissions office (traced out on PAS)

Admissions office sends both letters of appointment to the patient

Patient records held in the admissions office until the date of the OPPAd clinic appointment

OPPAd = Out Patients Pre-Admission - these appointments are given 2 weeks prior to the Out Patient admission appointment

OPPAd clinic appointment (usually on a Wednesday afternoon)

OPPAd Clinic held in the ENT department - not the Out Patients department

Patient records sent from admissions office to the ENT department reception ready for appointment (traced out on PAS)

Patient arrives for appointment

Patient details checked with Patient Notes at Reception

Patient and patient records go with nurse to fill out the blue OPPAd clinic form

Junior Doctor enters some of the required patient details

Nurse enters / checks basic patient details - some details can be covered by the use of a PAS sticky label

```
        │                                                                    │
        ▼                                                                    ▼
┌─────────────────────┐   ┌─────────────────────┐        ┌─────────────────────┐
│ Doctor checks any   │   │ Doctor also checks  │        │ Nurse completes any │
│ medication,allergies,│  │ that the patient    │        │ other sections on the│
│ if they are fit enough│─▶│ understands what is │        │ blue OPPAd clinic   │
│ to have general     │   │ to be done and why  │        │ form as required    │
│ anaesthetic etc.    │   └─────────────────────┘        └─────────────────────┘
└─────────────────────┘                                             │
        │                                                           ▼
        ▼                                                  ┌─────────────────────┐
┌─────────────────────┐   ┌─────────────────────┐        │ Completed blue OPPAd │
│ Doctor ensures that │   │ Doctor completes the│        │ Clinic form and the │
│ the consent form is │   │ anaesthetists section│       │ Consent form are    │
│ completed and signed│──▶│ of the blue OPPAd   │──────▶ │ append to the ENT   │
│                     │   │ Clinic form (not    │        │ section of the      │
└─────────────────────┘   │ enough anaesthetists│        │ patients records    │
                          │ at Derriford for the│        └─────────────────────┘
                          │ OPPAdd Clinic       │                   │
                          │ sessions            │                   ▼
                          └─────────────────────┘        ┌─────────────────────┐
                                                          │ Patient records are │
┌─────────────┐   ┌──────┐   ┌──────────────┐            │ then sent to the    │
│ In Patient  │   │ Yes  │   │ In Patient   │◀──────────│ appropriate Patient │
│ sent to     │◀──│      │◀──│              │            │ treatment location  │
│ wards to be │   └──────┘   └──────────────┘            │ (traced out on PAS) │
│ admitted    │                    │                     │ until the patient's │
└─────────────┘                    ▼                     │ appointment date    │
      │                       ┌──────┐                   └─────────────────────┘
      ▼                       │ No   │
┌─────────────────┐           └──────┘
│ Patients arrive │               │
│ for their       │               ▼
│ appointments -  │   ┌─────────────────────┐   ┌─────────────────────┐
│ all details are │   │ Plym Day Case Unit  │   │ Patients arrive for │
│ quickly checked │   │ Patients - notes    │   │ their appointments  │
│ in records      │   │ sent to the Plym    │──▶│ all details are     │
└─────────────────┘   │ Day Case Unit - not │   │ quickly checked in  │
      │               │ a hospital ward     │   │ records             │
      ▼               └─────────────────────┘   └─────────────────────┘
┌─────────────────┐                                        │
│ Doctor quickly  │                                        ▼
│ chats to the    │                             ┌─────────────────────┐
│ patient and     │                             │ Doctor quickly chats│
│ checks that     │                             │ to the patient and  │
│ nothing has     │                             │ checks that nothing │
│ changed since   │                             │ has changed since   │
│ the OPPAd clinic│                             │ the OPPAd clinic    │
│ appointment     │                             │ appointment         │
└─────────────────┘                             └─────────────────────┘
      │                                                    │
      ▼                                                    ▼
┌─────────────────┐                             ┌─────────────────────┐
│ Patient prepared│                             │ Patient prepared for│
│ for treatment   │                             │ treatment           │
└─────────────────┘                             └─────────────────────┘
      │                                                    │
      ▼                                                    ▼
┌─────────────────┐   ┌─────────────────────┐   ┌─────────────────────┐
│ Treatment       │   │ Theatre system up   │   │ Treatment performed │
│ performed as    │◀──│ dated               │──▶│ as desired in       │
│ desired in      │   └─────────────────────┘   │ theatre             │
│ theatre         │                             └─────────────────────┘
└─────────────────┘                                        │
      │                                                    ▼
      ▼
```

```
                                      Patient and records        Patient returns from
Patient goes to Erme  ◀──────────     (traced out on PAS)        treatment to recover
ward to recover                       may be transferred         in the Plym Day
                                      to Erme Ward               Case Unit
        │                                                              │
        ▼                                                              ▼
Patient stays over  ◀──────────────────┐              ┌──────┐   Patient recovers
night on the ward                      │         No ◀─┤  No  │   as desired - same
        │              ┌──────┐        │              └──────┘   day
        │              │  No  │    ┌──────┐                            │
        ▼              └──────┘    │  No  │                            ▼
   ┌──────┐                │       └──────┘                       ┌──────┐
   │ Yes  │                ▼           ▲                          │ Yes  │
   └──────┘           Out Patient      │                          └──────┘
        │                                                              │
        ▼                                                              ▼
   In Patient                                                    Doctor assesses
   admission          Nurse completes                            patient and
        │             some details on the  ◀─────────────────    completes / signs
        ▼             discharge sheet                            the discharge sheet
Patient recovers as                                                   │
desired                                                               ▼
                                                                 Doctor
Sometimes the       One copy of       One copy of               determines if
copy may be sent    Discharge sheet   discharge sheet           follow-up
to GP if patient is ──▶ given to Patient   appended to the      appointment
liable to forget to    to give to GP      patient's ENT         required
do it etc.                                record section              │
                                                                      ▼
            Patient          ┌──────┐                           Follow-up
            discharged  ◀──── │  No  │ ◀──────────────────────  appointment
                             └──────┘                           required
                 │                                                    │
                 ▼                                                    ▼
            Patient records                                     ┌──────┐
            returned to the                                     │ Yes  │
            medical records and                                 └──────┘
            traced out on PAS                                        │
                                                                     ▼
                                                                Out patient
                                                                follow-up
                                                                appointment
                                                                request form
                                                                completed
                                                                     │
                                                                     ▼
```
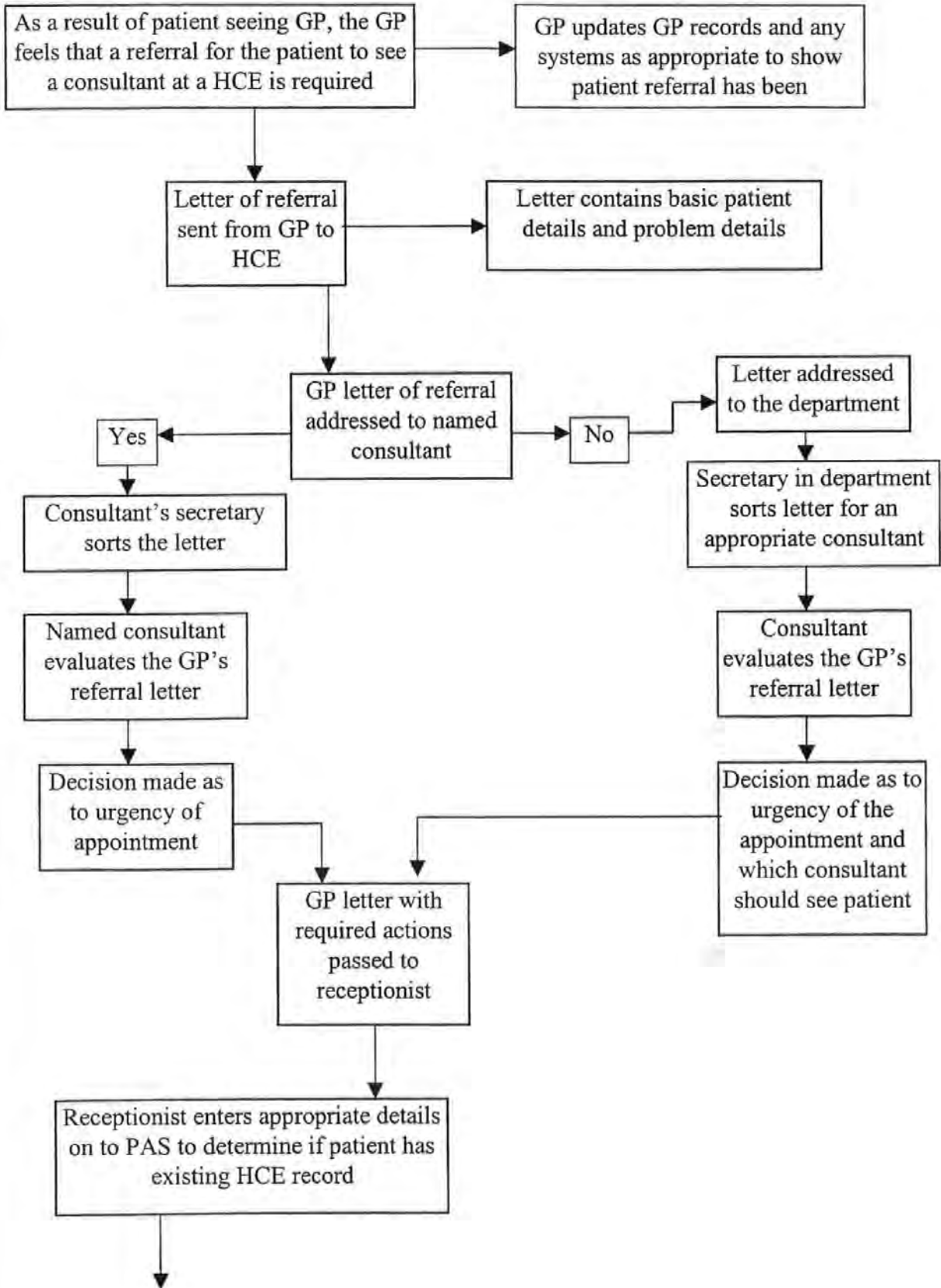
```
                                              ┌──────────────┐
                                              │  One copy of │
          ┌────────────────────┐              │ form sent to │
          │  One copy of form  │              │ the          │
          │  appended to the   │◄─────────────│ appointments │
          │ patient's records  │              │    office    │
          │ (fixed to cover of │              └──────┬───────┘
          │  patient record)   │                     │
          └────────────────────┘                     ▼
                                              ┌──────────────┐
   ┌───────┐      ┌──────────────┐            │ Reception of │
   │  Yes  │◄─────│  Follow-up   │◄───────────│ the named HCE│
   └───┬───┘      │ appointment  │            │  department  │
       │          │ date within  │            │ required to  │
       │          │   3 weeks    │            │     make     │
       ▼          └──────┬───────┘            │  appropriate │
┌──────────────┐         │                    │  follow-up   │
│Patient records│        ▼                    │ appointment  │
│  sent to the │      ┌──────┐                │    on PAS    │
│  appropriate │      │  No  │                └──────┬───────┘
│    (ENT)     │      └──┬───┘                       │
│  department  │         │                           │
│  for the     │         ▼                           ▼
│  follow-up   │   ┌──────────────┐           ┌──────────────┐
│ appointment  │   │ Records sent │           │   Reception  │
└──────┬───────┘   │   to the     │           │ generate and │
       │           │   medical    │           │ sent required│
       ▼           │  records     │           │   letter of  │
┌──────────────┐   │  until       │           │ appointment  │
│Records traced│   │ required for │           │ to the       │
│  out to ENT  │   │  follow-up   │           │   patient    │
│  department  │   │ appointment  │           └──────────────┘
│   on PAS     │   └──────┬───────┘
└──────────────┘          │
                          ▼
                   ┌──────────────┐
                   │Records traced│
                   │out to medical│
                   │ records on   │
                   │    PAS       │
                   └──────────────┘
```
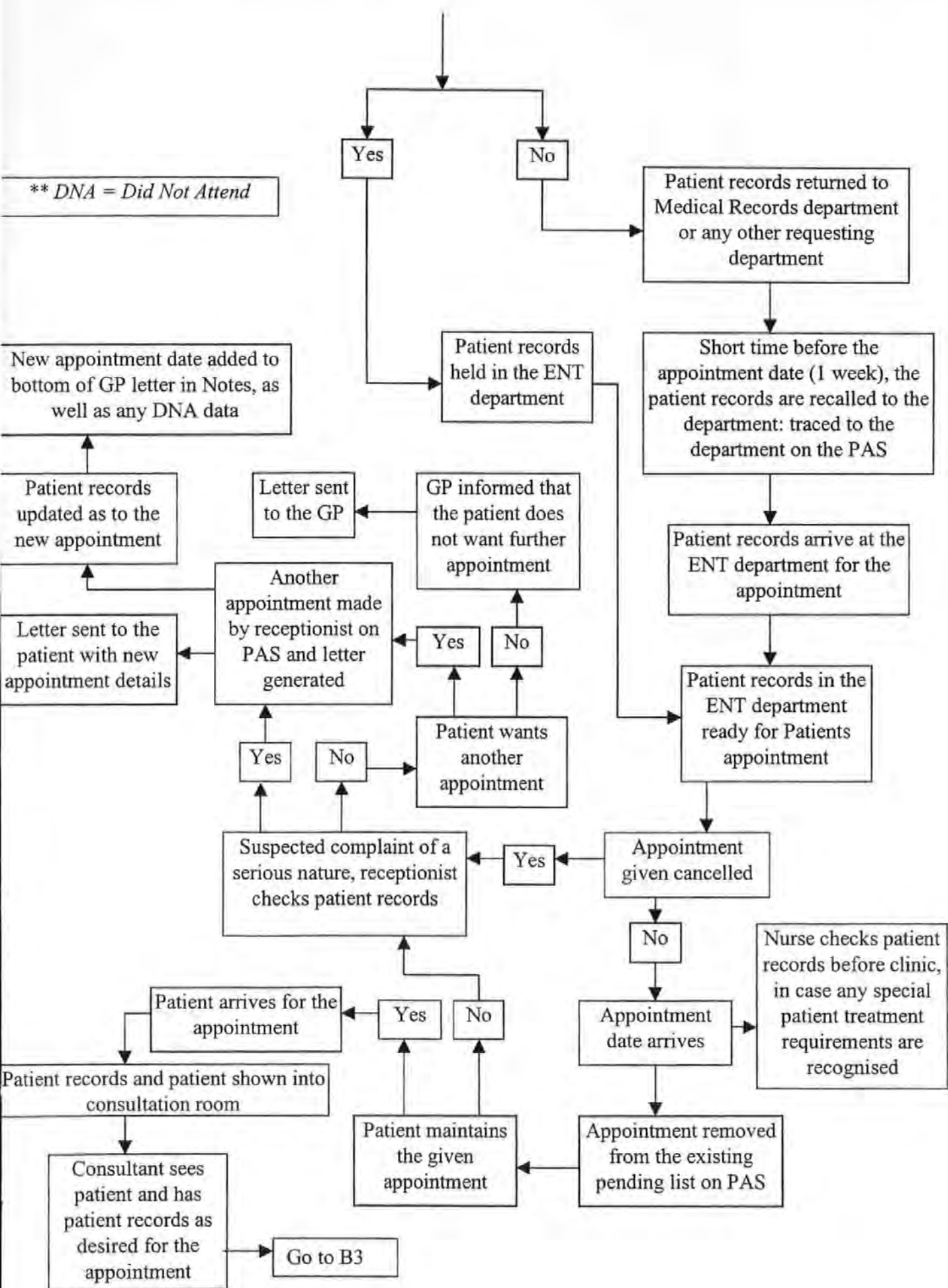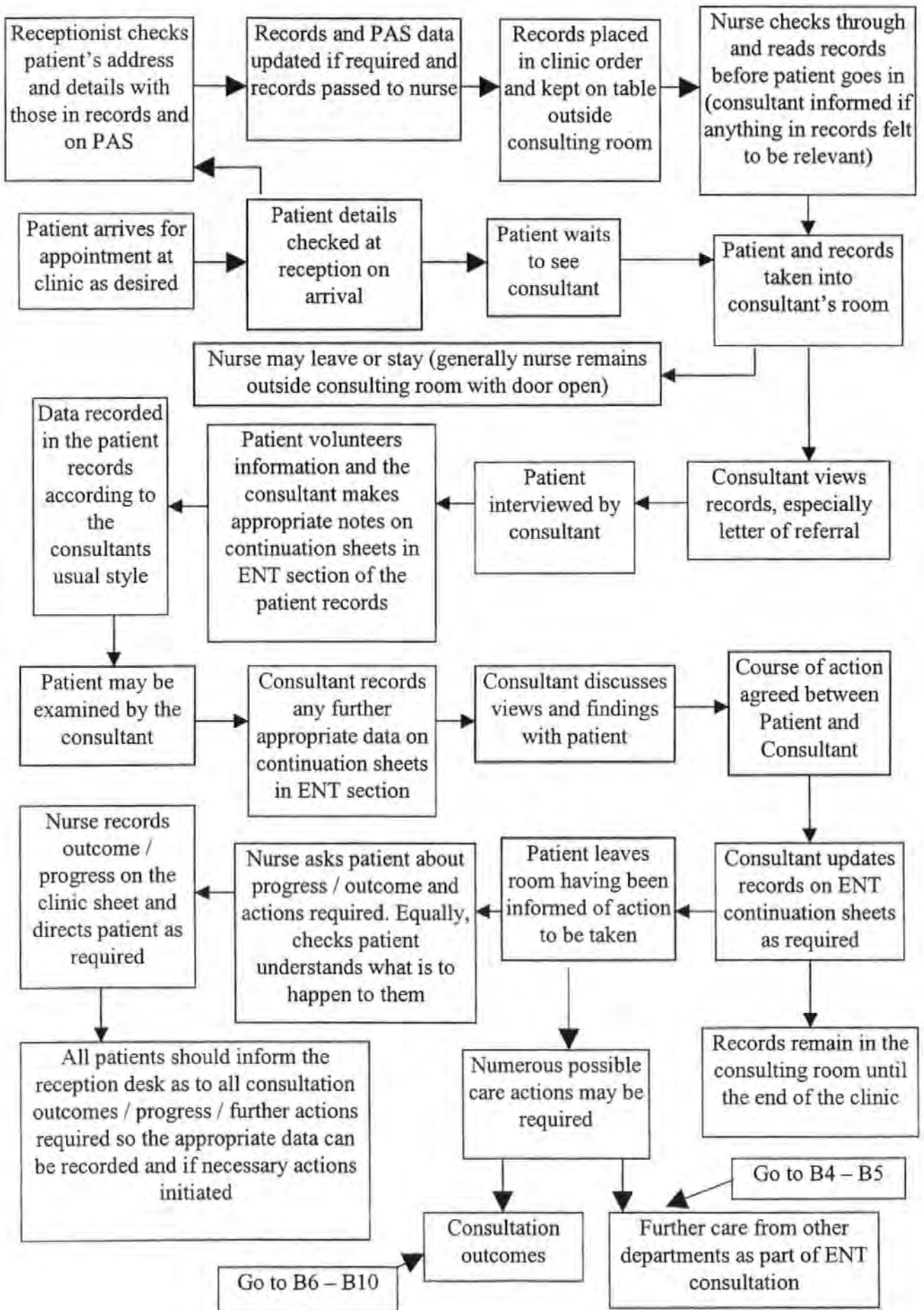
B10 Consultation care actions
(outcome: Out Patients treatment or procedure)

```
Consultation may          Consultant "STAMPS"         Consultant
result in patient being   the ENT continuation        enters required
referred to the Out  -->  sheets with the OP     -->  data into stamp
Patients department       stamp                        spaces
for treatment
```

```
Nurse asks patient what has   <--   Patient leaves the
happened in the consultation        consulting room
```

```
OP Procedure required,
requesting consultant, who can
perform the procedure, urgency
of operation, In Patient / Day
Case / Plym Day Case Unit,
general / local anaesthetic, sort
notice telephone number, tests
required, and any other
comments
```

```
Outcome of OP referral        Consultant dictates
recorded on the clinic        required actions to
sheet                         the dictaphone
```

```
Patient directed     Patient notes put on    At the end of the clinic session    Secretary reads OP
to the reception     one side until the end  the secretary collects  all the     stamp data and
                --> of the clinic session -->  notes and the dictaphone tapes  --> generates required
                                                                                    information
```

```
Reception note      Letter sent to the   <--   Letter checked and   <--   Secretary generates
the                 GP                          signed by the              letter to the GP
consultation                                    consultant
outcome
```

```
Copy of letter appended
to the patients ENT
record section
```

```
Patient leaves and waits to
hear from the HCE for the
OPPAd Clinic appointment
```

```
Urgent Out Patients
appointment
```

```
Secretary makes the
required appointments                            Secretary passes patient
for the OutPatient      <--  [No]   [Yes]  -->   records to the
treatment and the                                admissions office
OPPAd Clinic on PAS                              (traced on PAS)
```

```
                    │                                                           │
                    ▼                                                           ▼
┌─────────────────────────────────┐          ┌──────────────────┐   ┌────────────────────┐
│   Secretary generates the       │          │   Appointment    │   │ Admissions Officer │
│   required 2 letters to the     │          │ made on PAS for  │◄──│  checks notes and  │
│ patient, one with details of the│          │ the out patient  │   │  makes the required│
│  out patient appointment, and   │          │  treatment and the│  │    appointment     │
│   the other with the OPPAd      │          │   OPPAd clinic   │   │                    │
│ clinic appointment on PAS       │          └──────────────────┘   └────────────────────┘
└─────────────────────────────────┘                   │
                    │                                  ▼
                    │               ┌──────────────────────────────────┐  ┌──────────────────┐
                    ▼               │  Admissions officer generates 2  │  │    Admissions    │
┌─────────────────────────┐        │ letters of appointment to the Patient│ officer puts the │
│    Secretary returns the│        │ one with Out Patient appointment │──►│   patient on the │
│    patients records to  │        │  and one with the OPPAd Clinic   │  │   waiting list   │
│  the admissions office  │        │      appointment on PAS          │  └──────────────────┘
│    (traced out on PAS)  │        └──────────────────────────────────┘           │
└─────────────────────────┘                        │                              ▼
                    │                               │                  ┌──────────────────┐
                    │                               │                  │ Admissions office│
                    │                               ▼                  │ sends both letters of│
┌──────────────────────────┐        ┌──────────────────────┐          │  appointment to the │
│ OPPAd = Out Patients     │        │ Patient records held in │       │     patient      │
│ Pre-Admission - these    │        │  the admissions office  │       └──────────────────┘
│ appointments are given 2 │        │   until the date of the │
│ weeks prior to the Out   │        │      OPPAd clinic       │
│ Patient admission        │        │      appointment        │
│ appointment              │        └──────────────────────┘
└──────────────────────────┘                    │
                                                 ▼
              ┌──────────────────────────────────────┐    ┌──────────────────────────┐
              │ OPPAd clinic appointment (usually    │    │ OPPAd Clinic held in the │
              │     on a Wednesday afternoon)        │    │ ENT department - not the │
              └──────────────────────────────────────┘    │ Out Patients department  │
                │            │                             └──────────────────────────┘
                ▼            ▼
┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐
│  Patient records │  │ Patient arrives for│ │ Patient details  │  │ Patient and patient│
│  sent from       │  │   appointment    │ │ checked with     │  │ records go with nurse│
│  admissions office│─►│                  │─►│ Patient Notes    │─►│ to fill out the blue│
│  to the ENT      │  └──────────────────┘  │ at Reception     │  │ OPPAd clinic form │
│  department      │                        └──────────────────┘  └──────────────────┘
│ reception ready for│                                                      │
│  appointment     │                                                        ▼
│  (traced out on  │                                         ┌──────────────────────────┐
│      PAS)        │      ┌──────────────────────────┐       │ Nurse enters / checks basic│
└──────────────────┘      │ Junior Doctor enters some of│◄───│ patient details - some details│
                          │  the required patient details│   │ can be covered by the use of│
                          └──────────────────────────┘       │   a PAS sticky label     │
                                        │                     └──────────────────────────┘
                                        ▼                                 │
                                                                          ▼
```

```
                                              Nurse completes any
Doctor checks any          Doctor also checks  other sections on the blue
medication, allergies, if  that the patient    OPPAd clinic form as
they are fit enough to have  understands what is  required
general anaesthetic etc.    to be done and why
```

```
                        Doctor completes the
Doctor ensures that the  anaesthetists section of the blue  Completed blue OPPAd
consent form is          OPPAd Clinic form (not  Clinic form and the
completed and signed     enough anaesthetists at  Consent form are append to
                         Derriford for the OPPAdd  the ENT section of the
                         Clinic sessions           patients records
```

```
In Patient sent to   Yes        In Patient          Patient records are then
wards to be                                          sent to the appropriate
admitted                                             Patient treatment location
                                                     (traced out on PAS) until
                              No                     the patient's appointment
                                                     date
```

```
Patients arrive for their     Plym Day Case Unit        Patients arrive for their
appointments - all            Patients - notes sent to the  appointments all details
details are quickly           Plym Day Case Unit - not  are quickly checked in
checked in records            a hospital ward           records
```

```
Doctor quickly chats to the                           Doctor quickly chats to
patient and checks that                               the patient and checks
nothing has changed since                             that nothing has
the OPPAd clinic                                      changed since the
appointment                                           OPPAd clinic
                                                       appointment
```

```
Patient prepared for                                  Patient prepared for
treatment                                             treatment
```

```
Treatment performed as    Theatre system up dated    Treatment performed as
desired in theatre                                    desired in theatre
```

```
                              ┌──────────────────────┐                    ┌──────────────────────┐
                              │ Patient and records  │                    │ Patient returns from │
  ↓                           │ (traced out on PAS)  │                    │ treatment to recover │
┌──────────────────────┐     │ may be transferred   │                    │ in the Plym Day      │
│ Patient goes to Erme  │ ◄───│ to Erme Ward         │                    │ Case Unit            │
│ ward to recover       │     └──────────────────────┘                    └──────────────────────┘
└──────────────────────┘                                                            │
           │                                                                         ▼
           ▼                                                         ┌─────┐  ┌──────────────────────┐
┌──────────────────────┐                                            │ No  │◄─│ Patient recovers     │
│ Patient stays over    │◄──────────────────┐                        └─────┘  │ as desired - same    │
│ night on the ward     │                   │                                 │ day                  │
└──────────────────────┘         ┌─────┐    │        ┌─────┐                  └──────────────────────┘
           │                     │ No  │    │        │ No  │                            │
           ▼                     └─────┘    │        └─────┘                            ▼
      ┌─────────┐                   │       │           │                          ┌─────────┐
      │ Yes     │                   ▼       │           ▲                          │ Yes     │
      └─────────┘             ┌──────────┐  │           │                          └─────────┘
           │                  │ Out      │  │           │                               │
           ▼                  │ Patient  │  │           │                               │
┌──────────────────────┐      └──────────┘  │           │                               │
│ In Patient            │          │         │           │                               │
│ admission             │          │         │           │                               │
└──────────────────────┘          │         │           │                               │
           │                      │         │           │                               │
           ▼                      │         │           │                               │
┌──────────────────────┐          │   ┌──────────────────────┐  ┌──────────────────────┐
│ Patient recovers as   │──────────┴──►│ Nurse completes      │◄─│ Doctor assesses      │
│ desired               │              │ some details on the  │  │ patient and          │
└──────────────────────┘              │ discharge sheet      │  │ completes / signs    │
                                       └──────────────────────┘  │ the discharge sheet  │
                                                                 └──────────────────────┘
                                          │                                   │
           ┌──────────────────────────────┘                                   │
           ▼                                                                   │
┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐
│ Sometimes the    │  │ One copy of      │  │ One copy of      │  │ Doctor           │
│ copy may be sent │  │ Discharge sheet  │  │ discharge sheet  │  │ determines if    │
│ to GP if patient │─►│ given to Patient │  │ appended to the  │  │ follow-up        │
│ is liable to     │  │ to give to GP    │  │ patient's ENT    │  │ appointment      │
│ forget to do it  │  │                  │  │ record section   │  │ required         │
│ etc.             │  └──────────────────┘  └──────────────────┘  └──────────────────┘
└──────────────────┘                                                       │
                                                                           ▼
                 ┌──────────────┐  ┌─────┐  ┌──────────────────┐
                 │ Patient      │◄─│ No  │◄─│ Follow-up        │
                 │ discharged   │  └─────┘  │ appointment      │
                 └──────────────┘           │ required         │
                        │                   └──────────────────┘
                        ▼                            │
                 ┌──────────────────┐                ▼
                 │ Patient records  │           ┌─────────┐
                 │ returned to the  │           │ Yes     │
                 │ medical records  │           └─────────┘
                 │ and traced out   │                │
                 │ on PAS           │                ▼
                 └──────────────────┘      ┌──────────────────┐
                                           │ Out patient      │
                                           │ follow-up        │
                                           │ appointment      │
                                           │ request form     │
                                           │ completed        │
                                           └──────────────────┘
                                                    │
                                                    ▼
```

```
                                                              │
                                                              ▼
                              ┌──────────────────────┐   ┌──────────────────┐
                              │   One copy of form   │   │   One copy of     │
                              │    appended to the   │   │  form sent to the │
                              │ patient's records (fixed│◄─│   appointments   │
                              │   to cover of patient │   │      office      │
                              │       record)        │   └──────────────────┘
                              └──────────────────────┘            │
                                                                  ▼
                                                         ┌──────────────────┐
              ┌───────┐       ┌──────────────────┐       │ Reception of the │
              │  Yes  │◄──────│    Follow-up     │◄──────│    named HCE     │
              └───────┘       │ appointment date │       │   department     │
                  │           │  within 3 weeks  │       │ required to make │
                  ▼           └──────────────────┘       │   appropriate    │
        ┌──────────────────┐           │                 │    follow-up     │
        │  Patient records │           ▼                 │  appointment on  │
        │    sent to the   │      ┌─────────┐            │       PAS        │
        │    appropriate   │      │   No    │            └──────────────────┘
        │      (ENT)       │      └─────────┘                     │
        │  department for  │           │                         │
        │   the follow-up  │           ▼                         ▼
        │    appointment   │  ┌──────────────────┐      ┌──────────────────┐
        └──────────────────┘  │  Records sent to │      │    Reception     │
                  │           │   the medical    │      │ generate and sent│
                  ▼           │   records until  │      │ required letter of│
        ┌──────────────────┐  │   required for   │      │  appointment to the│
        │  Records traced  │  │    follow-up     │      │     patient      │
        │    out to ENT    │  │   appointment    │      └──────────────────┘
        │  department on   │  └──────────────────┘
        │       PAS        │           │
        └──────────────────┘           ▼
                              ┌──────────────────┐
                              │  Records traced  │
                              │  out to medical  │
                              │  records on PAS  │
                              └──────────────────┘
```
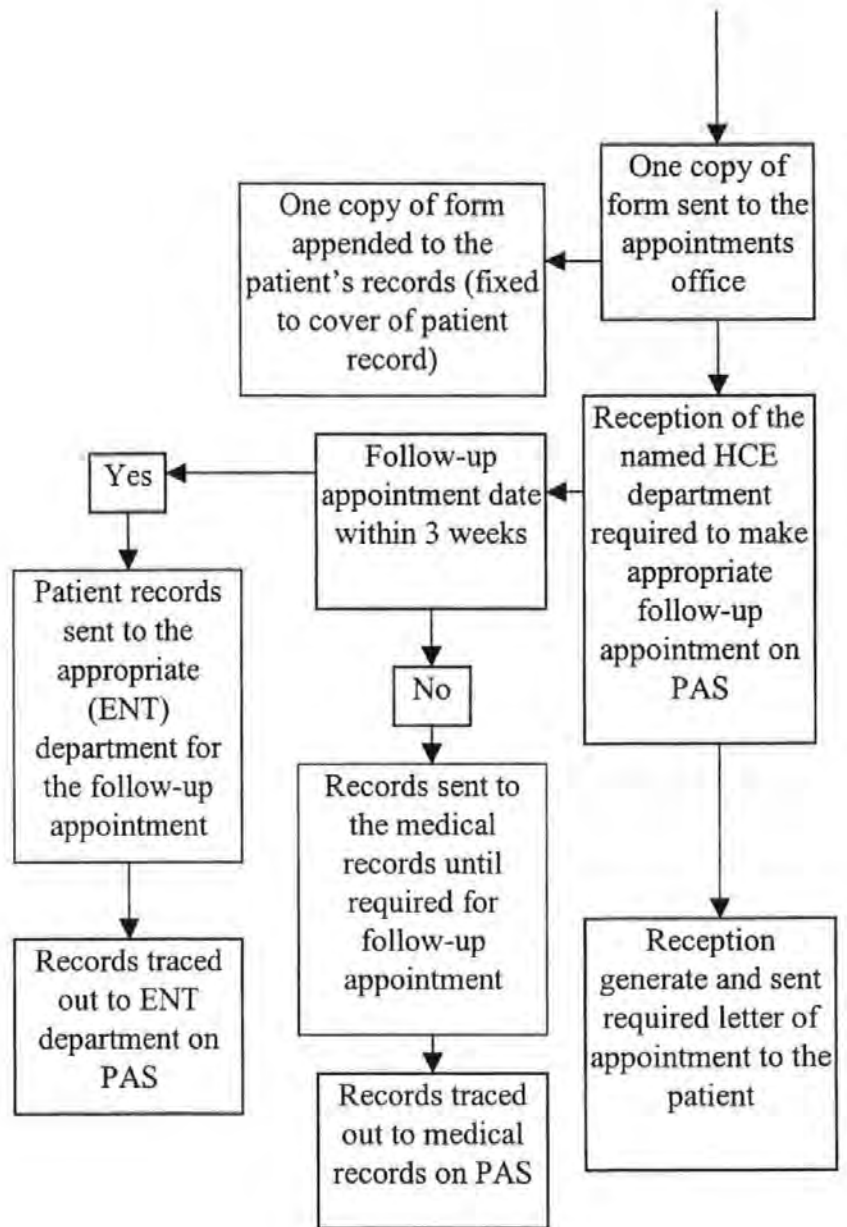
Appendix C

POSEIDON database structures

C.1 POSEIDON database

The actual items of data constituting the patient record were held in an Access database within a series of tables. The database contained three types of tables:

- definition - containing data for the defining of the patient;

- encounter - containing data detailing all the clinical data generated during encounters (also contain limited administration data);

- clinical - contain the actual clinical data generated (plus some administrative data).

There is a main patient definition table which uniquely defines the patient. All the other definition, encounter and clinical tables are indexed to this by the primary key (or master patient index), of the patient's hospital number. Within all the tables of the database data is held as a series of records. These are created as data is chronologically appended to the system.

The PI record section, and it constituent sub-sections, access data held by the system's definition tables as they present data concerning the patient's address, next of kin, GP details and personal circumstances, all of which enable the patient to be defined and administered.

Within the PI record section the system is required to present the most current patient details to the user. Thus when the PI records section and its constituent sub-sections are examined all the most current details are displayed as appropriate (i.e. the last

records added to the tables are presented). An overview of the presentation of the most current patient details within the PD sub-section is shown in Figure C1. Although the most current details are always displayed within all the PI sub-sections, all the records present within the appropriate tables can be viewed via the data manipulation pages, from the first record entered to the last.
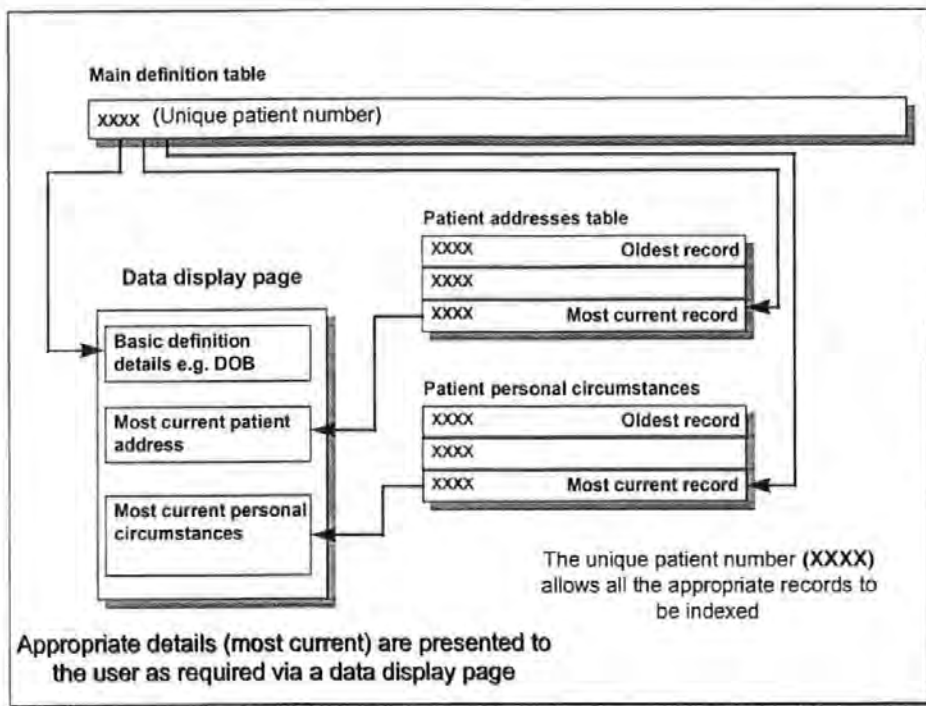
Figure C1 - Overview of the operation of the definition database tables

The records containing the data presented via the MH and PHC sub-sections is also held as a series of records in chronological order. Again they are all indexed to the main definition table via the master index (the patient's hospital number). However, within the system they are displayed in chronological order, usually being viewed in groups of three on screen. Figure C2 gives and overview of their display. Thus all

the patient's medication, procedural, conditions, private health care treatment and private health care insurance details can be viewed within the appropriate record sub-sections in chronological order.
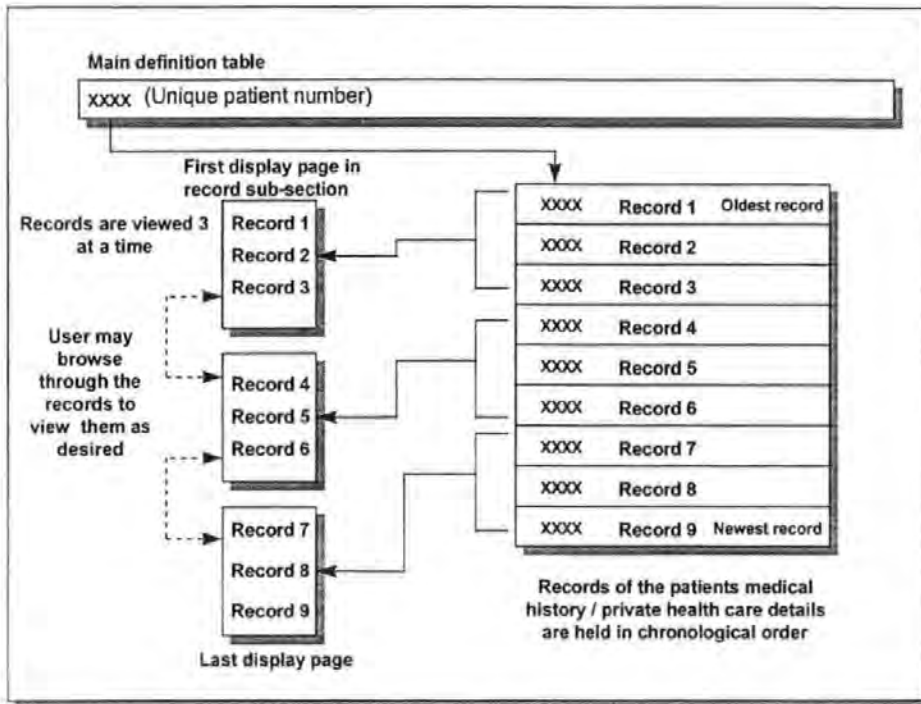
Figure C2 - Overview of the MH and PHC section database tables

The database also contains a main encounter table which uniquely identifies each patient encounter. It details the type of encounter (consultation or procedure), and the department responsible for the encounter's management. Other details such as the date, the type of referral and a unique encounter ID reference number are also present.

Each record in the main encounter table defines a hospital department responsible for the management of the encounter. Thus within the main departmental encounter table

of the appropriate managing department a corresponding record exists. This record uniquely identifies each departmental encounter or episode the patient has, and details all the items of patient data generated as part of the encounter.

The actual data constituting the clinical information of an encounter is held within a series of different indexed clinical database tables. Thus for each different type of clinical test, assessment, or treatment (e.g. Audiology test, ECG examination etc.) which may occur the clinical data generated (and the administrative data associated with it) is stored as a record within the appropriate clinical database table. Figure C3 shows an overview of this.
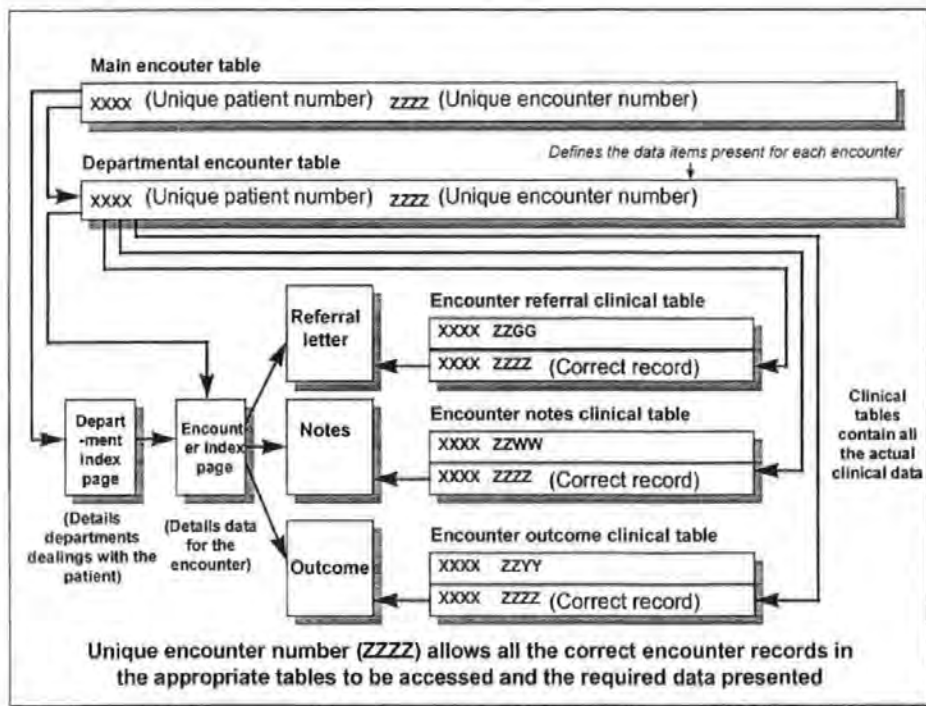
Figure C3 - Overview of the encounter and clinical database tables

To demonstrate the operation and interaction of the database tables, a patient encounter is described. When an appointment is given for a new encounter, such as an ENT consultation after a referral from a GP, a new record is created in the patient's main encounter table. The record has a unique encounter ID number, and details the type of encounter (procedure or consultation), the department responsible for managing the encounter (ENT), the encounter date, the encounter consultant and the type of encounter source (GP referral, self referral, on-going appointment etc.). All of these details are given to the system via the options selected and the data entered when the encounter is booked (i.e. appointment given).

As the encounter is created within the main encounter table, another unique record of the encounter is created within the appropriate department's main encounter table (here it would be the ENT department as this is the department managing the encounter). This table references all the encounters, or encounters, which the patient has had within the department in chronological order and details all the data associated with each encounter, or encounter.

For example, it details the presence of the referral data item, the consultation notes, any departmental clinical examinations, any interdepartmental clinical tests (e.g. X-rays etc.), any second opinions required and the outcomes defined for the encounter. In short, it details every item which was created during the encounter. The table also gives each item of encounter data an order number, so that the chronological order of the data generation is reflected in its presentation. Thus the referral data item has order number one and the notes two (as every consultation has notes). The remaining

order numbers are given as items of data are created. The final order number is given to the last outcome defined.

The actual clinical data associated with each encounter (such as the consultation notes, departmental examinations, inter-departmental test data and outcomes), is all held within appropriate clinical data tables (such as the consultation notes table, the referral data item table etc.). The records within these clinical data tables in conjunction with data (clinical, administrative, historical and definition) from other tables, enables complete items of patient data (such as an X-ray request) to be presented on screen in a composite fashion as required.

This is possible because the clinical database tables contain not only the appropriate clinical and administrative data associated with the particular clinical test, assessment or treatment being examined as part of the patient encounter but pointers or reference numbers to record sets held in other tables. The reference numbers refer to (or reference), information contained within records of other tables. For example, there will be reference numbers for the patient's address, GP, names etc. Thus when the items of data (such as a Biopsy request) are created the most current details are automatically presented and then recorded. This means that there is a permanent record of the definition data (patient address, personal circumstances etc.) current at the time of the data item being created.

So it can be seen that all the data required for a particular encounter can be generated and presented by using records which contain data, and reference data held in the

records of other tables. Hence there is no duplication of the data held between the different tables, and the integrity of the data is maintained over time, even though some details such as the patients address and circumstances may change. An overview of the mechanisms operation is given in Figure C4.
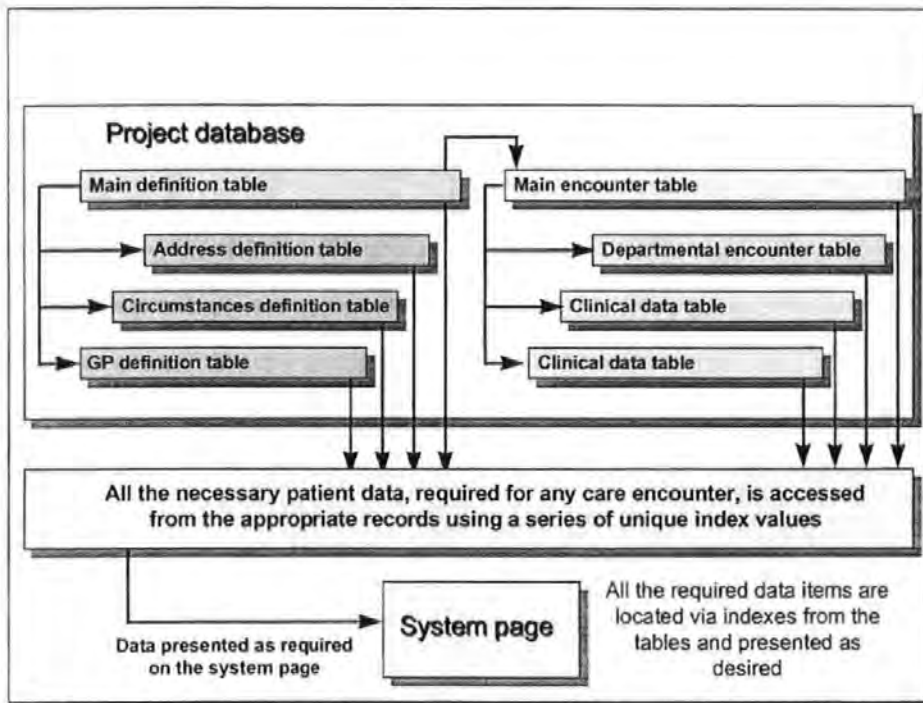
Figure C4 - Overview of the project's database structure

Appendix D

Evaluation questionnaire

POSEIDON

Confidential
Prototype Validation
Questionnaire

Nichola Jane Salmons

Network Research Group
University of Plymouth

Interviewee details :

Occupation ....

Department ....

Name ....

Date .... Time ....

Section 1 - system structure

1. Do you like the main organisational structure of the patient record, i.e. the record being composed of 4 main sections (Patient Details, Private Health Care, Medical Histories and Hospital Departments)?

   YES ☐   NO ☐

2. Within the Hospital Department sections do you like the use of index pages throughout the record, to structure the patient data (e.g. departmental encounters index pages, consultation and procedural encounter index pages, process index pages etc. in accordance with departmental operations)?

   YES ☐   NO ☐

3. Do you like the composite presentation of related departmental data (e.g. Radiology data presented within the Radiology department records and within the records of the requesting clinical department)?

   YES ☐   NO ☐

4. Do you like the way in which the record structure ensures and maintains departmental control of departmental operations (e.g. booking of appointments etc.)?

   YES ☐   NO ☐

Do you have any further comments on the record structure ?

....
....
....
....
....
....
....
....

Section 2 - presentation, functionality and utilisation

1. Do you like the use of menus to navigate, control and operate the system?

YES ☐   NO ☐

2. Do like the use of colours?

YES ☐   NO ☐

3. Do you like the use of buttons and labels on the index pages?

YES ☐   NO ☐

4. Do you like the use (emulation) of pages to present the data?

YES ☐   NO ☐

5. Is the data presented in an easily comprehensible, logical manner?

YES ☐   NO ☐

6. Do you like the maintenance (where appropriate) of the existing formats for the requesting and presenting of administrative and clinical data (e.g. X-ray and Haematology requests)?

YES ☐   NO ☐

7. Do you feel that the proposed system could / would integrate into the clinical workplace with some re-engineering of working practices?

YES ☐   NO ☐

Do you have any further comments with respect to the systems presentation, utilisation or functionality ?

....

....

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....

Section 3 – content

1. Does the system contain all the required non-clinical, administrative and personal patient data necessary?

<div align="right">YES ☐   NO ☐</div>

2. Does the system contain additional administrative, personal data which is of use (all previous GP's, addresses, medical conditions, procedures etc.)?

<div align="right">YES ☐   NO ☐</div>

3. Does the system contain all the necessary clinical data (e.g. reports etc.)?

<div align="right">YES ☐   NO ☐</div>

4. Does the system contain additional multimedia clinical data which is of use (e.g. ECG results, Biopsy images, X-ray images, clinical requests)?

<div align="right">YES ☐   NO ☐</div>

5. Does the system contain redundant data?

<div align="right">YES ☐   NO ☐</div>

Do you have any further comments on the data contained within the system ?

....
....
....
....
....
....
....
....
....

Section 4 - benefits

1. Will the system make the administrative tasks supported easier to perform (e.g. booking appointments, admission to the wards, updating of patient details etc.)?

   YES ☐   NO ☐

2. Will the system make the clinical functions supported easier to perform (e.g. requesting of clinical tests, referring of patients etc.)?

   YES ☐   NO ☐

3. Do you think that the system will save time (maximising the efficiency of the supported processes)?

   YES ☐   NO ☐

4. Does the system communicate the clinical and administrative patient information effectively?

   YES ☐   NO ☐

5. Does the use of multimedia data aid the communication, review, and evaluation of clinical data?

   YES ☐   NO ☐

6. Does the recording and maintenance of the clinical and administrative request, actual patient data, report and data updates produce a more comprehensive and composite record (is all recording necessary)?

   YES ☐   NO ☐

6. Will the proposed ubiquitous availability of the system and its composite nature aid the provision of clinical care (will the system make the delivery and support of patient care easier)?

   YES ☐   NO ☐

7. Will the system help reduce the number of mistakes made with respect to the administration and use of the patient data and the patient records (e.g. decrease mistakes in filling in details, always give current details etc.)?

YES ☐ NO ☐

Do you have any further comments with respect to the systems integration in to the clinical environment or its possible benefits ?

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Thank you

Appendix E

Publications

SECURE MULTIMEDIA SYSTEMS IN HEALTHCARE AND MEDICINE

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ABSTRACT

The aim of this paper is to examine the increasing potential for applying multimedia technology within the medical community. Multimedia is considered to be a particularly appropriate means for information delivery within Healthcare Establishments (HCEs), especially for that relating to patient care, and the paper considers the principal advantages in this area. The discussion then proceeds to highlight the fact that adoption of multimedia dictates new requirements for information security and, by the nature of the technology involved, also allows new approaches to be explored. On this premise, the outline of a security strategy for future multimedia healthcare networks is proposed. The discussion is supported by an example scenario and a brief examination of our own research groups efforts in this area.

INTRODUCTION - MULTIMEDIA IN MODERN MEDICAL CARE

Over the past twenty years computerised information systems have gradually been introduced to, and utilised within, a large number of healthcare establishments (HCEs). Information Technology (IT) now enables modern HCEs to provide more comprehensive medical care, comprising more numerous and more complex procedures. As such, HCE systems now process and handle information beyond simple text and graphics and more advanced medical applications may also generate digital images, full motion video and audio. The use of this multimedia information can considerably aid patient diagnosis and treatment (Ceusters et al. 1993).

As a result of recent advances in desktop processing power, the large scale use of multimedia-based healthcare systems is closer to being an achievable goal, with the presentation and delivery of multimedia information becoming possible at a viable price. This is largely due to the fact that PC-based systems can now represent a realistic platform for multimedia and can be found in numbers in most HCEs. In addition, telecommunications networks are now capable of handling the high speeds necessary to transfer large amounts of multimedia data, allowing further improvements to the speed of information delivery within and between HCEs.

In terms of advantages, the presentation of medical data in a multimedia format is considered to be ideally suited to the healthcare field as it inherently provides more information (Orozco-Barbosa et al. 1992), and in a form that is more easily comprehended than traditional text-based reports. This should indirectly help to improve the quality of care, as clinical decisions are made on the basis that the clinician has direct access to the most comprehensive information possible. In addition, it will allow the seamless integration of existing operational systems, with the ability to maintain a standardised viewing structure. As such, the potential applications of multimedia in healthcare are wide-ranging. For example, an area of significant potential will be the establishment of composite electronic health records, bringing together various types of multimedia patient data into a single entity (Arnold and Peter 1993). Such electronic multimedia record systems have the potential to significantly improve care delivery as they will allow immediate access to *full* patient data at any time, with flexible options for retrieval (whereas the same data may currently be held in several different places, making it difficult for clinicians to obtain all of the information that may be available).

REQUIREMENTS FOR SECURITY

It is important to recognise that a major consequence of the progression to multimedia will be an extension of the already significant reliance upon IT in healthcare establishments. This reliance stems from the increasing number of healthcare IT applications, particularly those relating to clinical care, that are now fundamental to routine clinical practice (Barber 1991). A number of future trends are predicted (European Commission 1994), with European project sponsorship (in the 4th Framework) under way, that will further increase this dependency. These include :

- increased intra and inter-HCE networking;

- increased exchange of data between HCEs;
- increased potential for sharing of facilities between HCEs;
- establishment and adoption of the composite electronic health record.

Due to the comprehensive nature of the information presented, it is envisaged that there is likely to be a even greater level of implicit trust in the correctness of the system. As such reliance upon IT increases, so too does the potential impact of any system unavailability or erroneous data. This, therefore, heightens the requirement to ensure that the availability and integrity of medical systems can be maintained.

In addition, further considerations arising from the increasing variety and complexity of data dictate a greater need for confidentiality controls. Firstly, the amalgamation of different forms of data into the composite record may potentially increase the sensitivity of the information beyond that of any of the component parts. Secondly, information that would previously have been held (and potentially secured) by separate applications would now be placed together, and thus the impact of a security breach would be significantly higher. The use of multimedia can, therefore, be seen to affect all three main principles of information security (i.e. confidentiality, integrity and availability).

As a result of these considerations, the authors believe that a different approach may be necessary to integrate security into multimedia systems and that the environment may also allow new opportunities to be explored.

A SECURITY STRATEGY FOR MULTIMEDIA HEALTHCARE SYSTEMS

Whilst many areas of security (e.g. physical, environmental and personnel considerations) will not be directly affected by the multimedia context, there will be noticeable effects in others; some significant, some less so (e.g. the quantity of data involved will affect the backup process in terms of increased storage requirements and, potentially, the time required to perform the task). The paper concentrates upon two aspects in particular which should be re-examined in light of the trends predicted above; namely *user authentication* and *data communications*. In both of these cases, an important issue will be the transparency of protection mechanisms employed. One of the main advantages of multimedia systems is that data can be presented in a more natural and "user-friendly" context. As such, there is a dilemma that whilst the systems must be easy to use and effective,

they must at the same time be made secure. This does not necessarily mean that users should be totally unaware of security (indeed, it will probably increase trust in the system if some security is seen to be present), but it must not interfere with their work and should be compatible with the general "feel" of the system.

User Authentication

User authentication mechanisms will still be required to prevent impostors masquerading at local terminals and workstations. However, two factors suggest that traditional password-based methods alone will no longer be sufficient protection :

- multimedia systems will significantly reduce the role of keyboard input in some contexts (e.g. information retrieval), such that it may not be required at all HCE terminals. As having to retain a keyboard simply for user authentication purposes would hardly constitute transparent security, an authentication mechanism not requiring this aspect would be desirable;

- the increased data sensitivity that could potentially result from the composite record context adds weight to the argument that passwords (which often provide a weak / unreliable basis for authentication anyway (Jobusch and Oldehoeft 1989)) should be supplemented by other mechanisms.

The use of smart card systems may have a place in overcoming these problems, but may not be practical as a compulsory measure as this would introduce an immediate financial burden across the whole system (which most HCEs would not be able to tolerate at the present time).

A appropriate alternative would be to utilise advanced user supervision systems which could operate transparently and in real-time throughout each session (Lunt 1993). A number of factors could potentially be encompassed by the supervision, including :

- times and locations of system usage;
- typical applications used;
- types of data accessed and how it is used;
- analysis of the users typing style (if a keyboard is still used).

The use of neural network techniques could allow appropriate information on these (and other factors) to be gathered automatically, with subtle behaviour patterns

being learnt in order to develop *profiles* for legitimate system users. Current user activity could then be continuously compared against the profile for the users claimed identity (with significant departures causing an alert to be generated).

In addition to the above, multimedia systems may allow many new options to be introduced for improving authentication. For example, appropriate hardware for implementing several biometric identification methods may already be present "as standard" in a multimedia configuration (e.g. cameras which may be used for image "faceprint" recognition, microphones and audio processing facilities for voice recognition). These techniques have been successfully implemented elsewhere, delivering adequate authentication performance and gaining a high degree of user acceptance (Sherman 1992). As such they should integrate well with multimedia systems. However, the presence of such hardware enhancements should not be a prerequisite of the authentication strategy for the same reasons as smart cards. Nevertheless, some mechanism should be incorporated to allow extra facilities to be utilised if they are present.

Future multimedia systems may, therefore, demand that a variety of authentication technologies are actually employed, based around an approach that is primarily software-oriented. These may then be linked / managed by an intelligent supervision system which can select the most appropriate mechanism to be invoked at any given point according to the current user activity and the type of system being used (e.g. keystroke analysis could be used in any text-intensive activity; facial recognition could be used if the host system is equipped with a camera). Note that once authentication has been conducted, any underlying data / application access and auditing controls could still be implemented in a traditional manner to restrict and monitor the activities of different classes of user.

Data Communications

One of the trends likely to result from the availability of more and better information is the increased sharing and exchange of data between HCEs. In the UK, the National Health Service (NHS) already plans to bring all aspects of voice and data communications together into a common framework, with all major HCEs having the facility to communicate electronically by 1996 (NHS Management Executive 1992). However, the transmission of composite records again raises the concerns of confidentiality and integrity (i.e. the need to protect messages against unauthorised interception, modification and falsification). Hence the requirement to have secure

data communications will also be correspondingly greater. A strategy is proposed that would introduce layered security at local, national and international levels with encryption of data between different security *domains* (based upon a Trusted Third Party (TTP) approach as shown in figure 1).
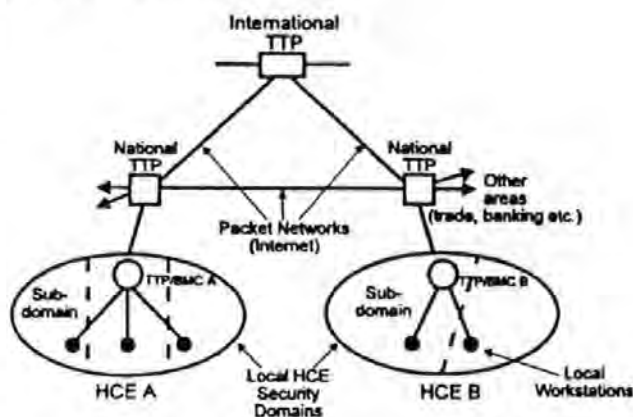
Fig. 1 : Secure Data Communications using a TTP hierarchy

The TTP would be capable of providing three main types of security service in relation to data transmission :

- integrity (e.g. checksums);
- non-repudiation (e.g. digital signatures);
- confidentiality (e.g. encryption).

These services would be applied, as appropriate, to communications at all levels of the TTP hierarchy. In addition, encryption could be used to protect stored data where workstations in the local domains cannot be physically secured. However, it should be noted that whilst the facility for encryption would exist, its use in healthcare is currently restricted in some EC countries. The operation of all data communications services could theoretically be made completely transparent to the end user (although in some cases, such as the use of digital signatures, users should be given some indication that a security service is being provided).

As can be seen from the figure, the Security Management Centre (SMC) introduced to handle the authentication system will also assume responsibility for securing communications in each local domain. The SMC facilities could be incorporated as part of an overall Network Management Centre.

This strategy would increase the importance of maintaining availability, with a reliance upon the availability of interconnected systems as opposed to earlier isolated ones. The hierarchy would, therefore, be

designed to be fault tolerant to enable secure operations to continue even in the event of individual TTP failure.

However, this strategy obviously depends upon the overall TTP infrastructure being in place before it can be realised. Therefore, in the short to medium term, individual HCEs and co-operating establishments will require alternative means by which their communications can be secured (AIM SEISMED 1994). In addition, due to the enormous volume of data involved in multimedia data communications, there are also questions that must be addressed regarding the need for compression and how Message Authentication Codes (MACs) may then be used. In the longer term, the fact that uses of the TTP would not be restricted to the healthcare domain could aid its introduction and acceptance at the national and international levels. The use of TTPs in the healthcare context is described in more detail in (Furnell and Sanders 1995).

EXAMPLE SCENARIO

This section presents an example scenario to illustrate how future multimedia data exchange would be likely to function within and between HCEs. This is, in turn, used to highlight the need for security at the various stages involved. To this end, the information flows involved in a potential multimedia healthcare system are illustrated in figure 2 and explained in the description below.
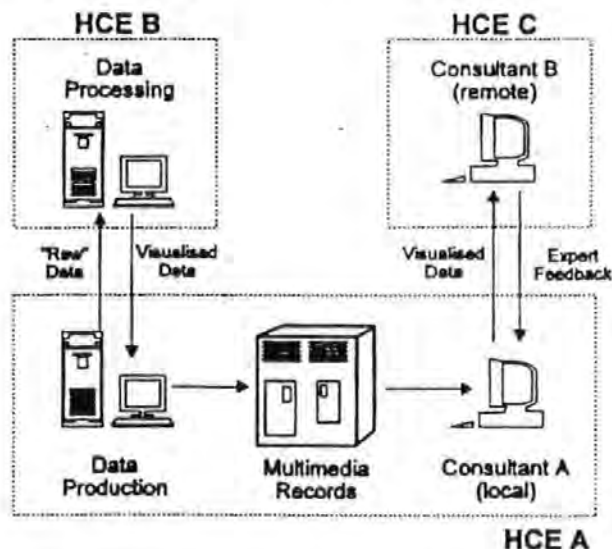
Fig. 2 : Multimedia Healthcare Application

The neurology department in one establishment (HCE A) performs a series of tests which produce a set of "raw" results data. However, HCE A lacks the equipment required to process and visualise the data, making it necessary to involve another site (HCE B). Once visualisation has been performed the results are transmitted back and stored in a database, from where they are subsequently accessed by a consultant at HCE A. However, further expert opinion is required and advice is, therefore, sought from another neurological consultant located at HCE C. Hence, the data is exchanged further, with the additional interpretation finally coming back to the originating consultant (allowing a more informed care decision to be made at HCE A). The consultants at HCEs A and C have access to a video conferencing link from their camera-equipped workstations, whilst the other parties in the scenario use standard workstations without such a facility.

From this basic outline, a general security specification can be given based upon the strategy described earlier. The different HCEs would communicate via local and national level TTPs, with all parties being authenticated by their local SMCs. Given that their workstations are equipped with cameras, the two consultants could potentially be authenticated by an image recognition system. However, the data production and data processing centres, utilising standard workstations, would have no facility for multimedia-enhanced authentication methods. Authentication of these parties would, therefore, be reliant upon the SMC facilities for activity supervision (possibly alongside traditional methods). The example is heavily communications oriented and the SMCs would communicate via the TTP hierarchy to authenticate and validate the various data exchanges and messages. The principal services required between HCEs A and B would be data integrity and confidentiality, whereas the HCE A / HCE C link would also require that the consultants were unable to repudiate information messages added to the system.

The example primarily illustrates the types of information exchange and consultations that the use of multimedia in healthcare will make possible. It also serves to underline the need for secure data communications between the various parties involved. The use of the TTP / SMC hierarchy would ensure that security was consistent across the three sites involved; a factor that considerably reduces the potential problems of sharing data and facilities as discussed.

CONCLUSION

The need for security is not unique to multimedia-based systems - indeed, similar demands already exist in many operational healthcare applications. However, the important point is that introduction of multimedia will serve to increase the demands significantly. Neither is

the proposed security strategy restricted to applications within healthcare establishments. However, the primary reliance upon software methods makes it particularly suited to HCEs, which are often more significantly financially constrained in relation to security than other types of organisation.

Our group is currently involved in the development, implementation and evaluation of a prototype multimedia patient records system in co-operation with a local HCE. Security is being considered as a key issue the project, with elements of the proposed strategy being addressed. It is hoped that the research will also help to identify other considerations that arise from the practical implementation of multimedia in healthcare.

The adoption and utilisation of multimedia technologies in healthcare is accelerating and it is likely that there will be a period of transition as research projects and pilot programmes (such as the EC 4th Framework) proceed in this area and produce their recommendations. From these, the principal uses and benefits of multimedia within healthcare will be established. We believe that it will be important for security issues to be considered during the planning and development of future systems, as the nature of the environment could well make it more difficult to securely integrate suitable protection later (or at least without it appearing to be an obvious afterthought).

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SIMULATION OF A MULTIMEDIA PATIENT RECORDS SYSTEM

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:STRACT

e paper highlights the need for, and the benefits of
ng, simulation during the development and
plementation of modern healthcare systems. Whilst
althcare establishments already utilise information
tems in a wide variety of disciplines, the majority of
tems are currently isolated, with patient records
gely based upon manual methods. As such, it is
visaged that the establishment of composite,
ultimedia-based patient records would considerably aid
re delivery. After a brief discussion of the advantages
at this would bring, the paper proceeds to highlight
w simulation can be employed to aid system design
d development in a number of areas (including the
er interface, records structure, security, networking
quirements and the profiling of future application
mands). The discussion is based upon work currently
ing conducted by the authors within a practical
search project.

TRODUCTION

uring the past twenty or more years computerised
formation systems have gradually been introduced to,
d utilised within, a large number of Health Care
tablishments (HCEs). Modern medical care requires
e use of computerised systems to process, visualise and
re vast amounts of information. The data produced by
ese more advanced medical systems consists of not
ly simple textual data but also digital images, full
otion video, audio and visualised graphics (Nelson and
dd Elvins 1993). The use of computerised systems,
th centralised and departmental, has resulted in HCEs

being able to offer ever more complex and
comprehensive medical care.

INFORMATION TECHNOLOGY IN MODERN HEALTHCARE

Computers now form an integral part of the process of
administering and monitoring patient care.
Additionally, computerised systems have also enabled a
wide range of complex scanning and diagnostic
procedures such as Computer Tomography (CT),
Magnetic Resonance Image (MRI) and Ultrasonic
Imaging to be offered (with the information gained then
being utilised in the planning and delivery of further
medical procedures). The increased use of information
technology has resulted in clinicians being able to
collect, generate, analyse and interpret ever greater
amounts of patient data. The availability and quality of
this data then enables the clinicians to prescribe and
administer the most appropriate healthcare programme
for the patient.

However, at present, within many HCEs there are
growing problems associated with the management and
organisation of the rapidly proliferating amounts of both
patient data and management / administrative
information. Due to the fragmented development and
implementation of the HCE information systems, there
tends to be little or no integration or exchange of data
between systems. The lack of information organisation,
in conjunction with the sheer volume of data, can often
result in decreased clinical efficiency, as more time is
spent attempting to search for and retrieve data from
different systems. Thus the benefits offered by the
availability of increasingly comprehensive patient data
are diminished and, therefore, in order to improve the
situation data needs to be made more portable,
accessible, comprehensible, and appropriately structured.

It is widely envisaged that these problems could be overcome by the adoption of composite patient healthcare records, based around multimedia technology (Treves et al. 1992).

ADVANTAGES OF A MULTIMEDIA-BASED HEALTHCARE RECORD

The use of multimedia patient data in healthcare has already begun and will inevitably increase as more clinicians are afforded the opportunity to produce and utilise high quality data at a relatively low cost. There are currently two developmental paths to the production and utilisation of multimedia data within healthcare. The first is that offered by the ability to obtain "raw" data via advanced techniques such as MRI and CT, which can then be visualised, manipulated, rendered and animated by powerful workstations, to generate the desired end result. At present this route is expensive due to the data collection and manipulation tools required, although it is already implemented in larger HCEs. The other path is that offered by the PC, where technological advancement is now reaching the point where clinicians can produce high quality multimedia data (including video, audio, graphics, images and text) both easily and relatively inexpensively.

Thus the way is clear for clinicians to be able to create and utilise multimedia clinical data. A composite multimedia record would improve the provision of patient care, as clinical decisions would be made with all the multimedia patient data available on one system, in the most easily comprehensible and informative manner.

The ability to view patients records easily will in turn enable clinicians to more comprehensively assess patient needs, responses to treatments, and on-going progress and may aid clinical decision making. Thus the patient will benefit from the use of multimedia data, in that they will be prescribed the most appropriate care plans. In addition, the healthcare providers benefit from the comparative cost reductions facilitated by the administering of the most suitable patient care.

The proposed system would ideally be able to integrate with any existing systems holding patient data, meet the desired user requirements, be secure against malicious or accidental intrusion, facilitate data communications within and between HCEs and be able to accommodate future medical advances and changes in working practices (Orozco-barbosa et al. 1992).

However, the introduction and implementation of multimedia patient records may prove to be problematic if there are not accompanying advances and improvements in the structuring, integration, portability, accessibility and comprehensibility of the data generated.

DEVELOPMENT OF A SIMULATION-BASED PROTOTYPE SYSTEM

This section examines practical work that is being undertaken by the research team to help realise the composite multimedia healthcare record concept. The general background is discussed, followed by a description of the simulation aspects involved.

Project Aims and Background

The remit of the project was to establish where the use of multimedia would be most applicable in healthcare and to define the structure, content and interfaces required for a multimedia-based records system. Additional considerations were the definition of most effective systems working practices, with the procedures required for the creation, appending, manipulation and management of the patient data.

The systems development was based at Derriford Hospital, a major HCE local to the research team. In terms of information systems, this establishment is similar to numerous others in the UK. Apart from a centralised Patient Administration System (PAS - which is accessible from all departments), a few independent departmental systems and a number of specialised stand-alone machines, the majority of patient data is generated and maintained manually.

It was established through interviews (described below) that the use of computers is alien to the majority of hospital personnel, with a worrying (and widely held) perception that computers will not form part of the future for healthcare. This view was generally based upon the belief that the computerisation of many operations and working practices would be costly and offer no real advantages. These factors suggested that the development of a simulation-based prototype would be the best way for the project to proceed, as this would allow an opportunity to demonstrate the future possibilities and benefits that would be offered, breaking down the resistance of the users.

Research Methodology

The task of developing a composite, multimedia records system is obviously immense. For this reason the scope of the study was limited, with a single department being selected to act as the "base" for the project. It was considered that the base should be a department in which there would be a number of opportunities for the introduction and use of multimedia patient data and one in which the patients are often referred to and between a number of closely associated departments over long treatment periods. As such, the Ear Nose and Throat (ENT) department was selected, with Radiology, Speech Therapy, Plastics, Microbiology, Dental Specialities and Maxillo-Facial departments as peripheral or closely associated referral departments.

The research method selected was that of performing discursive interviews throughout the selected departments. A range of staff were covered, from consultants to secretaries, so that the full scope of the departmental operations could be assessed. The data obtained was then used to create a prototype system which would then undergo recursive refinements. The desired system requirements and established working practices, along with user and departmental data exchanges and paths, were then abstracted and modelled from the interview results.

A significant issue in the design of the system was ensuring integration with current, and possible future, clinical practices. To this end, clinical staff were asked to identify "core non-flexible" and "core flexible" clinical and administrative practices and procedures. The "core non-flexible" practices and procedures were those which it would be impractical to change to any extent and which must, therefore, be maintained whether the patient records system was computerised or not. The "flexible" practices were those which could be re-engineered so long as the desired end result was still achieved.

The "non-flexible" practices tended to be made so by being either time sensitive (e.g. the requirement for immediate clinical reporting of results within the Radiology department, as delays could potentially compromise patient health) or a matter of established medical convention or clinical practice (e.g. that departmental appointments are always made internally). As such, the departments involved would find it impractical to perform them in any other way.

The "flexible" practices were those which could be made easier by the computerisation of the Patient Records System. These included the ordering and tracing of patient notes, the appending of data, and the searching for clinical details.

The interviews also established where it would be clinically appropriate to generate the multimedia data which would be used within the proposed records system. The selected departments each considered where, within their clinical discipline, it would desirable to obtain multimedia patient data (for instance, when would it be desirable to have video data of the patient, and what were the practicalities of generating it ?).

Uses of Simulation

Having used the interviews to establish the basic system requirements, the study could proceed to consider prototype implementation.

It is envisaged that once an initial prototype is developed and in-place at the hospital, simulation will form the core of its future development. A cross section of users will initially simulate the typical everyday use of a small number of demonstration multimedia patient records. From this the desired systems interface can be established. A number of different records structure styles can be offered, with the users then determining which is easiest to use. Different clinical scenarios will be simulated, which will require the records to be manipulated in a number of different ways.

From the record usage simulations a comprehensive range of individual record search options will be defined. These will indicate and define those data items and criteria (such as previous surgery, previous treatments, current and past medication, family history, noted medical conditions, etc.) by which the records need to be searched.

Once the use of individual records has been simulated, the project will move on to simulate a system dealing with a number of records, defining the functionality required with respect to multiple records. The users will be able to define the searches, and other functions, which the system must be able to perform between separate multimedia patient records. Thus at the end of the record usage simulation stage the preferred user interface, record structure, and intra and inter-record functionality will have been defined.

The next stage will be to simulate record creation and maintenance. Simulation in a real clinical environment will enable the clinicians to determine where, and when, it is practical to obtain multimedia patient data. The data collection processes must not intrude upon, or compromise, clinical working practices. The staff must then simulate the editing of the patient data, and the record appending practices required, again in a manner which integrates with other working practices.

Simulation will, therefore, enable the users to define and develop the most suitable practices for the collection, processing and maintenance of the multimedia patient record data. If these procedures can be made as simple and easy as possible then users, both clinical and administrative, will be far more inclined to pursue the use of multimedia in healthcare. The simulation environment may then be extended beyond this to consider other important aspects relating to multimedia records system implementation, including security, network requirements and additional functionality.

The requirements for data security can be considered and various approaches simulated. It is envisaged that the multimedia context will require an approach to security that is as transparent as possible, so as not to unnecessarily detract from the otherwise user-friendly nature of the environment (Furnell et al. 1995).

As an example, whilst user authentication could principally be based around a traditional password approach, it might be desirable to evaluate more friendly (and secure) methods within the context of the simulation environment. Alternatives could include the use of smart cards, real-time supervision systems (verifying identity by analysing factors of user behaviour such as typing styles and application usage) and / or various biometric identification techniques that might be feasibly implemented using existing multimedia hardware (e.g. faceprint or voice recognition). Through the simulation study, appropriate techniques or combinations could be established as required by different user groups.

There will also be a need for security restrictions at the departmental and user levels to control access, modification and deletion of different aspects of the overall records.

Once the security aspect has been simulated, the study can move on to define aspects of the systems network requirements and possible additional functionality. The

users will continue to simulate the everyday use of the system, but it will be extended to include additional features. These will include a range of departmental administrative, clinical audit, and management functions. A number of the proposed functions will reference the patient records data, whilst others will reference other data sources, some localised and some remote.

At this point the prototype simulation will not only be defining the desired additional system functionality, but will be helping to determine the systems integration and network requirements. By simulating the additional system functionality, the simulation will be able to establish those existing, or proposed, hospital systems from which data will need to be accessed. Thus the system integration requirements will be defined. The systems networking requirements will also be eluded to by the simulation of the additional functionality. From the use of the prototype it will be possible to determine the quantities of non-localised data required by the users, the data types required over the networks, and the acceptable system data throughput and response times, as well as the types and quantities of data transmitted by the users. Hence the simulation will give an indication of the systems network requirements. Security of data communications could also be considered here, with the simulation study considering various techniques that may be appropriate to ensure the confidentiality and integrity of transmitted data, as well as requirements for non-repudiation services (AIM SEISMED 1994).

The system simulation will also provide a valuable insight into the systems usage patterns with respect to the user types and help to determine the optimum working practices and duty ranges, for the different user types within the base department. Different systems operational modes may be simulated, in which the different user groups have subtly varying roles and duty ranges. From the simulation results the departments optimal operational mode can be established, thereby maximising systems and departmental efficiency.

CONCLUSIONS

At the end of the project, after the use of simulation as a development technique, in conjunction with the progressive implementation, extension and refinement of the prototype system, the users will obtain not a fully defined system but one which a least starts to address and overcome the numerous problems associated with

development of a multimedia healthcare records
em.

imulation study as described would allow time for
users to become more familiar with the technology
lved and would hopefully result in the development
a system which is of real benefit to them. The
erimental period would also enable the clinicians to
rmine where, and to what extent, the use of
timedia patient data is most advantageous. The in-
e use of a simulated prototype appears to be the only
option for the development of suitable systems as it
nly through such an approach that the desired end
lt will be achieved.

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3

Approaches to security in healthcare multimedia systems

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Abstract

This paper examines the need for security in modern healthcare applications and, in particular, the considerations that arise from the use of multimedia. Whilst multimedia is particularly advantageous for information delivery within Healthcare Establishments (HCEs), its adoption introduces some new requirements for information security. The paper presents the outline of a security strategy for future healthcare multimedia systems and networks and also highlights some new opportunities that may be offered by the technologies involved. The discussion is supported by an examination of the approach taken in the POSEIDON system, a prototype multimedia patient records system that is being developed within our research group in conjunction with a local HCE. This describes aspects of both the underlying analysis strategy and the system implementation, with particular reference to how security is being realised.

1   INTRODUCTION

As with almost all other fields, information technology has had a tremendous impact upon modern healthcare establishments (HCEs). Information systems are utilised in support of virtually all aspects of day-to-day operation, from administration to direct patient care. The systems themselves have also advanced over time, such that they now handle information beyond simple text and graphics; utilisation and storage of digital images, full motion video

and audio data is now within their capabilities. The use of this multimedia information can considerably aid patient diagnosis and treatment (Ceusters et al. 1993).

The wide-scale use of multimedia-based systems in healthcare is now viable thanks to the availability of capable and affordable core technologies. The necessary computing power to realise multimedia effectively is now accessible on the desktop, along with communications bandwidth to enable information delivery in acceptable quantities and speeds.

The presentation of medical data in a multimedia format has the advantage of being ideally suited to the healthcare field as it inherently provides more information (Orozco-Barbosa et al. 1992), in a form that is more easily comprehended than traditional text-based reports. As such, there are numerous potential applications of multimedia in healthcare. One application of particular interest is the establishment of an electronic healthcare record (EHCR) that can bring various types of multimedia patient data together into a single entity (Arnold and Peter 1993). The development of a composite patient records system would be beneficial to improve efficiency in four areas :

- utilisation of advanced medical data;
- use of clinical resources;
- service provision to the patient;
- administration and management of patient records.

The use of multimedia records has the potential to significantly improve care delivery as they will allow immediate access to *full* patient data at any time, with flexible options for retrieval. In current systems, relevant data may be held in several different places, which makes it difficult for clinicians to obtain all that is available. Multimedia will also facilitate the use of more advanced techniques, with the prospect that the data yielded can be directly incorporated within the patient record.

Intra and inter-HCE data communications are considered to be implicit in this arrangement. Just as the multimedia record improves the ability to communicate information content to the individual, so too does it provide a better vehicle for sharing the information with others.

2   SECURITY REQUIREMENTS AND MULTIMEDIA IMPLICATIONS

As in other establishments, HCEs require security to guard against a variety of accidental and deliberate threats to their systems and data. With regard to the latter, it can be seen that the healthcare field is by no means immune to systems abuse and, in fact, may be a more popular "target" than many other areas. This statement is substantiated by a recent survey of computer abuse in the UK (Audit Commission 1994) which considered incidents in a number of sectors including finance, manufacturing, local government, education and healthcare. A total of 334 including finance, responded to the survey, with 35% reporting some kind of incident (accounting for HCEs responded to the survey, with 35% reporting some kind of incident (accounting for 24% of the total abuse cases reported across all sectors). The fact that this compares with only 18 incidents (and 10% of the total) in the Commission's 1990 survey, signifies that the situation is getting worse. In most other organisations the principal impacts of abuse will normally be felt in terms of financial loss and disruption of activities. In healthcare, however,

various other factors will be equally, if not more, important (e.g. impacts on patient confidentiality, their safety and their trust in the HCE).

Whilst a need for security is clear, the nature of the healthcare environment is actually a complicating factor in the selection of acceptable measures. Firstly, controls are complicated by the fact that many areas of the HCE are (unavoidably) open to the public. Terminals are often widely distributed, with a necessity for many in public areas (e.g. on the wards). As a result, it is not always possible to implement sufficient physical security or rely upon continuous manual supervision. Secondly, a domain such as healthcare makes it foolish to insist upon a level of security that would greatly impede users in their legitimate work (i.e. security at the expense of care delivery) and so it is desirable for mechanisms to be transparent as far as possible. A final consideration is that of financial cost. HCE expenditure is likely to be prioritised in favour of purchases that will directly improve or contribute towards care delivery. Investments to improve security will normally only be approved if it can be demonstrated that the benefits will be greater than if the money was directed at enhancing clinical services (AIM SEISMED 1993). This restriction effectively means that hardware devices would not be adopted on a large scale, making software protection more favourable.

All of these observations show that healthcare makes many specific demands for security. However, it can be argued that the integration of multimedia systems into the environment introduces even more considerations. At the most basic level, the security requirements will be the same as those that already exist for protecting patient data (i.e. the generic IT security requirements to preserve confidentiality, integrity and availability). However, the use of multimedia does give rise to a number of further considerations, as listed below.

- The adoption of multimedia will extend the already significant reliance upon IT in healthcare. This stems from the increasing number of IT applications, particularly those relating to clinical care, that are now fundamental to routine practice (Barber 1991).
- The comprehensive nature of the information presented in a multimedia record may further increase implicit trust in the correctness of the system - which will, in turn, worsen the potential impact of system unavailability or erroneous data, as fewer contingency options will be available. As such, the availability and integrity requirements upon systems are further increased.
- Preserving the integrity of multimedia data is of more concern in that it may be altered in a nonobvious manner and even minor modifications to (say) an image may render it misleading or unusable.
- The amalgamation of different forms of data into the composite record may potentially increase the sensitivity of the information beyond that of any of its constituents.
- The use of scanners and other advanced medical equipment yields images and the like which may relate to any part of the body. Such data is often of an unavoidably revealing nature and may be highly personal when compared to textual descriptions, hence the requirement to maintain privacy is increased.
- Information that would previously have been held (and secured) by separate applications will now be placed together, and thus the impact of a security breach will be significantly higher.
- Data is stored in a directly broadcastable format, making unauthorised distribution far more straightforward than with paper-based records.

These considerations indicate that a different approach may be necessary to integrate security into multimedia systems.

3   INCORPORATING SECURITY INTO MULTIMEDIA SYSTEMS

It is clear that many aspects of security will be largely unaffected by the use of multimedia (with examples being physical, environmental and personnel security considerations). However, this will not be the case in all areas and we believe that two particular aspects should be re-examined; namely *user authentication* and *data communications*.

Unfortunately, the introduction of security is somewhat at odds with a multimedia system's "user-friendly" presentation of information, in that it is traditionally a barrier to straightforward access. As such, the transparency of protection will be a key issue if systems are to remain easy to use and effective. This point consequently forms part of the underlying rationale in the sections that follow.

3.1   User authentication strategies

User authentication mechanisms will still be required to prevent impostors masquerading at local terminals and workstations. However, the protection afforded by traditional password-based methods may no longer be sufficient as the composite record context will potentially increase the overall sensitivity of individual patient records, adding weight to the argument for passwords to be supplemented by other mechanisms. In addition, the suitability of passwords may also be questioned in that multimedia systems significantly reduce the requirement for keyboard input in some contexts (e.g. information retrieval), such that some HCE terminals will not need them. Retaining the keyboard simply for authentication purposes would be inconvenient and, as such, different authentication mechanisms would be desirable in these scenarios.

A suggested alternative is the use of user supervision systems which could operate transparently and in real-time throughout each session (Mukherjee et al. 1994). These utilise historical *profiles* of behaviour for legitimate users and compare them against current system activities (with significant departures causing an impostor alert to be generated). Individual behaviour profiles could potentially monitor a number of factors considered to be characteristic to each user, including :

- times and locations of system usage;
- typical applications used;
- types of data accessed and how it is used;
- method of interaction (e.g. keyboard versus mouse, command line versus menus);
- level of resource usage (e.g. memory, disk space and CPU time).

The profiles would be developed and refined over time using information collected automatically over the course of many active sessions (i.e. in the same manner as traditional audit trailing and event logging). Construction of the profiles could be assisted by using neural network techniques to allow subtle behaviour patterns to be detected. In addition, the

supervision system could monitor for general indicators of anomalous behaviour (e.g. out of hours access, frequent access violations etc.) which could also indicate an abuse scenario when considered in aggregation. This overall supervision concept is illustrated in figure 1 below.
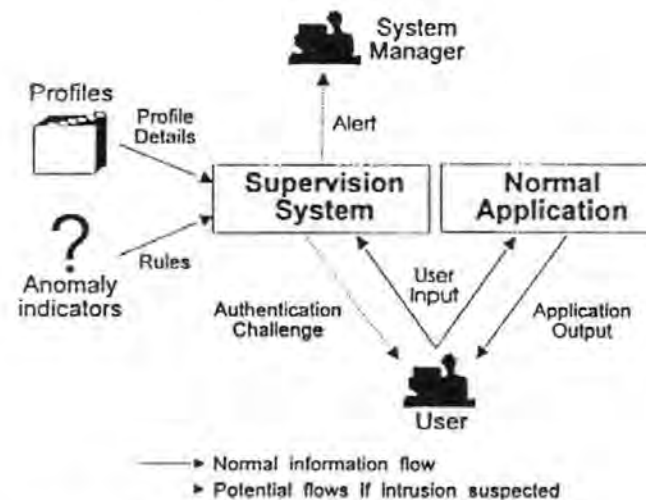
Figure 1 Potential operation of a user supervision system.

Multimedia systems also offer the opportunity for several alternative options to be introduced for improving authentication.   For example, appropriate hardware for implementing several biometric identification methods may be present "as standard" in a multimedia configuration, including the two techniques described below (Miller 1994).

- Microphones and audio processing facilities would enable voice recognition to be implemented. Speech can be analysed using a variety of parameters, including pitch, speed and waveform. Users could be authenticated by speaking a password/phrase which would then be compared against a stored profile entry. Software could normalise the input data to a constant rate, volume and pitch (to ensure compatibility with the reference sample) and eliminate variances resulting from abnormal behaviour such as shouting. Given that standard PC soundcards come with sampling capability and increasingly incorporate Digital Signal Processing (DSP) facilities, the addition of appropriate analyser software would make the approach feasible in the majority of multimedia systems.
- The presence of video cameras could facilitate the capture of images for use in "faceprint" recognition. This would be based upon a digitised scan of the face, which is then scaled, converted into vectors and fed into a neural network for comparison. Whilst facial recognition is complex, in that various factors (including expression, position, facial hair and lighting) may affect appearance, results have shown that identification can still be performed in well under a second.

These techniques have been successfully implemented elsewhere, delivering adequate authentication performance and gaining a high degree of user acceptance (Sherman 1992). As such they should integrate well within the healthcare multimedia context. However, due to the significant costs associated, the presence of such hardware enhancements should not be a prerequisite of the authentication strategy. Nevertheless, some mechanism should be incorporated to allow extra facilities to be utilised if they are present.

What would, therefore, be appropriate would be for a number of (software-oriented) authentication technologies to be available, which would then be managed by an "intelligent" supervision system. This would select the most appropriate mechanism to invoke at any given point according to the nature of the current user activity and the type of system being used (e.g. facial recognition could be used if the host system is equipped with a camera; analysis of user typing rhythms could be used in keyboard-intensive applications). Note that once authentication has been conducted, any underlying data / application access and auditing controls could still be implemented in a traditional manner to restrict and monitor the activities of different classes of user (see section 4).

The disadvantage of the approach is that biometric methods cannot be relied upon to make consistently correct authentication judgements, introducing the potential for false acceptance of impostors or false rejection of legitimate users. However, the more elements that are encompassed in the user profiles, the more characteristic they become. This increases their strength for identity verification, as false acceptances and rejections from one factor could be compensated for by the results from others.

Whilst it is noted that various other approaches, such as smart cards, exist which could help to overcome the basic authentication problems, they cannot currently be recommended as a compulsory measure due to the associated financial burden that would be imposed. Whilst the cost per unit here would be relatively small, it would become significant when applying the technology throughout an entire HCE or regional health authority domain. In addition, cards do not possess either the transparency or integration potential of biometrics/supervision or the ability to detect abuse by legitimate users which behaviour monitoring could deliver. The latter should not be underestimated, given that insiders have been found to account for the majority of abuse in previous studies (Evans 1991).

3.2   Trusted data communications

As previously mentioned, the multimedia record's ability to present more and better information is likely to result in increased sharing and exchange of data between HCEs. In fact, a number of future trends involving inter-HCE communications have already been predicted (European Commission 1994), including :

- increased intra and inter-HCE networking;
- increased exchange of data between HCEs;
- increased potential for sharing of facilities between HCEs;
- establishment and adoption of the composite electronic health record.

A current example of this is the establishment of National Health Service (NHS) Network in the UK, which aims to allow doctors to have instant access to online patient records.

However, this has already been criticised by the British Medical Association (BMA) and a variety of security experts for paying inadequate attention to security (Clarke 1996).

The transmission of composite records only complicates the issue further with additional concerns for confidentiality and integrity (i.e. the need to protect messages against unauthorised interception, modification and falsification). Hence the requirement to have secure data communications will also be correspondingly greater. A strategy is proposed that would introduce layered security at local, national and international levels with encryption of data between different security *domains* (based upon a Trusted Third Party (TTP) approach as shown in figure 2).
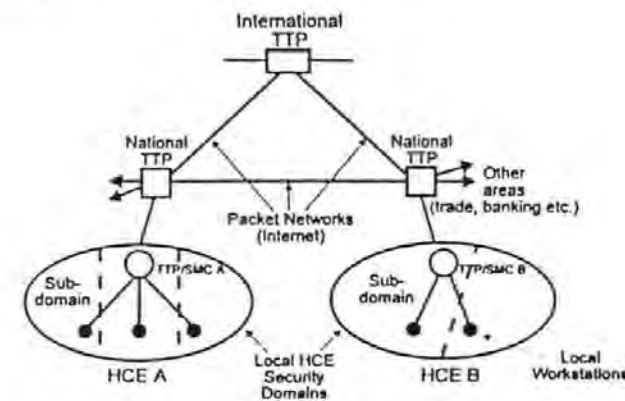
Figure 2   Secure data communications using a TTP hierarchy.

The TTP basically acts as a naming and certification authority, issuing trusted certificates of user credentials (principally their name and public key) which can then be placed in a directory allowing them to be accessed by other communicating parties. Certificates are signed by the TTPs at different levels, allowing other parties to trust the authenticity of the information held. This would enable three main types of security service to be provided in relation to data transmission, namely integrity (e.g. Message Authentication Codes), nonrepudiation (e.g. digital signatures) and confidentiality (e.g. encryption).

As can be seen from the figure, Security Management Centres (SMCs) are introduced to assume responsibility for securing communications in each local domain (Shepherd et al. 1990). These would also be capable of handling the authentication and supervision duties within the individual systems.

The actual authorisation of inter-domain operations would be based upon interactions between the SMCs involved. For example, to enable a user in domain A to utilise facilities on a system in a remote domain B, the relevant user details would be automatically exchanged between the two SMCs. SMC A could (for example) send a signed behaviour profile to SMC B which, after ensuring that the user is actually authorised to access the system, could be used for subsequent session supervision. With a secure association established, inter-domain operations can occur as normal, with the SMCs attempting to harmonise the security services offered at each end and the fact of their communications remaining transparent to the end-

user(s) involved. This transparency would also be true of the other communications services discussed, with all technical operations being handled by the security systems in each domain. However, in some cases, such as the use of digital signatures, it would be advantageous for the users to be given some indication that a security service is being provided.

The importance of maintaining availability would increase under this framework, with a reliance upon the availability of interconnected systems as opposed to the earlier isolated ones. However, fault tolerance is provided by the fact that each TTP in the hierarchy is certified by the next layer up, which allows for the loss of a hierarchical level (with the next higher order certificate being used instead). This enables secure operations to continue even in the event of individual TTP failure.

The way in which this framework would function can be best illustrated by presenting an example scenario. This involves inter-domain communications between three HCEs, as shown in figure 3 below.
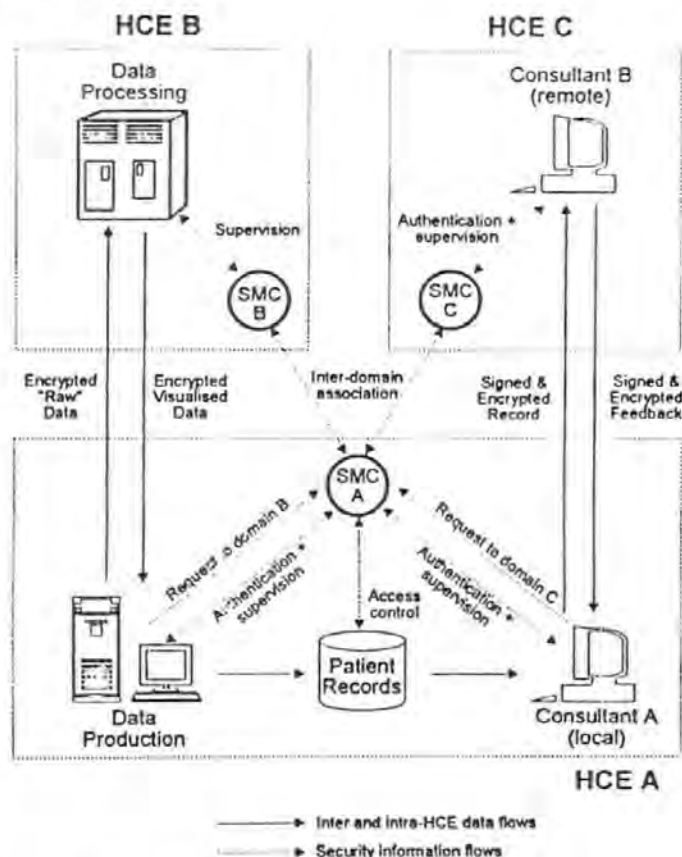
Figure 3 Secure inter-domain communication in a healthcare scenario.

The activities occurring in the figure can be explained according to the sequence listed below.

1. HCE A produces test result data and sends it to HCE B for visualisation.
2. The results are returned and stored in a patient records database.
3. A consultant at HCE A accesses the stored record.
4. The consultant seeks an expert opinion from HCE C and, therefore, sends them the record.
5. The consultant at HCE C then sends his interpretation back to HCE A where a final care decision can be made.

From this basic outline, a general security specification can be given based upon elements of the strategy described earlier. The different HCEs would be authenticated to each other by certified public keys obtained from the TTP, with all parties being authenticated locally by their respective SMCs. The SMCs would also mediate the various data exchanges and messages. The principal services required between HCEs A and B would be data integrity and confidentiality, whereas the HCE A / HCE C link would also require digital signatures to enable the consultants to verify the origin of the messages received.

The example primarily illustrates the types of information exchange and consultations that the use of multimedia in healthcare will make possible. It also serves to underline the need for secure data communications between the various parties involved. The use of SMCs would ensure a consistent level of security across the three sites involved (which considerably reduces the potential problems of sharing data and facilities as discussed), whilst the TTP certification hierarchy would ensure that the SMCs could be authenticated to each other.

It can be seen that the adoption of this strategy would provide the final component of a logical security system necessary to allow secure inter-HCE operations. Indeed, the potential uses of TTPs in healthcare have already been recognised within Europe, having been the basis for a dedicated project under the INFOSEC programme (INFOSEC THIS 1994) and further ongoing work. The issue has also been discussed in other work from our research group (Furnell and Sanders 1995), which presents a more detailed treatment of the subject.

4   EXPERIENCES FROM THE POSEIDON SYSTEM

This section describes practical work that is currently being undertaken within the research group in order to develop a prototype multimedia records system. The purpose of the work to date has been to analyse the healthcare environment, establishing the requirement for multimedia records and how they would be integrated. As such, the actual implementation of security has not extended to the advanced features discussed in the previous section.

The analysis was conducted within a local reference environment, namely Plymouth Hospitals NHS Trust, with a series of interviews being used as the primary means of determining system and user requirements. In order to ensure the validity and integrity of the work, the research was concentrated within a subset of the hospital departments, with these being selected to ensure that their intra and inter-departmental communications requirements were representative of the hospital as a whole. The Ear, Nose and Throat (ENT) department was selected as the core element of the investigation, with support from a number of closely associated departments (e.g. Radiology, Plastic Surgery and Maxillo-Facial) with which it

regularly exchanges data. In addition, views from relevant community-based care departments (e.g. Paediatrics and Speech Therapy) were also taken into account. With this range of departments contributing to the study, it was considered that the analysis could claim to have comprehensively examined the varying needs within a modern HCE.

An underlying requirement during the design was to produce a system that would not necessitate an unfeasible revolution of existing practices, but rather one which would integrate well and complement them where possible - a consideration which was particularly applicable when considering the approaches to security that would be incorporated.

The work has led to the development of a Windows-based prototype system, christened POSEIDON (Prototype cOmposite hoSpital multimEdIa recorDs fOr patieNts), upon which the feasibility of a secure multimedia records system is being investigated. The operation of the system is governed by seven "universal" menus, which group together the required features in a logical manner (such features include system navigation and the ability to create, view and utilise patient data). Each menu has a number of options, the availability of which is dependant upon the nature of the records screen in use and individual user requirements. The latter point relates to the ability to define user access profiles within the security sub-system. This use of menus is considered to offer the dual advantages of consistency and control.

Given the significant concerns over the protection of patient-related data that were previously highlighted in section 2, security has consequently been one of the key considerations in the realisation of the system. Whilst the features from section 3 have yet to be incorporated, some aspects have been addressed, the main areas being system access control and data integrity.

In terms of access control, users were classified according to a number of generic groups, with privileges being assigned according to varying responsibilities and needs within different HCE roles (in actual fact, the generic grouping only acts as a starting point for control and it is possible to tailor privileges to suit individual requirements). Possession of these privileges is then used to control access to patient data at differing levels of granularity. In this way it is possible to restrict access at the record level, at sub-record level or at data item level (remembering, of course, that a "data item" in this sense does not necessarily have to refer to textual information - access to image, video or audio data may also be selectively controlled). As data items are appended the user has the option to select an appropriate level of security, such as selective data access or a particular encryption algorithm.

With regard to the integrity of the data, it was considered vital for the system to be able to identify the users who have appended information to the records. In this way, activities are audited with date/time-stamped user details being recorded for later inspection. Anonymous activity is not permitted, which helps to ensure a level of user accountability and enables events or queries to be traced back to the source. Such reliable auditing is obviously impossible to achieve without an appropriate level of user authentication. For this reason, activities are "signed" using digital signatures. Integrity is also safeguarded to some extent by the operational controls imposed by the menu system - i.e. the inability to select functions that are inappropriate to a given context helps to prevent incorrect use of the records system.

Whilst POSEIDON does not currently support the full range of security measures suggested elsewhere in the paper, it should be noted that this aspect of the system is still under development. As such, it is hoped that further features will be incorporated before the end of the research programme.

5   CONCLUSION

In conclusion, computer security will always be required in healthcare to safeguard both the rights and safety of patients, as well as to allow the systems themselves to be used with confidence. The future will see further growth and expansion of both applications and users, with the issue of multimedia playing an increasingly important role. Security will need to be considered and developed in parallel with these new systems, with each innovation being secure in itself and not compromising that which already exists.

The proposed security strategies are by no means restricted to use in healthcare applications or multimedia systems, but the overall combination is considered appropriate on the grounds of both cost and the consequent ease of use.

The principal uses and benefits of multimedia within healthcare are still being established. Although the POSEIDON system is still under development, it is already providing a vehicle to illustrate some of the benefits that a multimedia patient records system will bring in healthcare. It is hoped that the findings from the prototype will feed into further research and development efforts, thus progressing the adoption of multimedia records on a wider scale.

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7 BIOGRAPHY

Dr Steven Furnell is a Research Fellow within the Network Research Group at the University of Plymouth. He graduated from the University with a first class honours degree in Computing & Informatics and a PhD in computer security. He has been involved in the development of the AIM SEISMED security guidelines for European healthcare establishments and has practical experience in the area of intrusion monitoring systems. His research interests also include Integrated Service Engineering and mobile communications.

Nichola Salmons graduated in 1991 with a BSc. in Applied Chemistry from the then Polytechnic South West (now University of Plymouth). This was followed by a PgD. in Computer Technology and Software Applications from the University of Central Lancashire in 1992, and an MSc. in Telecommunications Technology from Aston University in 1993. She is currently working towards her PhD at the University of Plymouth, which is being supervised by Colin Stockel, Peter Sanders and Steven Furnell. The POSEIDON system is being developed as part of this work.

Peter Sanders is the Director of the Network Research Group at the University of Plymouth. He is currently involved with research into security systems, network design and Integrated Service Engineering in association with industry and the European Union, where he is currently engaged on ACTS and Healthcare Telematics Applications projects. He is the author of a number of technical papers, reports and books in these areas.

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Dr Matthew Warren is a lecturer at the Plymouth Business School, University of Plymouth. His PhD was related to the use of security risk analysis within healthcare. Dr Warren has been involved in several European research projects such as AIM SEISMED and Healthcare Telematics Applications ISHTAR. His current research interests include multimedia security, risk analysis and security management.

4

Security Flows Analysis of the ATM Emulated LAN Architecture

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Abstract

As currently adopted by the ATM Forum LANE SWG, LAN Emulation specifications include many security weaknesses making communications on Emulated LANs (ELANs) vulnerable to heavy threats (in the sense of X800) such as masquerade, information disclosure and denial of service.

This paper aims at highlighting ELAN's security problems. To this end, a number of attacks scenarios are studied over the ELAN architecture and details relating to the way an attacker may perform each attack - how, from where, with which collusion (if any), which facilities, which level of difficulty - are given.

Keywords
Security, ATM, Emulated LAN, ATM LAN

1 INTRODUCTION

There are no doubts that ATM technology will be used as the means to support end-to-end data communications in the near future. However, since today's data communication infrastructures are built around "legacy LANs" (e.g., Ethernets, Token Rings), a radical change from the legacy LAN's technology to the ATM one seems impossible in practice.

In the LAN environment, ATM offers considerable advantages (Jeffries, 1994) (Vetter, 1995) (Biagioni, 1993) over the existing legacy LANs (referred to as "LANs"): it brings performance increase, but above all, it considerably simplifies LANs management since the virtual LAN concept developed in ATM enables simple virtual LANs reconfiguration from a management platform instead of having to change the wiring as normally done in legacy LANs.

Legacy LANs or LANs provide users with a vast base of reliable communications applica-

POSEIDON - A Composite Multimedia Hospital Patient Records System

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There have been many developments in the past few decades with respect to the provision of health care, its availability, administration, quality and complexity. Advances in technology have enable the provision and use of a range of computer aided diagnostic, analytical and procedural tools within medicine [1,2]. Development has also been under taken for the communication of the different data types produced by these techniques [3]. Health care has been subject to demands for increased efficiencies and ever greater provision.

The existing health care systems are undergoing numerous structural, managerial and operational changes, yielding savings and further efficiencies where possible [4]. However within any complex system such as health care, having dynamic and developing requirements, there is a point where certain static systems, practices and procedures, limit the systems possible developments and efficiency. An analysis of the health care system, with respect to its individual constituent systems, indicates that some of the existing patient systems, especially patient administration and records systems, are at present acting as system limitations for health care as a whole.

The development of a 'Composite Multimedia Patient Records System' would yield tangible benefits with respect to the more efficient use of clinical and administrative resources, the utilisation of advanced medical data, and an improved service provision. The proposed system would facilitate advances with respect to the administration and management of the patient records, the availability of the records, and the ability of the patient records to include multimedia patient data.

Thus the projects aim was to develop POSEIDON (Prototype cOmposite hoSpital multimEdIa recorDs fOr patieNts). In order to develop the prototype system a detailed analysis of the systems requirements was required. Obviously to define the exact needs for every hospital department would be an immense task requiring resources beyond the limits of this project. Thus in order to maintain the validity and integrity of the project with respect to the systems analysis, it was decided to concentrate the research within a limited number of hospital departments, whose inter-departmental and intra-departmental interactions formed a comprehensive example of the hospitals requirements as a whole.

In conjunction with the Information Department and a number of clinical staff at the co-operating hospital, "Plymouth Hospitals NHS Trust" in Devon, the ENT department was selected as the base research department. It was felt that this was a particularly suitable department as it provides a number of different clinic types, caters to a large number of patients, is involved in a number of joint specialist clinics, and works closely with a number of other hospital departments. It also utilises multimedia data, has a surgical role within patient care, and has a large administrative work load. Thus the department encapsulates a large number of the hospitals requirements as a whole.

To analyse the remaining requirements not present within the ENT department itself, the project looked at a number of what were defined as 'Associated Departments'. These were hospital departments which had a close, and integrated, working relationship with the ENT department. These relationships necessitated the regular interchange of patients, patient data, and correspondence. The associated departments analysed included Maxillo-Facial, Radiology, Dental Specialities, and Plastic Surgery. The inclusion of these departments enabled the communicative system requirements to be defined.

A number of other departments including Microbiology, Medical Photography, Medical Records, and the Information Technology department were also involved in the research. Their inclusion enabled the systems requirements for clinical services and administrative tasks to be defined. The inclusion of the views from relevant community based care departments such as Paediatrics, and Speech Therapy, was also made so as to complete the systems requirements. Thus the scope for the projects research was defined as being a comprehensive and representative, as the research identified a sub-set of hospital departments which demonstrated the hospitals requirements as a whole.

The research methodology utilised to establish the system requirements was that of performing confidential discursive interviews in private surroundings. The interviews were performed in a relaxed manner, being recorded, and later transcribed for reference. This ensured that the interviews flowed, and that the interviewees had confidence in their confidentiality and were able to express their views freely.

The interviews were performed throughout the base ENT department and the other associated departments. For each of the associated departments a number of interviews were performed, in accordance with a sectioned interview schedule, with a range of departmental staff types, clinical, administrative, secretarial, and nursing. Whilst for the base department the number of interviews was increased, so that several staff of each type were interviewed, the same structure and methods were maintained.

The interview schedule was carefully designed into sections, each of these sections contained a number of non-leading questions, which concerned a particular area of health care practices. The interviewees were firstly asked to describe their usual range of duties and responsibilities. They then answered, if appropriate, questions from each of the interview sections. These sections concerned their dealings with patients, the patient referrals and appointments processes, patient paper records, separate items

of patient data, the generation, processing and interpretation of patient data, clinical systems, administrative systems, views on computers, and future systems development.

A number of the more senior, managerial, and clinical staff were given a slightly different interview schedule which was designed to identify the more managerial based departmental problems and development needs. These interviews concentrated on what the departments overall responsibilities, duties, aims and constraints were and upon how they felt the departments, and health care, would develop and evolve in the future. A number of clinicians from a comparable department within another hospital were also interviewed, using the same methodology, towards the end of the interview stage of the research. This enabled the defined requirements between the hospitals to be defined and compared. The comparison of results found that the requirements identified were apparently generic, being present at both hospitals.

Analysis of the interview results yielded groupings of systems and user requirements, both across and throughout the co-operating departments and the interviewees. Also found were a number of patterns of systems requirements, about established working practices, current system inefficiencies, and current system deficiencies. The research also identified a number of extremely good, practicable and efficient working practices, which were recognised to be suitable for maintenance and inclusion within the proposed system. The project aims to provide a system which would not require the unfeasible revolution of clinical and administrative practices but one which would integrate and embrace them, enhancing their efficiency where possible.

From the analysis of the results patient based models of all the processes, and their component parts which occur with the base department, were constructed. These models defined a number of possible patient states within the departments, a patients state being their situation within the care process at a particular point in time. For each patient state the models defined fully the system requirements with respect to the request for and receipt of patient data, the production of patient data, the administration of the patient records, and the patients care requirements.

After defining all the processes which occur within the base department, and between the base and associated departments, the models were verified with clinical staff for their accuracy. At this point a practical analysis of a busy clinic was performed. The speed, workloads, practicable responsibilities, and environmental factors for different staff types were analysed. This yielded valuable practical information with respect to the design, operation, and implementation of the prototype system.

The system structure, content, presentation and capabilities were discussed with hospital staff during the design process. This enabled the system to be developed about those working practices which are not able to be altered without detriment to clinical care. It also enabled the users to define what system features would or would not be of use, comment as to the proposed practicable ease of use of the system, and identify possible problems.

The basic system is a windows based one, with the records structure being hierarchical in its nature. Its use and operation is driven, and governed, by the use of a small number of 'universal' menus, these are menus which group together the required system capabilities in a logical manner. Some of the menus are concerned with the navigation and use of the system, others are concerned with the viewing, appending, use, and generation of items of patient data. There are seven 'universal' menus within the system, each has a number of options which are present every time the menu is included within a particular page of the patient records. The options availability within the menu, when present, is dependant on the individual users requirements (defined by the systems security manager) and on the exact nature of the patient records page.

The systems design was as concise and logical as possible, enabling users not fully conversant with all the peculiarities of health care to use the system effectively as they require. The simple hierarchical structure, consists of a title page, leading to three main records sections "Patient Details", "Patients Medical Details", and "Departments". The "Patient Details" section allows the user to access, all the required non-medical patient details. The "Patients Medical Details" provides access to three other sections, "Medical Conditions", "Medical Procedures", and "Patient Medication", containing all the appropriate patient data. The patient record structure is illustrated in figure 1 below.

Figure 1 : Basic Patient Records Systems Structure

The "Departments" section provides access to the patients departmental hospitals records, the contents of which may be examined as required, by selection of the required (named) departmental option. The systems operation is then via a number of separate 'universal' menus. Each enables the user to perform the full range of tasks associated with a particular aspect or need within any area of health care. The presence or absence of the individual menus about any of the individual patient records pages was easily defined by relating the nature of the page to the users requirements.

The use of a hierarchical records structure allowed the required patient data to be separated, grouped and ordered to a greater extent in a logical form. This separation, grouping and ordering of the data enables the increased speed of access for the desired patient data. It also allows for the easier review of associated patient data, i.e. patient data relating to a particular patient care episode.

The use of 'universal' menus, for the command of the system, was decided upon as the number of options required within the system at any particular point was too great to consider command buttons. It was also the option which used least of the screen space, which needs to be given over to the presentation of the actual patient data. The use of 'universal' menus throughout the system helps to ensure the systems correct use, eliminating the ability to abuse the system operations, as only those operations applicable to the particular page of the patient records are available.

The security of the prototype system was carefully considered both with respect to the systems access, and the integrity and validity of the systems constituent data. The users were classified into a number of generic groups, and their privileges within the system were defined in accordance with their work place responsibilities, duties and needs. Although each member of staff could be placed into one of the generic groups, their required privileges could be flexibly and exactly tailored to their personal work place requirements. This ensures that the system does not impinge on, or compromise, the required working practices within the health care system.

Thus viewing and operational access for particular records, sections within the records, and particular data items within the records are defined in accordance with their needs. The system is able to carefully restrict users, as appropriate, with respect to their use of operational and viewing options within the patient records.

The validity and integrity of the data held within the individual patient records also needed to be ensured. It is vital that the system is able to show the users who have appended the patient data to the system, and the users who have, when required, verified the validity of the data appended to the system. Also recorded along with the appending or verifying user is the time and date of the operation. By creating an automatic record of those responsible for the appending and, when required, the verification of the data validity, the system avoids the possibility of anonymous and perhaps erroneous data appearing within the record and being acted upon in good faith by another user. Thus if a clinician has a query concerning an item of data, then they may contact the appender of the data. The integrity of the data and the appender is ensured by the use of digital signatures.

Although the system is presently being developed with respect to its actual coding, and has imitations with respect to its scope and aims, it is hoped that it will help to demonstrate the practical benefits which a future multimedia patient records system would bring to the field of health care. The system will show the benefits afforded by the use of a simple logical structure and operational ethos. It will also demonstrate the benefits afforded by its ease of access, viewing, incorporation and presentation of multimedia patient data, and its ability to facilitate clinical and administrative health care tasks and requirements. It is also hoped that the production of the prototype will stimulate further research and development so that the desired end system could be implemented and yield the numerous possible benefits to the health care providers and users.

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Appendix F

Letters of support

The following letters of support for the research undertaken and the ideas defined were received as a result of the authors receiving copies of the conceptual design and seeing a demonstration of the prototype system.

Mr. Paul Windle-Taylor was the main research contact at Derriford Hospital and, therefore, fully acquainted with the research environment of the project.

Mr. Sean Brennan is head of the NHS Electronic Patient Records Programme.

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Our Ref:pwt/mp/

21 May 1999

Miss N Salmons
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Dear Nichola,

Thank you for sending me the draft of your PhD thesis.

I read the sections relevant to myself with great interest and not inconsiderable awe. You have assembled a formidable document covering a wide field and your writing makes simple what is a very complex and difficult area of information technology.

I feel overall that your study has been well conducted and for a legitimate purpose. I know that you spent a considerable amount of time in and around the department and Derriford Hospital and I can see from reading your draft that this time was well spent.

Your demonstration of the system to me last year showed what enormous potential information technology can have in the handling of the patient record both in terms of storage and retrieval. I feel that this makes yet another significant step towards the possibility of the "paperless medical record". There has always been a considerable amount of discussion about this concept and it is nice to see change not only being proposed but being made.

I hope that you are successful with your thesis and would be both honoured and grateful if you would send me a copy for a departmental library. It will be a useful archive of the relevant documentation concerning information technology and clinical management.

With best wishes,
Yours sincerely,

Mr P C Windle-Taylor, MA, FRCS, MBA
Consultant Otolaryngologist

04 June 1999

Ms Nichola Salmons
"Avalon"
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Dear Nichola

Thank you for inviting me to read and comment on your PHD.

As you suggested I have not focussed on the grammatical content of your work but have reviewed it in the context of current strategic thinking.

The concept of having the MEHCR as an evolutionary, constantly developing system alongside the 'day to day' IT systems is one I too subscribe to.

In the EPR Programme we concluded that there were two concepts:

i.   the Active EPR, adopts the philosophy of using technology to support the clinical process. This would include order communication, electronic prescribing, departmental systems etc. In turn this will result in

ii   a historical EPR – a record of what has been done.

As I read your paper this is also the model you have adopted and the detailed work you have done will be valuable not only to yourself but also to those working in this area at a national level.

I look forward to receiving your final document and wish you well with it.

Yours sincerely

Sean Brennan
EPR Programme Manager