Chaos theory as a model for interpreting information systems in organizations

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Abstract. *Chaos theory concerns the qualitative study of unstable aperiodic behaviour in deterministic non-linear dynamical systems. Concepts from chaos theory have recently been applied as a model for interpreting organizational change and understanding organizational behaviour. This paper applies these concepts to the study of information systems in organizations. Key concepts from chaos theory are identified and used to develop an interpretive framework. The importance of understanding the initial conditions when an information systems strategy is developed or an information system is implemented is highlighted. The idea of strange attractors, patterns of behaviours of information systems, organizations and actors, which are repeated is developed, and the effect of internal and external events and choices is considered. These chaos theory concepts are applied to a case study of information systems strategy implementation in the UK probation service. It is concluded that concepts from chaos theory offer valuable support in developing a coherent and meaningful story concerning interactions between information systems and their host organizations.*

Keywords: chaos theory, complexity, information systems strategy, interpretive research, strange attractors, National Probation Service

INTRODUCTION

The complexity of organizations is such that organizational studies scholars have searched for metaphors and models to help describe and explain the complex social phenomena observed in organizations (Weick, 1998; Lamberg & Parvinen, 2003). The metaphors applied to understanding organizational behaviour and organizational change have included those derived from complexity sciences, including chaos theory (Svyantek & DeShon, 1993; Cilliers, 1998; Olson & Eoyongi, 2001). Complex organizational behaviour affects the development and implementation of information systems (IS). In addition, the use of IS affects organizational behaviour in ways that may not be entirely predictable (Orlikowski & Hofman, 1997). It is therefore reasonable to suggest that the metaphors and models applied to organizations may transfer to the study of information systems in organizations.

Metaphors and models provide the basis for interpretive approaches in information systems that seek to draw out patterns and shed light on complex social-technical situations. They act as sense-making tools. They are the scaffolding (Walsham, 1995) that enables the IS researcher's audience to make sense of an interaction between IS and its organizational context, to view the phenomenon holistically and draw lessons that may be applicable in other situations. While such models cannot be said to provide cause and effect explanations of social phenomena in information system studies, they can be seen as conceptual maps that enable the researcher's audience to navigate a situation, to view the underlying patterns and to incorporate such patterns into their world view for reference when they encounter similar situations in their practice or research.

Interpretive research involves both the selection of a method for carrying out the research and a model or metaphor as a framework for interpretation. Interpretive researchers in IS have tended to focus on case studies as the principal method. Whether longitudinal, historical or involving a series of snapshots, case study material provides the building blocks for the construction of interpretive models. Method and model are inextricably linked because the way in which the method is executed may be affected by the selected model. Additionally, the data collected within a case study may lend itself to interpretation through a particular model.

IS researchers have drawn on a variety of disciplines including sociology, philosophy and organizational studies as a source of models to act as lenses through which IS phenomenon are explained. Structuration theory has proved to be a popular model for linking individual social process and organizational social process concerning IS strategy (Walsham & Waema, 1994; Jones *et al*., 2004). Actor Network Theory has provided a model for examining several case studies of IS acceptance and implementation within organizations (Monteiro & Hanseth 1996). Models of power have been used to interpret IS strategy and implementation in organizations (Horton, 1998; Doolin, 1998). Other interpretive studies have drawn on philosophers such as Heidegger and Gadamer to provide conceptual models to guide the research process and outcome (Introna, 1997; Butler, 1998). Often, in addition to drawing from other disciplines, IS researchers extend models from other disciplines and construct their own models.

The purpose of this paper is to examine the potential of chaos theory as an interpretive model for understanding the complex interactions between information systems and their organizational environments. I suggest that chaos theory has potential as a sensitizing tool for identifying patterns in the interactions between information systems and their environment and may support the identification of significant events and their effect on the life of an information system within an organization. Chaos theory differs from other interpretive models in that its ideas and concepts are firmly grounded in the reductionist world of physical sciences and can be derived from mathematical studies. This paper draws out concepts from chaos theory that might form an interpretive framework for investigating information systems in organizations. In particular, concepts around the effect of initial conditions, evolving feedback loops and strange attractors are examined for their interpretive value.

To do this, I first introduce the principal concepts of chaos theory. The aspects of chaos theory of value in interpretive information systems studies are discussed. The resulting interpre-

tive framework is then applied to a case study concerning the implementation of information systems strategy in the UK probation service. I suggest that interpretive application of the concepts of chaos theory is of value in constructing descriptions of information systems interaction in organizations.

DEFINITION OF CHAOS THEORY

Chaos theory can be defined as 'the qualitative study of unstable aperiodic behaviour in deterministic non-linear dynamical systems' (Kellert, 1993). It is a part of complexity theory which concerns itself with non-linear dynamic systems whose behaviour does not follow clearly predictable and repeatable pathways. In linear systems, the relationship between an environmental factor and system behaviour is predictable and easily modelled. As the presence of an environmental factor increases, the system behaviour changes linearly in response to it. In contrast, behaviour in chaotic systems may be perceived as unpredictable. Periods of inactivity may be punctuated by sudden change, apparent patterns of behaviour may disappear and new patterns unexpectedly emerge. Such behaviour emerges in complex systems. This chaotic behaviour does not indicate a lack of order. Rather, the order is difficult or impossible to describe in simple terms and requires complex narrative description.

The systems explored in chaos theory are dynamic. They respond to the environment and are often inherently unstable. Where stability occurs, it is fragile and may be disrupted by small environmental changes. Chaotic systems react significantly to such changes and shift between a number of semistable states. It is the study of this fluid behaviour that gives rise to significant insights.

Chaotic systems do not manifest any fixed, repeatable patterns. Variables associated with the system do not repeat values, although they remain within a fixed, definable space. Such aperiodic behaviour is highly complex and permanently sensitive to small perturbations. Patterns emerge, persist for a while and then die off to be replaced by apparent randomness and then the birth of new patterns. These patterns are dynamic, never exact copies and in a state of flux.

Tsoukas (1998) suggests that chaotic systems are deterministic in that, given the initial conditions, there is one unique end point or goal of the system that can be mathematically derived. Small changes in the initial conditions may generate very different end points. If we consider an isolated system, in which initial conditions are determined and the system then runs to completion without any further intervention, then we can clearly determine the end point. However, determinism does not imply total predictability. Thietart & Forgues (1997) argue that cause–effect links, although deterministic, cannot be repeated. Similarly, Baskerville & Smithson (1995) suggest that causal links between management directives and organizational response should be treated with caution.

In many systems, the complexity is magnified as there is constant intervention involving new conditions and environmental change. Such a level of complexity may be impossible to fully explain and predict with limited human understanding, and simulations would be impossible to

build, given the limits of computer technology. Causality will operate in two directions such that system behaviour elicits actions and actions shape system behaviour. Relationships are recursive and changes have multiple causes.

It should be noted that Kellert (1993) argues that chaos theory may not be deterministic, despite determinism being an element of his definition of chaos theory. Taken in conjunction with quantum mechanics, the extent of determinism supported by chaos theory is limited. As the position of a particle in a system can only be localized to a finite bounded area and not precisely defined at a particular point, two identical chaotic systems with identical initial conditions and boundaries can be in different states after a period of time. As chaos theory is, to some extent, indeterministic, its interpretive application may be justifiable.

Finally, it should be noted that Kellert's definition suggests that the study of chaos theory is principally qualitative. Chaos theory studies seek to identify patterns in behaviour over the long term. Such holistic studies focus on qualitative changes. Chaos theory and complexity science can be applied in ways that are both objective, scientific, reductionist and generalizable and that are subjective, interpretive and individualist (Griffin *et al*., 1998; Chia 1998). Hence, it may be suggested that chaos theory may help reconcile the unpredictability and uncertainty of social and organizational systems with scientific, determinist frameworks.

Chaos theory first rose to prominence through Lorenz's work on weather patterns and then spread to other physical systems (Gleick, 1987). In organizational and managerial studies, its use has been both quantitative and qualitative (Ferdig, 2000; 2002). Levy (1994) applied chaos theory to explain the complex dynamics of the supply chain of a personal computer company. More qualitative studies by Griffin *et al*. (1998), Chia (1998) and Tsoukas (1998) have used chaos theory to provide frameworks for thinking about organizational theory. Gabriel (1998) used chaos theory as a basis for challenging the myth of managerial control. Byrne (1998; 2001) applied chaos and complexity concepts in an interpretive manner to analyse social policy concerning social exclusion. Butz *et al*. (1996) apply chaos theory to understanding the dynamics of the family and engendering family change. Families are seen as organic systems with boundaries and patterns which change in complicated ways. Anderson (1999), Boisot & Child (1999) and Frank & Fahrbach (1999) use chaos theory as part of the broader discipline of complexity theory to provide models to describe organizations as complex adaptive systems. Stacey (1993; 2002) and Lissack (1997) proposed the application of chaos theory as a basis for understanding business strategy and the generation of business strategy. Furthermore, some management practitioners have used chaos theory as a basis for catalysing organizational change (Fitzgerald, 2002; Fitzgerald & van Eijnatten, 2002; Van Eijnatten & van Galen, 2002).

In information systems, Beeson & Davis (2000) identified some complexity concepts as being valuable in studying organizational change and information systems, and apply them in a general way to study the implementation of a fingerprint identification system. Ward & Dhillon (2002) applied chaos theory to the analysis of quantitative data from information strategy studies. More recently, Merali (2004) explored the significance of concepts in complexity theory in describing the network phenomenology of information systems.

This range of studies illustrates the wide applicability of complexity theory and, specifically, chaos theory, to phenomena where the interactions between many factors are such that clear cause effect relationships cannot be established, where complex interactions give rise to emergent behaviour and individual effects cannot be isolated. The complex interactions between actors and technology that occur in the development of information systems strategies, the implementation of IS strategies and the development of organizational change in response to information systems may be open to interpretation within a chaos theory framework. There is a need therefore to develop an interpretive framework based on chaos theory that will act as a sensitizing tool for researchers and practitioners involved with information systems in their organizational environment. The following sections explore key elements in chaos theory that may be used to construct an interpretive framework for studying information systems.

ELEMENTS OF THE CHAOS THEORY FRAMEWORK

At its heart, chaos theory is concerned with the initial conditions of a system and the effect of positive feedback on changes in that system (Gribbin, 2004). However, a review of organizational studies literature suggests a number of key concepts that should be incorporated into an interpretive framework based on chaos theory (Kellert, 1993; Beinhocker, 1997; Lissack, 1997; Thietart & Forgues, 1997; Chia, 1998; Gabriel, 1998; Griffin *et al*., 1998; Tsoukas, 1998; Fitzgerald, 2002). These concepts are summarized in Table 1 and considered individually in this section.

Domain of interaction

Any entity, including an information system, exists within a defined and bounded space. This phase space or domain of interaction encompasses all possible states that a system could be in. In interpreting an information system in an organization, the researcher should define the domain of interaction and identify its boundaries. An example of a domain of interaction might be an accounting system within the finance department of a major organization over its lifetime. Within that domain of interaction there is then a finite set of possible events that could occur and outcomes from those events. The domain of interaction will contain the total number of behavioural consequences of that information system. It will define the scope of the information system and the scope of its influence on the organization. The domain of interaction may be the use of an organization-wide information system within a department. Alternatively, it may be the entire internet in which the effects of one agent-based system are traced. The domain of interaction will define the possible connections between the organization and the information system. An interpretive analysis should define the organization, the nature of the information system or systems being studied and the relation with the organization. The effect of the information system may then be examined in terms of the selection of possible behaviours within that domain.

Table 1. Some key conceptual tools in chaos theory

Domain of interaction/Phase space	Scope of influence of information system, space encompassing all possible behavioural consequences.
Initial conditions	Set of initial states of the organization and information system at start of period of change.
Strange attractors	Patterns of behaviour of information systems, organizations and actors; general regularities that are self-similar.
Outcome basin	Subset of the domain of interaction within which the strange attractor iterates.
Events and choices	Incidents, external or internal, planned or emergent, that change information system/organization interactions by amplifying initial conditions through positive feedback.
Edge of chaos	Non-equilibrium point at which critical factors concerning the information system and the organization are poised to force a shift to a new strange attractor.
Bifurcation	Point at which qualitative change between two states occurs, leading to an irreversible organizational transformation.
Iteration	Cycle of repeating behaviour of a strange attractor. Cycle of interaction that provides positive feedback to amplify initial conditions.
Connectivity	Extent and complexity of network of organizational and technological relationships that supports knowledge flow and supports positive feedback.

Initial conditions

The initial state of an organization and its systems at the point where a change being studied occurs influences the dynamics and outcome of that change. Chaos theory suggests that initial conditions are a critical component in determining how the non-linear dynamic behaviour progresses. Two otherwise identical chaotic systems with slightly different initial conditions will eventually diverge greatly, no matter how small the initial difference (Kellert, 1993). Furthermore, slight changes in initial conditions may, through positive feedback, have a large effect on the outcome of an information system implementation within an organization. Such sensitive dependence on initial conditions is a distinguishing characteristic of chaos theory. Beeson & Davis (2000) suggest that small differences in initial conditions or early choices may lead to marked differences in emergent practice.

An interpretive model using chaos theory should be explicit in defining the initial conditions. While cause and effect cannot be incontrovertibly determined or, indeed, reproduced (Thietart & Forgues, 1997), discussion of initial conditions provides a foundation for suggesting explanations for complex organizational outcomes. Initial conditions may include descriptions of technical platforms, organizational structures and key actors. A careful reflection on, for example, the scope and nature of an existing information system and the roles and characteristics of stakeholders may point to significant influences on a replacement information system and its organizational outcome. An interpretive treatment requires the selection of key initial conditions through reflection on the whole case study.

Strange attractors

Strange attractors are characteristic, dynamic, semistable patterns of behaviour that organizations, information systems and actors exhibit over time. Understanding the behaviour of a system involves reconstructing its attractors. Such non-linear patterns of behaviour occur within a defined subset of the domain of interaction. This subset of possible behaviours is known as the outcome basin.

Strange attractors are not steady states, but temporary patterns of behaviour that may be changed at any time. Decisions and factors both internally and externally may 'knock' the information system and the organization out of stability and move the behaviour to a new strange attractor within a new outcome basin. For example, in information technology (IT) governance, the centralization of IT services may be considered as type of attractor that, although evolving over time within the organization, operates within a generally understandable pattern. Changing events, such as the selection of a new IT manager, a decision about which market to be in, a choice by shareholders, or a merger may shift IT governance over to a decentralized configuration in which a new general pattern occurs (Figure 1). Hence, the IT governance system may oscillate between two outcome basins – centralized and decentralized within which a number of variable and evolving managerial behaviourial patterns – the strange attractors – may occur.

Identifying strange attractors in organizational behaviour is an important element of the interpretive process. Such foci of behaviour may be found in patterns of response to organization

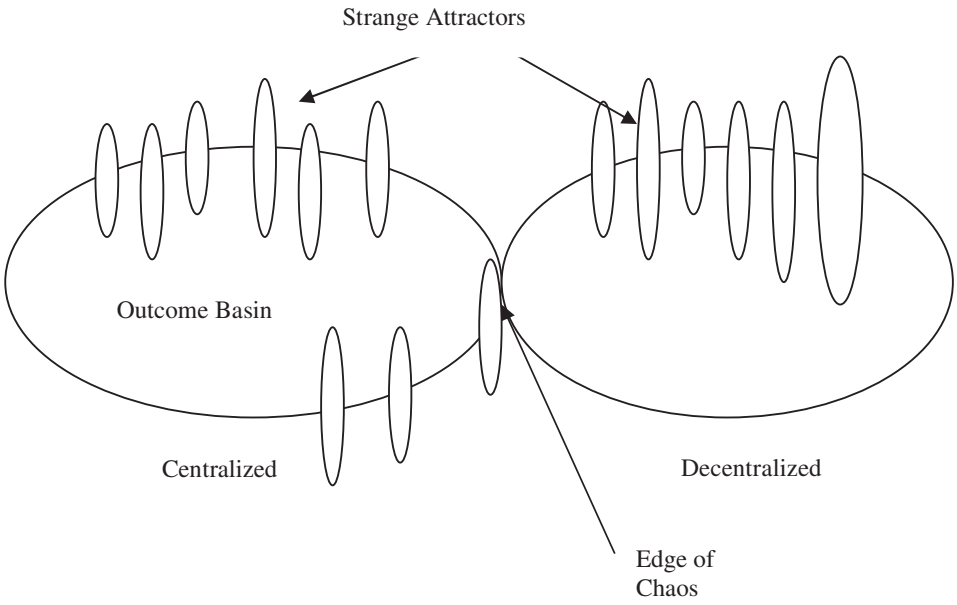

Figure 1. Changing but cyclical patterns of IT governance behaviour within outcome basins.

change initiated by an information system, repeated meanings or interpretations applied by participants to an organizational phenomenon, and values and beliefs that organizations and individuals rally to.

Thietart & Forgues (1995) describe strange attractors within organizations as 'organisational configurations which demonstrate regularities in their macro-characteristics even though they may reveal large differences in their internal processes.' Interpretive use of chaos theory as a series of metaphors for exploring the role and effect of information systems in organizations will involve recognizing general patterns and looking for shifts between semistable attractors and exploring reasons for those shifts. Strange attractors in IS use within organizations may take many forms. Repeated patterns of wrong use of IS and patterns of resistance and acceptance of IS may provide examples of strange attractors involving information systems.

Strange attractors enshrine 'temporary stabilities in a sea of change' (Chia, 1998). The focus of our interpretive use of chaos theory is on this sea of change and the shifts that occur between strange attractors within outcome basins and between outcome basins.

Events and choices

Within the life story of an information system, events occur and choices are made that significantly influence its role in the organization. These events and choices may amplify the effect of initial conditions on the eventual outcome of the information system strategy, its development and implementation and the nature of the strange attractor into which organizational behaviour temporarily settles. Such events and choices may provide positive feedback. This feedback may give rise to emergent behaviour within the organization that could not be originally predicted by examining the initial conditions.

Hence, an interpretive analysis using chaos theory should seek to identify events acting on the information system and choices made by managers, implementers and users. It should also examine the effect of choices that were not made and seek to tease out feedback loops that may be amplifying certain behaviours or characteristics and driving behaviour towards particular strange attractors.

Edge of chaos

External and internal events and choices made by organizational participants may drive the organization away from a temporary stable state towards a critical point where dramatic change results from chaotic behaviour. The edge of chaos is the point at which the system may shift to a new qualitative state in which it expresses new emergent behaviour. This behaviour can be described in terms of a new strange attractor. This change may be seen as a phase transition that results in novel forms of self-organization. (Beinhocker, 1997). When the organization is on the edge of chaos, its behaviour can potentially take one of many directions as it shifts to a new strange attractor. If a domain of interaction is pictured as being a landscape

flooded with water, with two deep pools, separated by a sand bar with shallow water, representing two strange attractors, then currents of water on the sand bar may flow in either direction and are unstable compared with currents flow round the two pools. Using an edge of chaos metaphor to explore information system behaviour in an organization will involve identifying critical points that result in shifts to new emergent behaviour. For example, at what point does lack of information within an organization trigger a shift towards the acceptance of an information system solution?

Bifurcations

For the purposes of this study, a bifurcation can be defined as a qualitative change in the behaviour of a dynamic system. This change may involve a sudden shift from one strange attractor to another, triggered as the system 'topples' over the edge of chaos. Large fluctuations in behaviour may occur as the system takes up a new alternative state. Such a state change is irreversible (see Prigogine & Stengers, 1997). However, following a bifurcation, the next bifurcation could involve a shift back to a previous behavioural pattern or strange attractor; that pattern will not be the same as the previous occurrence of the strange attractor.

The interpretation of the effect of an information system in an organization will involve looking for occasions when the behavioural pattern concerning, for example, the use of the information system within the organization abruptly changes. Alternatively, the occurrence of a bifurcation may involve the splitting of an attractor into two (known as periodic doubling) that will result in the replication of higher level patterns of behaviour at lower organizational levels. Such repetition of higher level behaviour at lower levels is described as self-similarity. Interpreting a case study to identify bifurcations may provide clues to the presence of strange attractors. The use of time lines may help clarify such movements in non-linear organizational systems.

Iteration

Use of an information system results in organizational change which, in turn, changes organizational behaviour. Aperiodic cycles of interaction allow feedback which amplifies initial conditions and contributes to the evolution of the organization and its information systems. Each behavioural iteration within an outcome basin is slightly different to the one before.

Thus, initial conditions are influenced by events and external factors. Decisions or choices are made by actors, including managers and users. The effect of these choices may be to amplify apparently insignificant initial conditions. As further events and choices provide positive feedback to amplify particular initial conditions, the organizational iterations in behaviour move from the centre of the outcome basin to the edge of chaos. At that point, the instability of the system is such that a bifurcation occurs in which the organization shifts to a new set of behavioural patterns representing a new strange attractor. This cycle of chaos (Figure 2) provides a dynamic framework within which to interpret information systems in organizations.

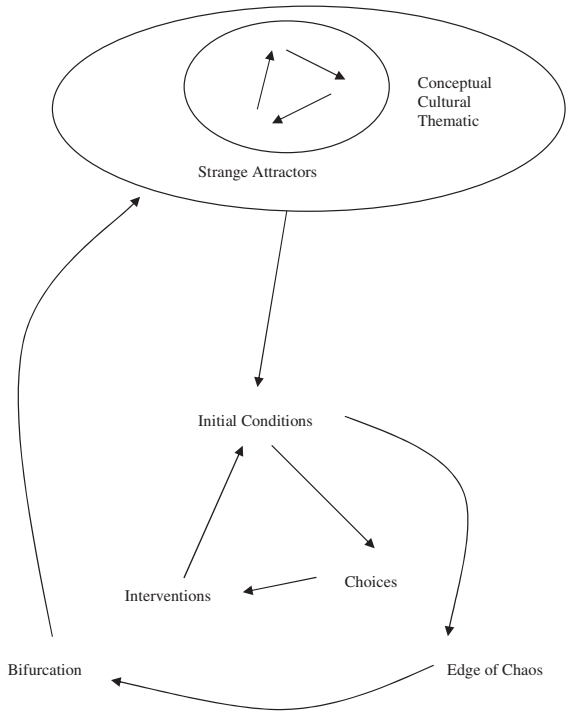

Figure 2. Cycle of chaos.

Connectivity

Organizational change resulting from information system implementation must result from interactions between actors, whether human or machine, within the organization.

Information, values, processes and behaviour are transmitted through relationships which, hopefully, add value to the organization. Lane & Maxfield (1995; 1996) identified the importance of generative relationships in organizations as a foundation for organizational strategy. It is the relationships within the organization and spreading outside the organization which give rise to complex layers of organizational behaviour, to chaotic phenomena and to emergent behaviour.

An organization may be viewed as consisting of a network of relationships, which are supported by information systems (McBride, 2002). Within these networks, subcultures or communities-of-practice may exist (Wenger, 1998; Walsham, 2001a). The interactions within these relationships provide dynamic networks of connection that support knowledge flow, enable the spread of socialization and encourage the growth and death of concepts, ideas and values. They also support the generation of feedback that amplifies particular views, initial conditions and strategies that may already be present in a small way. The vast complexity of these networks of connection within the organization gives rise to chaotic behaviour, cyclical patterns

and strange attractors. The complex networks of interaction support emergent behaviour which cannot easily be reduced to a simple set of influencing factors and is inherently uncertain and unpredictable. Exploring connectivity may be an important element of an interpretive framework using chaos theory as its foundation.

APPLYING CHAOS THEORY INTERPRETIVELY TO INFORMATION SYSTEMS

The application of chaos theory will involve telling a story that traces a historical path, analyses the organizational effects of the IS dynamically, and identifies the unexpected and the margin effects of the information system on the organization (Tsoukas, 1998). By using chaos theory, the development of an information systems strategy, and the progress of an information system within an organization through development or procurement to implementation and use may be described by:

- a set of initial conditions;
- a series of choice or non-choices;
- a set of interventions resulting from choice and environmental effects;
- a set of strange attractors towards which organizational behaviour concerned with interaction with the information system tends; and
- a set of outcome basins within which many strange attractors occur.

The cyclical behaviours of strange attractors within outcome basins and the iterations between different strange attractors may be explored. Interpretation will then involve looking for recurring patterns of behaviours, identifying where feedback is occurring and studying the connectivity of the organizational systems to identify possible conduits of feedback.

The next section discusses some of these ideas using a case study based on the progression of an information systems strategy within the UK Probation Service over a period of 8 years.

Material for the study was derived from probation service documents (Home Office, 1999; 2000), the National Audit Office (NAO, 2001) and a local study of information system strategy in five local probation services (Musgrave, 2000). The Home Office and National Audit Office (NAO) studies provide a detailed description of the progress of the National Probation Service Information Systems Strategy (NPSISS) over its entire lifetime and provided a key text for identifying events that could be interpreted using chaos theory. The local study involved the analysis of local information systems strategy documents, supported by interviews with IS staff and senior probation officers within the five probation services. This study was used as a source of local opinion and comment that linked with the national study (NAO, 2001). It is not the aim of this paper to provide a comprehensive description of the case, which is best obtained from the NAO report, but to provide a chaos theory-based interpretation of the progression of the NPSISS over a period of 8 years.

NATIONAL INFORMATION SYSTEMS PLANNING IN THE UK PROBATION SERVICE

The UK Probation Service is part of the criminal justice system that supports the work of the courts and other justice agencies. It aims to protect the public, reduce re-offending, ensure the proper punishment of offenders, increase awareness of effects on victims and rehabilitate offenders. The service provides reports on offenders for use by the courts, runs bail hostels and supervises offenders in the community where the offender is subject to a community services order or requires supervision following release from a prison sentence.

Until April 2001, the probation service consisted of 54 autonomous regional probation services, funded 80% by the UK Home Office and 20% by local authorities. These local services were accountable to local management committees that were ultimately accountable to the UK Home Secretary. In 2001, the service was reorganized into a national probation service with 42 local areas, which correspond to police regions, and are subject to significantly greater central control and 100% central funding.

The Probation Service's work involves a large amount of report writing, monitoring and recording the progress of community and probation orders. The Service's reports, which assess the risk and danger that the offender represents, and outline community supervision proposals, are highly influential in sentencing and determining release. Supervision proposals are designed to enforce conditions imposed by the court and to reduce the risk of re-offending. The national caseload on any 1 day is in excess of 200 000.

Such services require a large amount of information processing. Accurate and up-to-date information on an offender's activities that is easily accessible and transferable must be provided.

In 1993, the NPSISS was adopted. This committed the Home Office and local probation services to establishing a national IT infrastructure and using a standard case recording and management system (CRAMS). The main contract for both infrastructure and CRAMS development was awarded to Bull Information Systems in 1994. The budgeted project costs of the strategy over 10 years were £97 million. Costs after 7 years were £83 million, 34% above forecast. The full economic cost, taking into account Year 2000 and service costs not allowed for in the business case estimates, was 70% above forecast (NAO, 2001). Home Office targets required all local probation services to be connected to the national IT infrastructure by March 1999. In practice, 47 of 54 services were connected by the end of 2000, and 42 reported benefits from being connected. CRAMS implementation was much less successful. By March 2000, 36 of 54 local services had received a complete CRAMS roll-out, a year later than planned. Ten services refused to implement CRAMS. Only 16 local services were making substantial use of CRAMS. These were generally small services, accounting for only 20% of overall probation services budget (NAO, 2001). Services involved in early roll-outs of CRAMS were sent software that did not work, and a pilot version of CRAMS had to be withdrawn. Some local services experienced severe data migration problems. A wide range of problems led to 12 services using alternative case management systems and 15 services developing systems to supplement CRAMS. In September 1999, work on the development of CRAMS was suspended.

CRAMS was to be maintained and supported but effectively was no longer a viable system. Work began on a successor system, COPERNICUS. However, this was halted 5 months later and rendered obsolete by the development of a new IT strategy.

The following paragraphs apply the chaos theory concepts to identify significant events and behaviour. Table 2 summarizes the relevant elements from the case study.

DOMAIN OF INTERACTION

The phase space of the NPSISS consists of 57 local probation services and a central Home Office unit. The local services are autonomous, but advised by the central unit and work within a common statutory framework, with national standards. The focus for interpretation is the NPSISS, started in 1993, well before the establishment of a National Probation Service in April 2001. The focal aspects of the NPSISS are the IT infrastructure, involving networking and provision of PCs in each local probation service and the provision of CRAMS. Selection of this boundary was influenced by the timescale and scope of the NAO and Home Office reports and the implementation spread of CRAMS. Within the boundary of this social system, a large num-

Table 2. Some significant concepts and behaviour in the NPSISS case study suggested by chaos theory

Domain of interaction/Phase space	57 local probation services, National probation service, IT infrastructure – network and PCs, CRAMS.
Initial conditions	Autonomy of local probation services, Variety of approaches and extents of computerization, Selection of Northumbrian information system.
Strange attractors	Single data store concept, User interface inadequacy, Inadequate management reporting by CRAMS.
Outcome basin	Set of all interactions between CRAMS and local probation services, set of all models of organizational data arrangement.
Events and choices	Selection of Northumbrian system, Selection of Bull, Changing of project directors, Addition of 'Early Warning System, Lack of link to criminal justice system, Local implementation decisions, adding to CRAMS, generating alternatives.
Edge of chaos	Loss of confidence in CRAMS, lack of usefulness of CRAMS, PA consulting report.
Bifurcation	Shift to new organizational structure and appointment of new IT head.
Iteration	User interface repair attempts, management reports production from CRAMS, Rumour spreading.
Connectivity	Formal: lack of adequate centre/local communication, Informal: networks of professional connections amongst local probation services.

ber of variables may be examined. The researcher is inevitably selective in what events, factors and concepts are pursued.

INITIAL CONDITIONS

When the NPSISS was initiated in 1993, there were wide differences in approaches to IT in local services and in the extent of computerization. Systems were developed locally, or in local consortia based on geographical proximity. Systems were stand alone with different data definitions and little integration.

The 54 local probation services were largely autonomous. Many had gone their own way with IT. Local services wrote their own IT strategies within the guidelines of the NPSISS, showing how they would implement their local strategy. There was a general lack of enthusiasm and some resistance to the central strategy. Views ranged from wanting the NPSISS to go wrong, to considering it not ideal but needing to make it work (Musgrave, personal communication).

In 1993, the Information Strategy Steering Committee decided that the new national case management system should be based on an existing system from a local probation service (Home Office, 2000). There was a choice of three existing systems produced in Northumbria, Cambridgeshire and Hereford and Worcester. Based on an evaluation, the Northumbrian system was selected. This single decision had wide implications for the success of the IS strategy and the CRAMS implementation. It turned out to have less functionality, documentation and design material than the evaluation had suggested. The effect of this initial decision was amplified as implementation progressed.

In addition to the initial software problems, the initial organizational environment, in which a central formal committee ran the project, involved implementation in a devolved local service.

These organizational and technical initial conditions had widespread and significant consequences for the eventual failure of the IS strategy. Hence, a first step in applying a chaos theory framework is to examine the initial conditions and to look for events and decisions that have amplified influence later on.

STRANGE ATTRACTORS

Some concepts in information systems act as magnets for strategy and draw everyone's attention, although their practicability may not be really evaluated. They may represent utopian goals that are in reality prohibitively costly to achieve or technically impossible. However, the attraction of the idea is that it is easy to obtain resources and people based on the rhetoric surrounding the concept. Such concepts give rise to repeated behaviour in which the organizational actors attempt to achieve an impossible goal. Conceptual attractors are repeated patterns of organizational behaviour generated in pursuit of a particular conceptual goal.

The 1993 strategy proposed one such conceptual attractor, a vision of relevant, accessible information available to all, based on a single data store in a national database. This concep-

tual attractor was a powerful driver for strategic direction. It acted as a utopian vision which may have been realistically impracticable at the time.

Once implemented, users experienced problems in using CRAMS and found it difficult to operate (Home Office, 2000). Problems with the user interface repeatedly appear in reports and at the steering committee as a major issue. The theme of interface inadequacy behaved as an attractor, surfacing as a main reason for suspending pilot implementations. It acted as a brick wall into which the project consistently ran. The first version of CRAMS, installed in Surrey and the West Midlands in November 1995, was withdrawn by the Home Office in February 1996 because of interface problems (NAO, 2001). In 1997, 'there were some stories about CRAMS within the service suggesting that it was less than a good system and these stories were serving to set expectations and run the risk of rejection of CRAMS' (NAO, 2001). Reports on CRAMS's usability were initiated internally by the CRAMS user group in 1998, and externally by consultants from University College, London, UK in February 1999, by a testing consultancy in August 1999 and by a consultancy in April 2000. The reports were triggered by concerns about usability and confirmed those concerns. Attempts to correct usability problems never seemed to succeed. Thus, several iterations of concern about usability (driven by rumours as well as experience), commissioning reports by consultants and attempting to rectify the problem occurred over a 4-year period. Thematic attractors represent concerns expressed by participants that give rise to patterns of behaviour. In this case, quality of user interface may be a thematic attractor that led to repeated behavioural patterns aimed at rectifying the user interface problems.

The management information capability of CRAMS was quickly found to be inadequate and resulted in national and local attempts to develop report suites. Here, a behavioural attractor iterates four times between March 1997 and May 2000. First, in March 1997 Bull was commissioned to develop test and validate 80 reports. No specification was provided, Bull did no work and the advance payment for the work was returned. Next, in March 1998, Bull was commissioned to deploy GQL, a specialist-reporting software, to provide the local services with the ability to write their own reports. No specification of reports was provided, very few reports were delivered and the project was halted. Then, the Home Office agreed to pay for work done so far if 20 reports were delivered. The reports delivered were unhelpful and basic, providing some operational reports, probably specified by programmers. These were abandoned (NAO, 2001).

A new GQL project was established in January 2000 to develop a set of standard reports. No specifications were provided, and the project was suspended in May 2000 because there was no indication of what reports should be developed and for whom. Here, a behavioural pattern or attractor emerged, based on lack of communication, lack of ownership and lack of specification. The pattern of social interaction involving the IS development only stopped when CRAMS development was suspended.

A further type of strange attractor may emerge from cultural patterns of behaviours and cultural assumptions that are difficult to break free from. Over the course of the IS strategy programme, there were seven programme directors between 1993 and the end of 2000 (NAO, 2001), of which only three had IT experience. The cultural message that IT projects are no different from other projects and need probation service experience, not IT experience, to man-

age them may have been a strong force that may have acted as an attractor for management behaviour. Cultural attractors involve repeated behaviours based on underlying cultural assumptions. Here, perhaps the repeated replacement of the programme director derived from cultural expectation concerning what the role involves.

EVENTS AND CHOICES

The early decision to base the national CRAMS on an existing case management system was a choice that had dire consequences. The system was a VAX-based system that would turn out to be very difficult to convert to a Unix-based Oracle system. The risks associated with this migration were not evaluated technically. Senior officers in the probation service were frightened of the possibility of another big-bang IT project going wrong and saw the Northumbrian system as a tried and tested solution. However, it was not considered that the Northumbrian system did not aggregate data and had been put together on a shoestring budget. The resulting Unix-based system was hard to use, its interface described in one report as illogical, inflexible and unforgiving of user error. Despite being derived from a locally developed system, CRAMS could not produce the necessary information for monitoring compliance with national performance standards. Information had to be extracted manually from CRAMS and typed into a spreadsheet.

In December 1994, the Home Office appointed Bull Information Systems as the prime contractor to deliver the IT infrastructure and CRAMS. This followed the evaluation of tenders by a national group. Tenders were evaluated on technical merits, training provision and financial value for money. The evaluation exercise involved 'huge grids of scores and weighting . . . [it] looked terribly scientific' (Musgrave, 2000). Final choices of system and supplier were made centrally by the IS steering committee.

Events and choices that affected the progression of the NPSISS occurred both nationally and locally. Nationally, the changes in programme director had a negative effect. Changes in the management team also led to problems for Bull in identifying whom to talk to about contractual issues. New centrally generated legislation also affected the NPSISS. For example, an Early Warning System introduced in April 1999 to improve the management of high-risk offenders was not allowed for in CRAMS. This forced local changes to cover for the new requirement. Also, benefits from linking CRAMS with other criminal justice agencies were not seen because of delays in implementing information systems in other agencies.

Locally, benefits from the NPSISS were expected to be generated primarily by implementing CRAMS once the IT infrastructure was in place. Each local service made its own individual choices as to:

- whether to implement the IT infrastructure;
- whether to implement CRAMS;
- whether to use CRAMS;
- whether to provide add-ons to CRAMS; and
- whether to re-engineer business processes to suit CRAMS.

Five local services did not implement any of the NPSISS because of reliance on a common case management system, which they felt was superior to CRAMS. Locally, a myriad of decisions concerning IT infrastructure and CRAMS implementation, involving the definition of local strategies and the addition of add-on information systems and technology increased the complexity and acted as feedback, affecting initial conditions.

The interpretation of a case study will involve (1) selecting choices and events that the researcher believes to be influential and (2) explaining their role in the progression of the information system in the organization.

EDGE OF CHAOS

Changes in staff, technical inadequacies in software, lack of communication and neglected basic information services management processes were among the factors that moved the NPSISS project towards the edge of chaos. Technical inadequacy of CRAMS, arising in part from the selection of the Northumbrian system, and circulating rumours about CRAMS, amplified perceptual and technical problems, strengthening the view of the usefulness of CRAMS and moving many autonomous local probation services to take their own route to supplement CRAMS or look elsewhere for support. Equilibrium was disrupted and, critically, a report from PA consulting on the management processes led to a major shift in organizational structure and the abandonment of previous IS behaviour and strategy. This involved a massive shift of organizational form from the old semistable state to a new semistable state. A new organizational structure was created, a new head of IT appointed, central IT staff numbers were increased from 12.5 to 50 and a new IS strategy was created.

ITERATIONS

Cycles of repeated behaviour can be discerned throughout the history of the NPSISS. Repeated attempts to change the user interface, to provide report suites and to release the CRAMS software are clearly present in the case study. The identification of such iterative behaviour may lead to explanations of why the organizational or social behaviour follows the track of a strange attractor and is, in a sense, doomed to repeat itself. Such behaviours may only be changed when there is a catastrophic shift to a new set of strange attractors and hence a new set of iterative behaviour.

Chaos theory also contains the idea of self-similarity in which patterns of structure or behaviour are repeated at different levels of hierarchy or granularity. For example, patterns of behaviour concerning attempts to extract useful information from CRAMS which were seen nationally and resulted in aborted attempts to generate report suites by Bull, were also present locally where local probation services attempted to extract their own reports (NAO, 2001).

CONNECTIVITY

The nature of the social and technical networks associated with an information system is of key importance in supporting the feedback and amplification of initial conditions that produce chaotic behaviours. The NPSISS business plan did not make provision for extending the network to the Home Office Probation Unit. This may have reduced the quality of communication by the head office with local office.

The IT strategy was run by an IS steering committee which, while having representation by chief probation officers from local services, was very much a central committee with no mechanism for promoting acceptance and ownership of the NPSISS by local services. While the IS steering committee approved initial systems, it had virtually no involvement in their local implementation. In addition, other key decisions including purchasing the third-party reporting tool, GQL, and suspending further development of CRAMS were taken outside the committee by the Home Office.

There was no overall strategy for communicating information about the NPSISS and CRAMS. *Ad hoc* communication with chief probation officers and other probation service staff did not constitute effective communication. Lack of connectivity between the Home Office and local probation services could be contrasted with communication among local probation services which may have served to propagate stories and rumours about CRAMS. Local connectivity supported feedback and therefore the amplification of some initial attitudes about CRAMS, whether supported or unsupported. The heavy workload in CRAMS roll-out reduced the level of communication provided.

Changes in social connectivity may affect the amplification of social messages concerning IS usage and implementation, and hence affect the effectiveness of IS implementation. In interpreting the social effects of an information system, it is important to understand the nature of the organizational and social networks within which it resides. Here, concepts from small world mathematics may be of relevance (Watts, 1999).

Identifying networks of connectivity in this case study would require the identification of connections and conduits of information flow at a local level. Formal reports from the NAO and the National Probation Service only identify the lack of formal communication and connectivity within the dynamic system. The informal connectivity and networks that may have contributed to the amplification of particular perceptions of CRAMS and attitudes to NPSISS would not be visible from the analysis of formal documents. The local study (Musgrave, 2000) suggested that informal connectivity was much more significant and extensive than formal connectivity. Such informal networks would enable amplification of particular initial conditions and enable chaotic phenomena.

CONCLUSIONS

Interpretive research involves the construction of a story about events and suggests some reasons behind them (Walsham, 2001b). It recognizes the subjectivity of both the participants and

the researcher. The participant's statements, whether in interviews, or, as in our case study, documents from the Audit Commission and the National Probation Service, represent a subjective view of events and causes. The researcher also interprets these phenomena through the lens of his or her subjectivity.

This paper explores the use of chaos theory to provide conceptual scaffolding for extending the understanding of information systems in organizations. As a subset of complexity theory, the ideas of chaos theory are based on a view of organizations as non-linear dynamic phenomena in which emergent behaviour results from the interactions within complex networks of social and technical agents. Such complex behaviour may not be open to linear analysis of the factors affecting the organization as the number of factors is too complex and their interactions too involved.

The importance of theories based on complexity theory, chaos theory and non-linear dynamics has grown in organizational and management studies, but remains a neglected source of inspiration in information systems. This paper provides a step towards remedying this situation. I suggest that the core concepts of chaos theory may provide phenomenological support for interpreting organizational interactions involving information systems.

In treating organizations and the information systems that reside in them as non-linear systems, a number of assumptions are made (Lichtenstein, 2000). Change in the system is taken as being constant. Any apparent stable state is treated as temporary. Organizations and their information systems cannot be decomposed into simple elements because the complex interactions between processes give rise to new emergent behaviour. System elements are interdependent and interactions between them are non-linear such that linear causal links cannot be made. Most significantly, for an interpretive use of chaos theory, effects within non-linear systems are non-proportional. Small inputs can have large effects, and large inputs result in no significant change.

The use of chaos theory may provide a framework for describing and interpreting the dynamic interactions involved in the determination of IS strategy, the implementation of IS and the use of IS over a period of time. Ideas such as initial conditions, strange attractors, edge of chaos and bifurcations provide support for developing a coherent and meaningful story that offers valuable insights into the interactions between information systems and organizations. A study of the initial conditions within an organization at the point an information system is introduced may give some indicators as to why subsequent phenomena occurred. A search for behavioural patterns repeated within the organization over time may be valuable, particularly when linked with shifts in organizational structure or IS usage.

Using chaos theory as an interpretive tool will be valuable in concentrating the researcher's focus on the dynamic progression of the information system's involvement in the organization. It will support the highlighting of organizational and individual choices made in the provision of the information system. It encourages the surfacing of dynamic patterns of behaviour that, once identified, may lead to new insights concerning the role and development of the information system within the organization. In particular, chaos theory emphasizes the importance of initial influences on the development of the information system. However, chaos theory is more concerned with the dynamic story developing over time and the social interactions

involved. It may miss important elements required for a rounded interpretation such as culture and power structures if they do not change over the period studied.

The study to which the concepts of chaos theory have been applied involved the expensive failure of an IS strategy in a public sector organization over a period of years. The story is well told in the Audit Commission and Home Office reports. However, in reading the material it became apparent that chaos theory could be used as a framework to draw out significant events and patterns of behaviour. In particular, initial choice and conditions would affect the outcome of the NPSISS. Repeating patterns of behaviour could be identified and examples of chaos theory concepts listed (Table 2). Using concepts from chaos theory helped to explore significant issues arising from the NPSISS case and helped in making sense of the progression of events over time. Application of chaos theory provided practical insights concerning the management of information systems strategies, but it may not result in new theory without further work.

Any interpretation of a case study is inevitably incomplete. Incompleteness is no less an issue with a chaos theory-based interpretation. The complexity of the interactions within an organization and with its information systems is such that only some issues will be highlighted.

Within an organization, there may be many interactions, attractors, and edge of chaos effects operating. The completeness of the picture depends on the depth of focus. As we look further into the organizational phenomena, new initial conditions and attractors may emerge. Like an organizational Hubble telescope, more detailed studies of local organizations and interactions may reveal further organizational attractors like Hubble identifying thousands of galaxies in what was taken to be empty space.

Some key initial conditions may be missed. In searching for patterns of behaviour, some strange attractors may be overlooked because of their complexity. An interpretation may only highlight some aspects of the whole story. Indeed, there may not be enough information to construct a joined-up story.

However, those initial conditions, choices and strange attractors that are identified may provide useful insights into the behaviour of information systems in the organization and may suggest behaviours to be looked for in other future cases. Additionally, to be of value to practitioners, ideas from interpretive framework should be simply structured and clearly defined so that the practitioner, with little time for detailed study, may easily pick up a concept and use it as mental scaffolding.

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Biography

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