Aligning Knowledge Management with Customer Requirements in Mobile Telecommunications

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Keywords

Knowledge Management, Organizational Memories, Artificial Intelligence, Case-Based Reasoning, Telecommunications, Deployment Issues, Enabling Technologies, Intellectual Property.

1 Introduction

In this paper we discuss the challenges involved in applying Knowledge Management and Organizational Memory (KM and OM) techniques in the domain of mobile telecommunications. A variety of AI approaches and methods are necessary to address the technological complexities associated with the rapidly evolving standard specifications of second- and third-generation mobile networks. Mobile telephone technology has been characterized by successive evolutions over the past fifteen years. Each evolution has delivered substantial improvements in the services and functionality offered to subscribers but has been accompanied by major increases in complexity of standards and protocols. Each iteration of the standards has built upon the most successful aspects of the previous generation, plus innovative techniques and intellectual property aimed at providing a superior and enriched end-user experience.

Within the context of a large organization, KM has to align itself with a number of strategic activities and objectives if it is to deliver maximum benefit. We describe the key drivers behind KM projects in telecomms, and emphasise the importance of building knowledge networks to support KM activities. We illustrate approaches for linking corporate strategy to KM using industry best practice methodologies such as *Malcolm Baldrige* criteria and TL9000 certification. A crucial consideration for any technical KM activity is the linkage to Intellectual Property (IP) development, such that the company derives the maximum revenue stream from patent royalties, whilst reusing the IP assets within the company to maximize competitive advantage. We describe how knowledge mapping activities can assist in defining key areas for strategic patent portfolio development, and identify gaps and weaknesses vis à vis the competition. KM activities are characterized by the wide-ranging interpretations of their role and purpose. For the purposes of this paper we define KM as a management discipline that treats intellectual capital as a managed asset. To this end it enables the streamlining and enhancing of Data, Information, and Knowledge, and uses tools and techniques as necessary, including process engineering, organizational dynamics, and appropriate knowledge-based technology. Successful KM must embrace a wide diversity of knowledge sources, especially in organizations whose centres of excellence are geographically widespread and in some cases virtual. Another goal of KM is to cultivate knowledge where it exists within the enterprise, such that the context within which knowledge is used is also captured. This should also lend greater meaning and ease of understanding by relating knowledge to other information sources. These issues are addressed further in Section 3.

2 Challenges for KM/OM in Mobile Telecommunications

The growth in use of mobile telephones over the past decade has been nothing short of astounding, surpassing even the most optimistic analysts' estimates. At the end of the 1980's, high equipment and running costs positioned the mobile as a status symbol. Gradually the adoption by businesses increased, and commercial users began to depend on being able to communicate from anywhere, to anyone, at anytime. To comply with regulatory requirements the cellular operators rapidly expanded their national coverage footprints, which had the consequence of providing a massive increase in capacity. The predominance of daytime business users meant that large amounts of off-peak airtime could be sold cheaply to domestic users, and the mobile phone moved into the mass-market mainstream, following intensive lifestyle marketing campaigns in the mid-1990s.

This model of subscriber growth and new market penetration was replicated across Western Europe and the USA, and mobile network operators began to challenge the traditional domestic wireline suppliers. In developing countries, the fixed-line infrastructure was far less mature, and cellular networks offered a much cheaper method of providing nationwide telephone availability. In addition, the emergence of the mobile telephone as a commodity item caused manufacturing costs to tumble, and the uptake of cellular by the youth and lower-paid communities became viable. The combination of these factors conspired to give market penetration rates as high as 70% by the beginning of the 21st century. This is illustrated in Figure 1.

Such rapid changes in customer demographics have put considerable strain on handset and infrastructure suppliers as they attempt to provide differentiated products, based on global standards, to a broad and ever-changing diversity of network operators and subscribers. Companies have been forced to identify their key strengths and capitalise on them, whilst outsourcing or selling off business units that are not profitable. In the course of fifteen years, companies such as Nokia have transformed themselves from traditional diversified manufacturing businesses into technology suppliers with a highly-developed brand. Others, for example Qualcomm and ARM holdings, have instead sought to build their entire

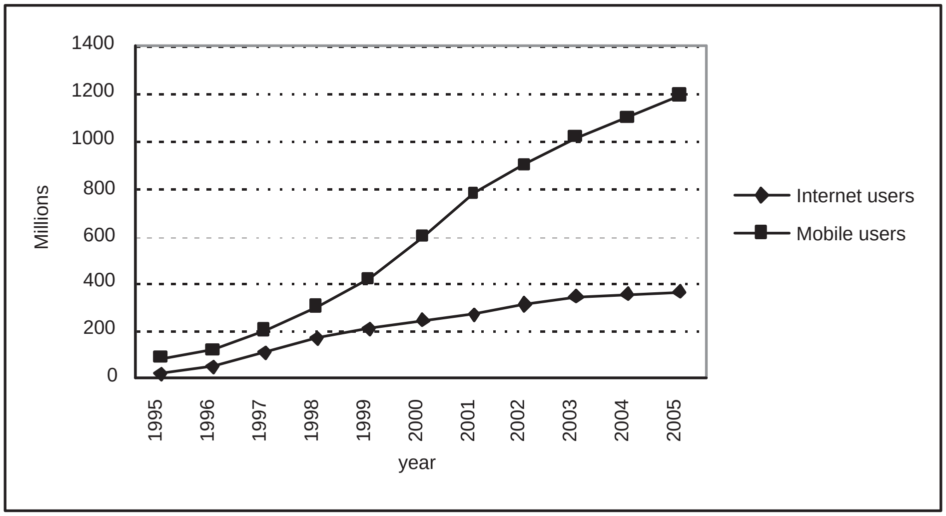

Fig. 1. Predicted growth in mobile subscribers and desktop internet users

business model around licensing of core technology and IP assets. Transformations such as these are only possible in companies that are able to identify and manage their tangible knowledge assets, securing IP rights and copyright as appropriate, and leveraging off their internal intellectual capital with a structured approach to KM and OM.

For network operators, the challenges have been if anything more acute. New subscribers have demanded ever-improving quality of service, whilst competition has forced airtime costs down. To fund network rollout and investment in new cellular technologies such as GPRS and UMTS (3G) licences, the operators have sought to drive down their capital and operating costs through supply chain management.

Two major quality improvement initiatives have been adopted within Motorola and elsewhere in order to meet the challenges outlined above: the *Malcolm Baldrige Award Criteria*, and the *TL9000 Quality System Requirements*. In the next section of this paper we briefly summarise the characteristics of these initiatives, and illustrate their importance to KM activities in our industry.

3 The Malcolm Baldrige Criteria

The Malcolm Baldrige National Quality Award [1] was established in 1987 to help stimulate American companies to improve quality, productivity, and profitability. Motorola was one of the first companies to be granted the Malcolm Baldrige award, in 1988. Since that time, the company has integrated the Baldrige criteria within its own internal Performance Excellence management process, by which corporate strategies are communicated through balanced scorecards to individual business units and ultimately individual workers' performance goals. The Baldrige criteria and assessment process are described in detail in [1]; the framework for the criteria is summarised in Figure 2.

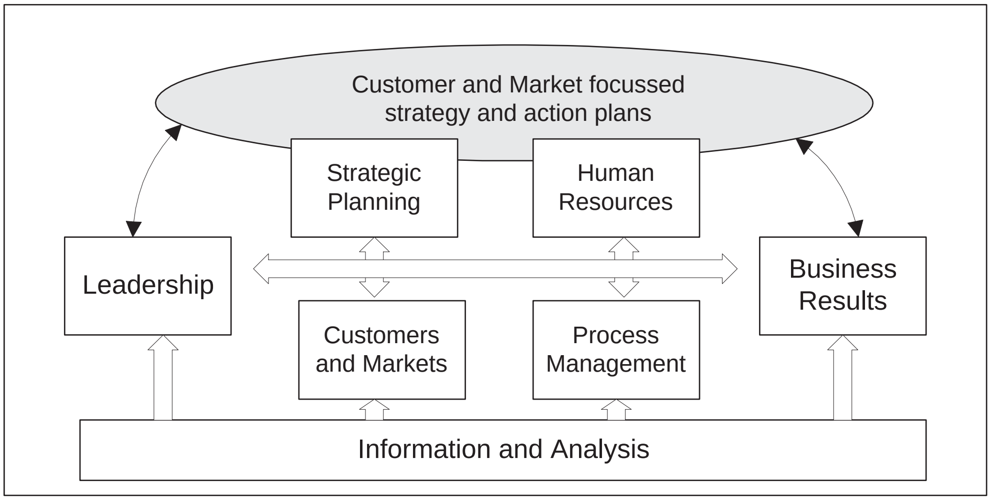

Fig. 2. Baldrige Criteria for the Performance Excellence Framework:
A Systems Perspective.

The framework clearly encompasses all operational entities and business units. The linkage of Leadership to Business Results is performed through Customer Focus, Human Resources development, Process Management, and Planning. Feeding all these activities is an Information and Analysis system. Effective KM has a crucial role to play in many areas, most obviously in the Process Management and Information and Analysis systems.

Underpinning the systems model, the Baldrige Criteria are built upon a set of 'Core Values' essential to high-performing businesses, one of which is *Continuous Improvement and Learning*. This is characterized by the Baldrige Foundation as follows:

> "Organizational learning includes both continuous improvement of existing approaches and adaptation to change. Learning needs to be embedded in the way your organization operates. This means that learning:
> – is a regular part of daily work;
> – is practiced at personal, work unit, and organizational levels;
> – results in solving problems at their source;
> – is focused on sharing knowledge throughout your organization; and
> – is driven by opportunities to effect significant change and to do better."

The relevance of these criteria and core values to the success of any KM activity cannot be overstated, as they encapsulate the board-level sponsorship and commitment which is frequently identified as a fundamental attribute of all successful KM projects. The KM practitioner is thus seen to be directly involved in developing systems, communities of practice, processes, information repositories and workflows which are a necessary part of any attempt to meet the Baldrige Criteria. (Note that although the Baldrige Award is US-focussed, the Deming Prize in Japan is very similar in conception).

The value to the company of pursuing these initiatives is clear: in 2000 the share price performance of Baldrige Award winners outperformed the S&P 500 Index by 4.4 to 1, and has consistently outperformed the index since the comparative study began in 1995 [2]. We show how these criteria can be used to frame requirements for creation of a global knowledge base in Section 5.

4 The Quest Forum and TL9000

In 1996, a number of telecommunications supply companies joined to create the Quality Excellence for Suppliers of Telecommunications Leadership (QUEST) Forum, whose goal was to create a consistent set of quality system requirements for the worldwide telecommunications industry. The Forum reviewed the ISO 9000-series quality standards, and decided that supplemental requirements were needed in the following areas:

- reliability and associated costs;
- software development and lifecycle management;
- requirements for specialized service functions such as installation and engineering;
- requirements to address the unique relationship between telecommunications service providers and suppliers (characterized by a high level of collaboration and cooperative problem-solving demanded by the dynamic nature of the industry).

Estimates for the cost of poor quality vary, but the QUEST forum estimated this figure worldwide at between $10-$15 billion per annum - the potential savings are clearly enormous. In 1998 the Forum produced the TL9000 handbook [3] which is the Telecommunication industry's extension to ISO9000.

The benefits associated with compliance include:

- Enhanced customer/supplier relationships
- Overall cost reduction and increased competitiveness
- Enhanced management and improvement of subcontractor performance
- Creation of a platform for improvement initiatives.

Clearly, the benefits of TL9000 are highly customer-oriented, and they provide excellent drivers for a KM strategy within a large organisation such as Motorola. Some of the goals of TL9000 compliance can be achieved through traditional management and organisation engineering; however we believe many of the requirements can only be met through establishing a KM culture which encompasses processes, communities of practice, and integrated KM systems to manage the corporation's knowledge assets. By adopting these approaches within the context of frameworks such as TL9000 and Baldrige, the KM activity can be directly linked back into corporate strategy.

In the remainder of this paper we describe a case study of how such techniques have been successfully applied within Motorola. We then discuss how this approach may be extended to embrace organisational learning and innovation - exploiting KM as a means for generating new and valuable IP.

5 The Challenges of Global Knowledge Base Creation

In this section we describe our experiences with the construction and maintenance of knowledge base systems and in particular we use the construction and deployment of a global system to elucidate the challenges, processes, gains and drawbacks of such a system.

The TSEC (Technical System Engineering Council) knowledge base is an internal repository of system engineering knowledge: documents, FAQs, cases, problem-solution descriptions, scripts, relevant programs etc. The knowledge is predominantly supplied and controlled by primary and key experts in the field of system engineering for mobile communication networks, and caters for a user base of several thousand system engineers scattered globally throughout Motorola's Global Telecommunications Solutions Sector. The popularity of the knowledge base has been in its ability to provide both a significant search and dialogue tool, and also to allow engineers and business personnel to contribute to the knowledge base. This then creates a more complete and holistic view of the problem domain embodying the depth of technical knowledge juxtaposed with the demands of business direction. The contributions to the knowledge base are controlled via a rigorous workflow imposed on the system whereby all artefacts submitted by authors must undergo both a technical review, for sanity, and an administrative review, for consistency of presentation and to maintain coherency in the overall coverage of the knowledge map of the domain.

The growth of the mobile communications networks have resulted in a dearth of suitable skillsets and a surge in engineering requirements through operations and maintenance and global service offerings. This, coupled with the demands of rapidly changing technology and standards, has necessitated the introduction of information systems that meet the demands of engineers and customers from all levels of competency. It is no longer sufficient to provide just the standard information retrieval facets of text search and hypertext systems (which alone can be tedious to use in the smallest of problem domains and impossible to search in a larger, more complex problem domain). These methods generally cater adequately for single layer, domain/task knowledge bases that are often used in supporting functions. The challenge then is for a knowledge-based solution that provides:

- a central focus for all knowledge intensive tasks;

- a multi-layer, multi-faceted approach that caters for different levels of expertise, different tasks and different levels of abstractions for knowledge usage;
- access to high impact/high frequency issues in greater depth and codification than low-medium impact and frequency issues;
- support for Communities of Practise. The relation here between the community and the system is essentially symbiotic;
- rigid workflow structure but also structure that is easily and quickly adapted to different work practises or business needs;
- a non-intrusive method of enhancing and supporting daily knowledge intensive activities, preventing duplication and divergent mechanisms for accessing and contributing material;
- a focus, centred around a problem domain and not the tasks that a particular user community performs. Traditionally, successful knowledge systems have primarily dealt with typical help-desk scenarios where users are essentially performing similar tasks at similar levels of expertise and have a requirement to provide a similar and systematic outcome for customers. A knowledge base for experts and system engineers working at the forefront of ever-changing technologies and standards, and providing services for customers, requires a diverse view of knowledge in a particular domain. The goal here is to provide a synthesis of knowledge, supporting a cohesive view for *customers* (even through indirect paths) as opposed to a system that merely supports the predefined tasks of workers.
- a mixture of artefacts such that a hierarchical view of the domain is constructed that is invisible to the user. Documents, cases and nuggets of information, hyperlinks, scripts and data are treated in an identical manner as far as the search engine is concerned. The differentiation is created by means of a virtual ontology that serves as a conceptual framework and strategy pointer for the creation and maintenance of the knowledge base. Figure 3 describes the typical knowledge descriptions of such an organisation as we have discussed here.

The TSEC repository had to be globally accessible at all times for all users; consequently it was necessary to provide both browsing and authoring capabilities over a web-based interface, via common web browsers. This eliminates the need for client maintenance and local knowledge base replication, but places additional constraints on the product choices for implementing the solution. Most commercial knowledge base packages provide a rich web interface for end-users of the system, but far fewer have a fully-functional web interface for knowledge reviewers and authors. Furthermore, additional work was found to be required to add structure and semantic content to the user interfaces. This was done through the creation of 'templates' to guide the experts through the knowledge classification and review cycle in an intuitive manner.

The benefits which have accrued from the adoption of the TSEC repository include:

- rapid leveraging of timely information for dealing with customer issues;
- consistency and completeness of task knowledge;

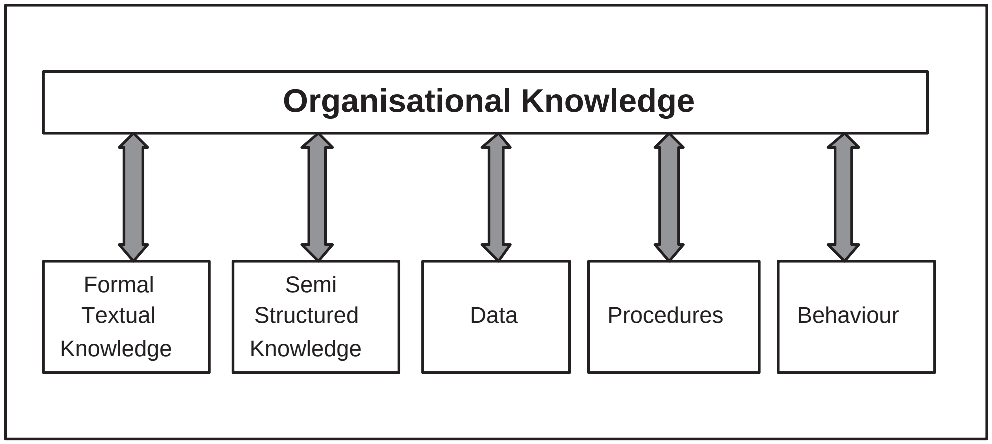

Fig. 3. The Typical Knowledge Descriptions of an Organisation

– business- and organisation-imposed flow of knowledge;
– integration of business strategy with knowledge application and exploitation. This provides a useful platform for identifying gaps in IP coverage.

However, these benefits may only be realised when a process for specification and refinement of knowledge is utilised; such an approach is described in the next section.

6 A Methodology for Knowledge Specification and Refinement

Practitioners of knowledge management recognise the need for process application when building an enduring and relevant knowledge base. Process, in construction and subsequently in authoring provides a common framework for authors, knowledge engineers and users. Consistency in use and in the knowledge repository is a desired attribute of any knowledge base and provides the user with a baseline for expectations of content, and speed in searching. Authors too are provided with a method for gauging knowledge coverage in the repository. The application of a process has proved essential in order to enforce this. The KADS methodology is one such methodology [4]. The KADS methodology consists of several components:

– the task, domain, expertise, and communication models that propose a framework for modelling and analysing tasks, the domain knowledge required to perform them, an expertise model that provides profiling of expertise sources and the communication aspects required to perform the tasks.

– templates for knowledge modelling activities: knowledge identification, specification and refinement.

The KADS methodology forms a realistic starting point for a KM process framework at the level of an organisational memory, however the method and models have been built primarily for extensive life cycles akin to expert system engineering and must be tailored for application to more rapidly changing knowledge bases, such as the information and problem solving knowledge bases in Figure 4. In [5] we describe methods for adapting such a methodology for application to problem solving knowledge bases.

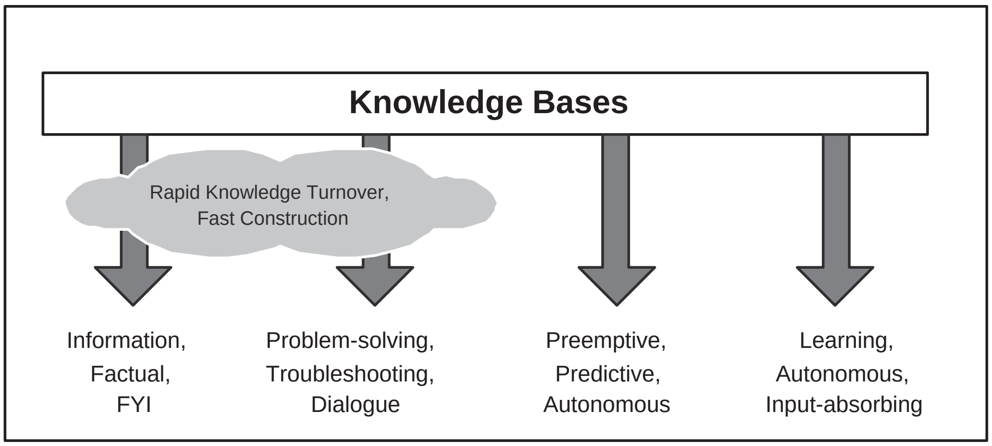

Fig. 4. Common Knowledge Bases Forms

The processes adopted for the TSEC knowledge base have been based on the methods and processes gained through experience of several similar projects, and follow a refinement model that maps the creation of a suitable domain and representation ontology which is then refined to a progressive and usable knowledge inventory, as detailed in Table 1.

Associated with the knowledge specification is the choice of technology, software and user interface. These influence the utility of the knowledge base inasmuch as the knowledge content itself does. The user interface delivers information to the user and offers methods and configuration mechanisms for retrieval. The appearance and meaning of the knowledge can be impacted by the user interface and consequently a user interface must cater for all levels of usage that will be demanded of it. In the case of the TSEC knowledge base, all the relationships between experts from different functions (mentioned in Section 4) were to be catered for, along with different user levels, different tasks and differing task levels and all across a range of mobile communication technologies. Further information and guidelines for user interface construction for such knowledge bases can be sought from [6]. We do not delve further in the discussion about suitable technologies here; we have provided a discussion for the merits and application of Case-Based Reasoning to KM projects in [7].

1 Establish user base and circumscribe domain
  — Identify level of solutions to be provided
  — Identify typical queries to be dealt with
  — Establish level of disclosure for proprietary and sensitive material
2 Construct domain and reference ontologies based on 1.
  — Frequency/Impact based knowledge identification
  — Identify core knowledge
  — Expertise model
  — Communication model
3 Establish key tasks and contexts for user base and link to 2. to create knowledge inventory
4 Overlay business drivers on knowledge inventory
5 Attach workflow and construction and maintenance timelines.

Table 1. Simplified Knowledge Specification for Rapid Turnover Knowledge Bases

7 Organisational Learning, Intellectual Property and Innovation

As we have discussed above, KM within an innovative enterprise needs to address several different disciplines. Figure 5 illustrates how KM can relate the various knowledge-intensive activities within an organisation. Knowledge base development helps capture the expertise of key resources and represents this in an accessible and reusable form. The knowledge represented therein is used to enhance the understanding and exploitation of data gathered from the field - large volumes of statistics, measurements, and other performance information from deployed networks. Improvements in network performance, processes, and designs may generate opportunities for IP development, such that genuinely novel ideas may be protected and exploited. Once defined through the patenting process, the organisation is then well-placed to automate and codify the novel techniques and algorithms which have been surfaced through the application of KM, and to embed them in product. The cycle begins again as engineers observe the behaviour and performance of new products, and begin to organise this information in the knowledge base.

The expertise modelling techniques discussed above can be very powerful in identifying areas which are of critical customer importance and where the performance of the suppliers' products and services presents opportunities for improvement. We have found the application of Altshuller's Theory of Inventive

Problem Solving ("TRIZ", [8]) to be a most useful addition to the KM practitioners' toolkit in this context. This technique, when supported with appropriate software tools, allows the identified domain experts to model the problematic systems under consideration, and then to identify 'contradictions' in the system requirements. For example, a mobile handset may require a long battery life, but must also be as light and small as possible. TRIZ helps the engineer by suggesting techniques to overcome the contradiction which have been found to be useful in other patented discoveries. In this example, TRIZ may suggest 'segmentation', prompting the engineer to separate the hand-held portion of the phone from the battery, and linking the two using Bluetooth or Wireless LAN technology. Some software packages, such as [9], also give the user the ability to search globally for similar patents, to assess quickly the opportunity for IP development.

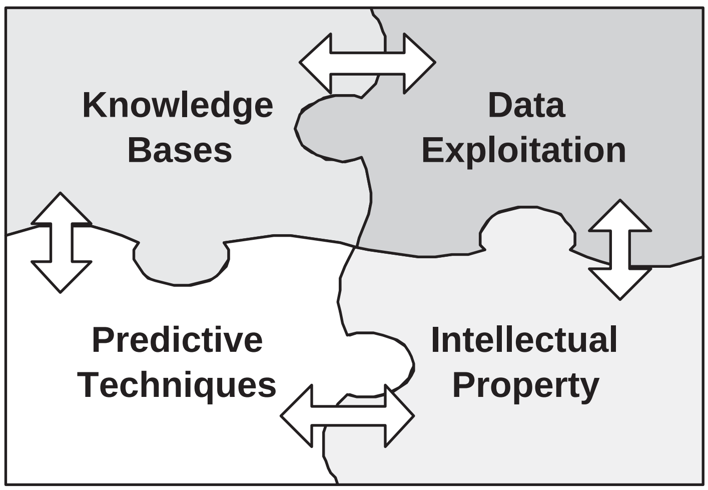

Fig. 5. Integrating KM and AI techniques

Generating a functional model of a system for problem-solving purposes can also identify system components where more sophisticated algorithms and AI techniques may be called for. The TRIZ methodology encourages the systematic reduction in design complexity by 'trimming' - eliminating components from a design by transferring their function to other components. In software systems this is exemplified by the increasing use of distributed computing systems and peer-to-peer computing, where centralised control and decision-making is dispersed to remote components for faster local processing and action. Here, data mining techniques can be used to autonomously generate and adapt the algorithms in the embedded components, often eliminating the need for expert intervention at centralised operations and maintenance centres.

8 Summary

We believe KM and OM techniques can be successfully introduced into any organisation when they are aligned with corporate goals and objectives. This approach mandates a constant customer focus (which allows earned-value to be quantified and monitored), and an integration with other strategic quality initiatives such as TL9000 and Baldrige Criteria; this is particularly important in a rapidly changing business such as the mobile telecommunications industry. Knowledge base development, Communities of Practice, IP portfolio mapping, inventing and innovation, and more advanced AI techniques should be viewed as components of an integrated approach to KM which delivers tangible business benefits to both customers and suppliers.

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