Distributed Knowledge Management Based on Product State Models – The Case of Decision Support in Health Care Administration

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Abstract

Knowledge management has inspired a shift from a transaction to a distributed knowledge management (DKM) perspective on interorganizational information processing. The DKM concept structures the knowledge creation, knowledge sharing and knowledge exploitation in organizations according to a product state model (PSM) required for management of technological diversity. Each player in the network acquires specific knowledge from other players for decision support. This article shows the relevance of the DKM model in a case study of a distributed decision support system (DDSS) in heath care administration in the US.

Keywords:

Distributed Knowledge Management, Product State Model, Decision Support Systems, Health Care.

1. Introduction

The transformation of business in the Internet era will rely upon knowledge-based decision support systems far beyond the present known Internet search engines and data capturing robots, cookies and other agents. A recent empirical study found that large corporations have been increasing the number of distinct technologies in which they maintain capabilities over and above the number of their products [26]. Their range of technological competencies is increasing due to systemic inter-dependence with the supply chain and the widening technological opportunities. Development in these technologies is relevant to the competitive advantage of products and services [2]. Therefore, management of technological diversity becomes decisive for competitiveness [35]. Only by using proper knowledge-based product models can management profit from the diversity [15]. These challenges to management are reflected in a demand for technologies that can help manage knowledge in business corporations [16]. In public administration, attention to the needs of individual citizens has raised public administrative expenditures. This trend puts pressure upon public administration to find more efficient ways to manage the use of information technology [3].

In this article, we present a distributed knowledge management model that structures decision support systems based on product state models among a number of interdependent organizational units. The recurrent information for the decision support system comes from a network-wide support for product state models of the participating organizations.

First, we will present theoretical arguments for the model. The applicability and relevance of the model will then be illustrated in a case study.

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The article is structured in seven sections. The first section after the introduction presents decision support systems and knowledge management followed by a section introducing the concept of a product state model before launching the concept of distributed knowledge management. In the fourth section, we will present an argument for a new kind of decision support called distributed DSS. The fifth section provides a case study illustrating the applicability of the DKM concept. The case shows that distributed decision support systems based on distributed knowledge management generate efficient and high service quality for the stakeholders. This conclusion is outlined in section six. Section seven concludes the article.

2. Decision Support Systems and Knowledge Management

Today, almost all business data are digital and stored in databases, whereas decision-making still relies upon a fraction of these data. Decision support systems (DSS) are build around the concept of a decision-maker presuming well-defined decision making roles within the company. Changes in organization through the 80's and 90's have invested decision-making powers in cross-functional teams and ad hoc working parties, reflecting increased attention to the business environment and technological opportunities [53]. Often, these entities would not use DSSs, mainly because the systems had been structured according to the traditional lines of business. The need for on-going redesign of decision support appeared as the need for best practice cases, guidelines, etc.

Knowledge management has traveled in the wake of BPR projects that have reorganized business processes. New means for knowledge creation and knowledge sharing have been designed to meet the demand for appropriate, flexible and timely customer response.

The transformation of business processes associated with BPR is subject to redesign using knowledge-based systems to cope with the pace of change in organizations [48]. Electronic commerce associated with the Internet generates a momentum for new decision support systems and knowledge-based systems to support new business opportunities in electronic markets [12]. These systems exploit search engines on the World Wide Web to capture information worldwide and the platform-independent access to services on the Internet. While business is changing worldwide, there is a pressure for organization-wide decision support demanding an interorganizational basis.

Parallels to the trends in business are found in public administration and in particular within health administration. Not simply because of the huge funds involved, but because the stakeholders in health administration are organized in ways that span bureaucracies, markets and interorganizational relations – as e.g. local patients, practitioners, pharmacies, regional hospitals, boards at the state level, national health insurance companies and federal government policies and laws – Medicaid provides a fine case to illustrate the complexity and scope for distributed knowledge management.

2.1 Beyond Classic Decision Support Systems

A recent textbook brings knowledge beyond the traditional expert system approach closer to DSS, arguing that any decision-making process has a knowledge by-product. The decision output may be regarded as a new piece of knowledge, but just as the decision itself, genuine new knowledge may also be provided [33]. To varying degrees this by-product may be accumulated and adopted to change the algorithm of the DSS. If it does not lead to a change in the parameters of decision-making, it will act as a passive stocktaking to accumulate decisions.

A DSS is dependent upon knowledge acquisition for design of the decision mechanism and later for input into decision-making. Context defines the nature of knowledge. The definitions of context include four types. The management levels (top, middle, lower and operating personnel), the degree of concurrency (versus serial decision-making), organizational design (determining the kind of interrelationships that exist between managers) and finally the degree of maturity [33]. Different decisions by the decision-maker correspond with the different contexts.

We have also seen multi-participant decision making (MDSS), some in the form of group decision support systems (GDSS) and others as meeting systems facilitating unstructured, creative decision processes. The multi-participant family of DSSs serves multiple types of users with an elaborate structured system accommodating domain knowledge, relational knowledge and presentation systems. Such systems as well as the “decision room”, the “teleconference systems”, etc. have been implemented as wide area information systems, search agents on the Internet, “know-bots”, etc. In each case, the tool performs a decision making step for the user, presenting a set of choices that fits the user’s request without revealing the underlying knowledge management structure of the mechanism.

Neither has the potential of MDSS been fully exploited on the Internet as a cost-efficient channel for distribution of DSS products [38]. The Internet might become an infrastructure for more interdependent models of DSS, extending DSS into multi-participant, interdependent decision support systems, as we will show.

Within the tradition of artificial intelligence, knowledge-based systems (KBS) are developed to capture expert knowledge and to build inference rules. The purpose is to substitute the knowledge-based system for the expert human decision-maker [37]. The AI oriented knowledge-based systems focus substantially on the cognitive issue of individual experts. It has been suggested that re-orientation of KBS towards a knowledge system at the level of organization will bring the present issue of knowledge management into contact with classic issues of knowledge retrieval and knowledge modeling [31].

In this article, we will suggest a more radical model, taking advantage of distributed knowledge management built upon product state models over networks: a model that differs significantly from present knowledge management models.

2.2 Beyond Knowledge Management

Economic organizations have always first and foremost been engaged in converting or applying knowledge to create economic value [55]. Trends that drive management to consider new business models for the extended firm include a multinational-based organization of R&D, production, distribution and marketing, the competitive pressure to innovate, a shorter time to market new products and services, and an increased reliance upon suppliers, partners and specialist consultants [27]. Management has to look for enhanced degrees of automation and integrated routines in order to select and focus on significant decision parameters.

Knowledge management represents issues reflecting the need for solutions of routines insufficiently supported or supportable by the organizational structures of modern business. The scope of knowledge management encompasses individual competence and organization memory, knowledge creation from tacit to explicit knowledge, including the role of organizations in facilitating the creation of knowledge [51].

Japanese manufacturing quality models have generated a new interest in knowledge creation and sharing [41,50]. In these models, knowledge is created within the corporation as part of a cooperation process between workers and departments. Polanyi [56,57] provided the distinction between tacit and explicit individual knowledge. Nonanka & Konno’s [49] contextual knowledge creation in an organizational framework placed knowledge in a collective memory as social knowledge, known also from Spender's view of social or organizational knowledge [67]. Whatever the industry, organizational knowledge can be achieved if the proper organizational routines are available to process tacit knowledge [69].

Today, knowledge is considered an asset when shared with other employees at the level of knowledge rather than at the level of functional tasks or as the product outcome of the division of labor. Thus, it is the interchange of knowledge *qua knowledge* that represents the significant change in the management of knowledge compared to previous ways of managing knowledge [31]. Ultimately, this implies seeing the firm as a distributed knowledge system [71].

The classic questions of KM were how to motivate specialists to share their knowledge [70], how to make employees capable of sharing knowledge [13] and how to balance historical knowledge with current knowledge through "organizational learning" or through codification changes.

The first models focused on knowledge acquisition issues much along the lines of AI research a decade before [17]. The challenge to management in knowledge-intensive businesses became how to make team members in knowledge creation contribute efficiently to share their business methodologies to provide for the clients' needs [52]. Incentive schemes have moved to the fore as knowledge management is now a high-priority management objective for the organization.

Means of sharing took the form of a knowledge repository much inspired by enterprise resource planning models with a centralized corporate database. In the second kind of models, we find information quality issues along with best practice objectives that take knowledge across functional entities between divisions or subsidiaries to make knowledge an organizational asset [17]. Disseminating knowledge was a matter of information retrieval and acquisition by each user as seen fit. Little or no decision support was offered from these repositories. What they offered were results from previous learning that could only be accessed if its existence was known.

A third kind of models moved to widen the scope of knowledge management by including business partners in a broader network of knowledge exchange. In particular, manufacturing and service suppliers in customer support took advantage of the Internet in moving knowledge beyond organizational boundaries [22]. Supply chain information exchange attracted attention with its scope for increase of overall efficiency. Supplier-buyer relations have been studied for years as a mix of efficiency, revenue sharing or power asymmetry. Recent findings have discovered that these relations are long-term relationships that build on mutual trust, cooperation and broad-scope relationships adding up to strategic partnerships with balanced relation-specific investments [5]. The inter-organizational relationship, whether considered from the strategic perspective of technology management or the operational perspective of buyer-supplier relationships, concludes on the same note of a broader partnership. Unlike previous, often hypothetical, discussions of virtual organizations, knowledge management systems in the supply chain network provide a potential to enhance the performance efficiency of everyone participating in the network [68].

The sequel to knowledge management has been the application of information technologies, first represented in the acquisition of knowledge in a knowledge repository and later represented in network models like intranet and extranet [16,63].

The question we are facing is how to create knowledge management for the exchange of knowledge with business partners. The traditional dichotomy of acquiring information either in *reactive* mode [23] with a specific decision to make or in *proactive* mode to scan and monitor the environment to detect problems is not preemptive. Between the reactive and proactive modes we find the network of interdependent decision-makers acting on information specificity. Knowledge management should contemplate the configuration supplementing network theory that explores "co-specialized assets, joint control, and collective purpose" [1, p. 86].

The knowledge management literature has structured knowledge creation, sharing and exploitation at the level of the organization, but has little to offer at the level of interorganizational relations.

3. Distributed Knowledge Management and the Product State Model

3.1 Product State Models

Revisiting knowledge management literature did not give us the conceptual foundation for interorganizational knowledge management, although we found prolific evidence of a need for such models in the management literature. The literature on interorganizational relations takes two quite different directions in regard to information systems – one is a strategic business model discussing partnerships and the other is electronic data interchange discussing data models. Neither vindicates a model of knowledge management at the level of interorganizational relations. On the other hand, observers of business life find business conducted in markets, organizations, and in many intermediate forms of collaboration, for example joint-ventures, alliances, partnerships, and international product teams [10,58,59].

In the absence of a general information model in knowledge management, we offer an extended product model, a product state model (PSM) developed within engineering systems [43]. The data and data interchange defined for manufacturing products address the need for modeling before manufacturing in order to detect necessary adjustments in consequence of version changes, changes requested at the shop floor, or changes in intermediate products, etc. [36,42,43,65].

The PSM model can be generalized after re-interpretation to the issues of interorganizational knowledge management. The economic models of technology have been greatly developed and elaborated within the last decades, giving support to re-interpretation of the product state model in the general term of technologies conceived as capabilities, i.e. technology as a complex of knowledge issues covering know-what, know-how, and know-why [15,26,46].
A product state model describes the knowledge guiding business and technical processes that provide for development, procurement, production, provision, use and disposal of a specific product or service. The complete knowledge representation of the processes and components of a product or service we call a *complete* product state model (CPSM).

3.2 From Product State Models to Distributed Knowledge Management

Let us now turn to the case of applied theory for business. In practice, no economy provides for CPSMs representing only a theoretical case of complete knowledge. We argued above that business management is required to cope with systemic technologies of a variety that poses limits to knowledge in the single business unit in a market economy. The reason for considering knowledge management in a business economic context is incomplete knowledge of technologies and imperfect markets for technologies (as knowledge).

Instead of an economy of perfectly competitive markets, we will look at workable competitive markets with N business units each with an incomplete product state model, where N is neither very large nor very small.

Assumption: $0 \ll N \ll \infty$

Given this assumption, there is scope for a distributed knowledge management approach with N product state models, each of which contributes knowledge to some other business unit. Each business unit requires information from others to enhance the decision-making quality related to its product state model while at the same time contributing information to other units.

We do not consider the equivalent of a *complete* PSM as the sum of *N* product state models because we do not assume perfect procurement, production and provision for all business units and for all products when we have incomplete markets. There are several reasons for this. First, there is rarely a choice of just one technical path. The vertical structure is subject to imperfect economic valuations among alternative, but incompatible (non-substitutable) technical paths. Furthermore, some technologies may be complementary [47]. Second, the formation of a vertical structure is not an automatic market outcome. It is subject to discrete business decision-making in several business units. Finally, the competition between companies has moved into competition between chains, alliances and other kinds of groupings of companies reflecting the systemic nature of technologies in products and services. Product and services are rarely provided by a single business unit, but by several more or less interdependent business units [10]. Considering several PSMs for a single product or service - since neither a single unit nor *N* business units manage the complete PSM - will create the option of competing PSMs for the same product or service. The “end-to-end” business processes take place across a number of business units where the structure of value added within each unit is due to competitive market processes and organizational decisions. The complete product state model is not determined by a vertical economic and technical structure identified *ex ante*. It is broken up into a number of *partial* PSMs reflecting the division of labor in a market economy. Boundaries of rationality, on-going technological development and tacit technological knowledge entering the PSM preclude any option of constructing the complete PSM. A partial PSM may be no less useful irrespective of the lack of a complete model because it identifies the core capabilities and competencies of the corporation and detects the technological and business process interdependencies that require close observation and possibly countervailing strategies [27,72].

Given these constraints, management is obliged to limit the product state model to certain parts of the theoretical, complete product state model. Where this limitation is insignificant compared to the complete model, a knowledge management approach is unjustified, if not irrelevant, which is also the case with very simple products or services.

For very complex products and services, a product state model will be both distributed and incomplete: distributed in terms of a number of different contributing business units; incomplete in terms of the bounded knowledge scope in each of the partial product state models. Each business unit operates a partial product state model that is contingent upon access to information from other business units relevant to the maintenance and development of their product state model. This information may not be available for free. Therefore, if each partial product state model is incomplete in itself, the summation of all the partial models will not add up to a complete model. Therefore, we never find complete market systems for complex technology [2].

Specific knowledge (e.g. know-how) within the confines of a business unit is required to make up for the lack of complete markets for technologies that the unit depends upon in operating their primary technologies. The unit needs to know how to adjust their technology to other intermediate or complementary technologies that they procure for development, production or provision. Even multi-technology corporations have distributed rather than distinctive core competencies [26].

In contrast to assumptions in the classic concept of knowledge management, the theory of a partial PSM *rejects* internal knowledge (tacit or not) as a sufficient basis for knowledge management for non-simple products and services. Only if a complete product state model can be established is the idea of knowledge management from within the single business unit tenable, making a distributed knowledge management model superfluous. The idea of distributed knowledge management is relevant where several business units each contribute to a partial product state model of the product or service.

3.3 Distributed Knowledge Management

The management of business units copes with incomplete knowledge by entering into a business network (vertical structure) with exchange of specific knowledge in support of their product state models, creating a distributed knowledge environment. We model this inter-unit business environment in distributed knowledge management.

Management of the technologies and business processes within business units amounts to what we call knowledge management. The *distributed* knowledge management model moves the focus from the structure of a *given* product state model to the *dynamic* changes in the product state model [40]. It is only by incorporating the relevant technologies and business processes of several PSMs that an incremental enhancement or a radical development in non-simple products and services can be realized. Keeping the change of a (partial) PSM within the confines of a single business unit places severe restrictions on the changes. However, changes are bound to take place in a product, if not before, then later in a mature product's demise if subject to the laws of the product life cycle. In order to keep up with users' demands for change in a product or service, the management of a PSM is bound to reach into knowledge residing in the PSMs of other business units and in other sources of knowledge. How does management do that?

In a now classic economic analysis, the insufficiency of markets regarding this type of information was established [62]. Instead of competitive markets, we find interorganizational relationships, collaboration, and other forms of relationships, which supplement the imperfect markets for technologies. The characteristics of the PSM, the nature of the relationships that management has established with other business units, and the maturity of technology markets will determine access to product knowledge. It is expected that the more collaborative the relationship, the more freely will knowledge be exchanged between companies. Many studies of informal exchange of technology between engineers have shown the importance of mutually beneficial exchange relations, which means that only if you have something to offer yourself will you receive something from others [32]. The relationships between business units in distributed knowledge management may also find predecessors in the more formal interorganizational relations.

What has distributed knowledge management to offer? The generic idea of DKM combines the interdependence of one partial PSM to others with the idea of knowledge acquisition rather than just the operational exchange relationship. The exchange relationship nurtures opportunities for growth, enhancement and improvement beyond the present state of affairs. In fact, the very idea of the complete product state model sets the agenda for distributed knowledge management, i.e. the idea of the complete and perfect model as an ideal vis-à-vis a parochial view. While the ideal product state model does not materialize in all but the simplest products and services, it is an ideal to which everyone makes every endeavor to approximate as much as possible.

In terms of knowledge creation, the DKM model emphasizes the opportunities of learning from gaining access to knowledge about contingencies and implications of organizational activities. It is characteristic of the generic product state model that it includes data on the product not only in terms of design or maintenance, but it also provides opportunities for product enhancement and improvement during the product's life cycle, thus accounting for process innovations and product improvements. Applying recurrent specific information to a PSM is to emphasize the life cycle aspect that at any given moment characterizes a product state model, showing the position of the present performance in light of opportunities.

Another characteristic of DKM is the idea that knowledge sharing is not about sharing the "same" information, but about gaining access to the specific information that will enhance and develop the particular knowledge of an organization. This idea reflects a division of labor penetrating knowledge management, but with the difference from the manufacturing division of labor that knowledge has less specific boundaries than any particular product. Sharing knowledge requires an interorganizational network for an efficient recurrent interchange of specific information.

Finally, we recognize the opportunities for exploiting knowledge to invent, redesign, redevelop and shift ways of operation by funding research and development activities in almost every major business organization. The preconditions and power to change routines have become embedded in organizations.

In practice, life cycle models have been on the agenda in quality management, for example in ship maintenance schemes required by insurance companies, and product models have been applied to product design. Total life cycle models that include scrapping or recycling of materials are now applied e.g. in the automobile industry in Germany.

PSM applications, containing design and product models in a life cycle context, offer opportunities to review implications of design and manufacturing at less cost than if revisions had to be implemented after plants, machines, tools, etc. had been constructed [44,61]. Today's objective is to bring real time PSM into manufacturing, offering agility, on-going opportunity for revisions of production schedules, designs, etc. in response to customer use, demands and market changes. Yet there has been no widespread use of product state models. Governmental, environmental protection schemes or voluntary, environmental certifications of companies all take advantage of environmental state models of (manufacturing) sites. Other fields of public administration that are as sensitive as environmental protection to public opinion are public health services, where scientific results have next to immediate impact on administrative procedures, medical plans, insurance claims, subsidies, etc.

The merging of the life cycle, the product and the product state models into life cycle-based product state models requires a more extensive knowledge exchange and product modeling than classic DSS and KM systems. The case of the Arkansas Medicaid health care program holds many of the specifications of a distributed knowledge management system based on product state models. Before presenting the case, we will elaborate on some implications of the DKM model with respect to decision support.

Summing up, the concepts of decision support systems (DSS), knowledge management (KM), and product state model (PSM) constitute the foundation of distributed knowledge management. The purpose of DKM is knowledge exploitation of a particular business domain.

The next section will show how PSM embedded in distributed knowledge management creates a case for a new kind of decision support.

4. Decision Support for Distributed Knowledge Management

Information versus knowledge or the partial versus the complete or the structured versus the unstructured representation of meaning has been posed as a challenge to the significance of management information systems for many years [53]. Why are these concepts persistently conceived as opposites? The problem is as old as the logic problem of parts and wholes, where Russell and Whitehead found that the whole is more than the sum of the parts, stating the existence of an organizing principle as the n+ element that is not an element itself. This "handling knowledge" has been called procedural knowledge, to be distinguished from descriptive knowledge. Reasoning knowledge adds know-why to the know-how of procedural knowledge [33]. We need knowledge of another order than descriptive knowledge to arrive at reasoning and procedural knowledge.

The kind of information in which we take an interest is asset-specific, by which we mean that only information relevant to the product state model is of value [11]. The product state model reflects the state of knowledge at any given time in the history of the product and is a platform for a variety of data on engineering properties. The PSM also addresses data on prices, customer usage, data on customers, dealer information, distribution channels, etc., all as far as it is relevant to the performance of the companies contributing value added to the product reaching end-users. In this sense, descriptive knowledge is required.

The network of businesses offers an exchange of information that feeds into the PSM of each business in such a way that the operational decisions are made efficiently, and at the same time there is information that fits the development of the PSM of each company. Thus, electronic networks form an essential part of any DKM. We consider each player in the network as managing knowledge about the PSM as well as the specific information required to take advantage of the PSM in decision support systems. In decision support models, we find a claim for both kinds of inputs [33]. On the one hand, decision making based upon the received information, and on the other, information processing required to adjust the present decision making model, i.e. to undertake the revision of decision parameters related to the product state model.

The distributed knowledge management model captures relevant on-going changes in the external and internal business context of the associated DSSs, reflecting changes in the PSM. The changes in PSM may require adjustments or modifications in a DSS according to examinations. The PSM changes due to improvement, enhancement and other impacts from knowledge creation and sharing based upon information exchange among the partners in the network. The DSSs operating in the network in different value-added processes will be adjusted to the new PSM if the difference to the previous state of parameters has a significant impact upon the decision-making effectiveness or efficiency. This timing may vary across business units and PSMs.

Not all companies in the network may need to reconsider the PSM of their core business in each of the networks in which they participate. Some networks may exchange specific information of high relevance to the company, whereas others may hold less valuable information in regard to the PSM. A cost-efficient participation in a DKM network depends upon the company's internal information processing requirements and its capacity for making good use of the information which, of course, is strongly influenced by the received information's impact on the PSM. Building decision-support systems to handle speed and timeliness of information, amount of information or variety of information, etc. generates knowledge or inputs to knowledge acquisition [4].

Information technologies support data acquisition and processing for decision-making. This is also the case where several different aspects of a PSM depend upon information from a number of business units or markets. On-going processing in decision-support models getting data from various sources is found in many different contexts: forecast and warning services (weather, hurricanes, earthquakes, etc.), market development assessments, error detection and tracking in complex telecommunication systems, and many others. When we also reach into different business units with interdependent decision makers, the category of multiple organizations applies [37].

The variety of known decision support systems is presented below in two dimensions.

	One Decision Maker	Multiple Decision Makers
One Organization	Classic DSS	Conference systems
Multiple Organizations	Multiple DSS, Group DSS, Organization DSS, e.g. search engines on the Internet	Electronic market trading systems

Table 1: Types of decision support systems.

The combination of multiple organizations and multiple decision-makers represents electronic market trading systems, where information systems support both supply and demand for products. In financial markets for electronic currency, shares and bonds, the DSS represents each market as a current price and offers an opportunity to buy or sell. From a knowledge management viewpoint, this is a simple system because only price information is exchanged. Financial news reaches the dealers almost as fast as prices in the electronic market compensating the dealers for this information paucity. The system presents the latest price reflecting the latest deals. It also offers the dealer the choice of configuring graphic presentations of historical prices, listings of major financial news and other information processing needed by the dealer to decide whether to buy or sell. The financial information systems qualify as decision support for dealers.

These decision support systems do not preempt the decision support for distributed knowledge management. The DKM model imposes a contingency upon DSSs that is particularly relevant to the product state models and which is not made explicit in the above table. In the example above, we saw combinations of multiple organizations and decision-makers where prices in electronic markets represent a decision-making interdependence between all participants. In the DKM model, we 'generalize' price as an instance of descriptive knowledge into the product state model. However, price is not sufficient, descriptive knowledge to act upon in a market economy with imperfect markets. We need to exchange much more than prices to entertain product state models. This is the difference between knowledge in PSMs and prices. The common denominator between DKM and price is the contingency of all participants in terms of previous trading in the market. DKM requires that each PSM reflects the status of the other models because all PSMs are interdependent. If we had a completely mechanical interdependence, all PSMs would have to change in ways exactly matching each others' change to make the "machine" run. This is too restrictive a metaphor for the knowledge-based interdependency between PSMs. It does not reflect the tacit knowledge that is also present in a DKM.

We can distinguish the DKM model from other types of information systems on the dimensions of interdependency and multiple decision-makers. Information systems include information technologies as well as organization (see Table 2).

	Single User System	Multi-Participant System
Independent Decision Making	Classic DSS	ODSS, GDSS
Interdependent Decision Making	DSS with knowledge by-product, e.g. search engines	DKM Networks

Table 2: Types of IS for decision making.
Note: The abbreviations are: Organization Decision Support System (ODSS) and Group Decision Support System (GDSS).

The dynamic interdependence between PSMs explains why DKM requires a specific type of decision support that is not represented in Table 1 above. Within an organization, any decision depends somewhat upon previous decisions. This is partly reflected in the concept of organizational "memory" and learning [24]. The DKM model extends the concept of memory to include PSM-relevant decisions made in other businesses. The decisions made in one business unit are real in their consequences to all other businesses in the distributed knowledge management model.

Translated into DSS, this means that the change in one DSS has an impact upon other DSSs that in turn have an impact upon other DSSs, etc. Depending upon the scale and scope of change in PSMs inflicted upon the DSSs, we may see a spiral of changes in the PSMs, and thus a dynamic change of the overall DKM.

	Knowledge creation	Knowledge sharing	Knowledge exploitation
Knowledge Management	Cognitive models	Organizational Learning	Best Practice
Distributed Knowledge Management	Product State Models	Interorganizational network support of Product State Models	Distributed Decision Support Systems

Table 3. Knowledge management models.

When considering information technologies in support of decision making within DKM, the specificity of these DSSs is the generic interdependency. The differences between KM and DKM are given in Table 3 above.

The distinction is made to acknowledge an interdependent, multi-participant DSS. Stressing the asymmetric knowledge sharing in DKM leads to an aspect rarely considered in DSS, namely the interdependency between independent DSS applied in independent organizations!

Decisive for DKM is the construction of data interchanges conceived in a knowledge management context of several product state models and encompassing several independent organizations. Equally decisive is the exploitation of acquired data in the product state model. As indicated previously, information systems support is a sine qua non for the construction and maintenance of a product state model. Systems support for the PSM does not match any DSS scheme. No DSS model takes into consideration the submission of an information by-product for a third party as an integrated process of the data acquisition for the next decision cycle (what might be called the "double loop" of decision-making in DKM). This extension of the decision cycle constitutes a higher order of complexity compared to what is included in the description of a DSS application. In this respect, DKM represents a new challenge to the concept of DSS. This kind of DSS we call a distributed decision support system (DDSS).

Considering the generic characteristics of DKM, these are described in regard to knowledge creation, sharing and exploitation. For each of these, we stipulate that the framework of decision support needs to include the critical issue of access and sharing of data. A precondition for a mutual trust in knowledge exchange is to understand the DKM model in some detail. The (restricted) publication of data perceived as confidential introduces a competitive risk to the participants who release it. Since every participant in a DKM network offers data and receives data from some other partner, it is a mutual risk. It may not seem to be a symmetrical risk. Consider the interdependency of PSMs: the validity and reliability of data offered is a precondition for validity and reliability of data received. This precondition does not automatically apply to exchange of any data. It is the result of a premeditated way of constructing and validating data. In the health care systems case, we find data exchanged in mutual trust of their validity and reliability as well as data made subject to verification procedures.

In general, it is not possible to determine the amount and kind of information technology and applications support suitable for DKM. It is not done with a data warehouse with the DSS taking advantage of it! A PSM requires extensive data acquisition and processing capacity, and the integration of logistics adds to the number of applications. Not a single application can support DKM. The enterprise resource planning systems that encompass the organization's manufacturing, accounting, logistics, human resource management, etc. equivalent to the application modules implemented may become a vital part of a PSM if supporting the logic of data modeling in PSM. The critical issue in DKM is the data access on a continuous basis. This is a matter of business policy and stakeholders' interests more than it is a matter of data definitions. It is only if persuaded by generally accepted theory or by examples that management will risk their information autonomy, although it may be a freedom of the ignorant.

The exposition of DKM is supplemented with a case study that in some detail illustrates the principles advocated and presents a set of technologies applied for the purpose of distributed decision support.

5. A Case of Decision Support in Health Care Administration

5.1 The Case of the Arkansas Division of Medical Services

The purpose of the case study is to illustrate the applicability and relevance of the Distributed Knowledge Management Model. The case study is based on a project undertaken by the major information technology service company Electronic Data Systems (EDS) in cooperation with the Arkansas Division of Medical Services (DMS). The case provides some insight into how the Health Care Administration is being fundamentally transformed [7,28,29,60,66].

The Arkansas DMS administers the state's Medicaid program. The Medicaid program is nationally funded by both federal and state contributions. The Medicaid program is intended to provide for nursing home care. Supplementary to the Medicaid program is the Medicare program, which is intended to provide acute care for hospitalization, visits to a doctor's office, medical tests, and a limited amount of skilled nursing care for recuperation from an acute illness [8]. The Medicaid program has evolved in three decades into a $150 billion public health care program, serving approximately 36 million beneficiaries in the U.S. [9].

The challenge of the Arkansas DMS is to balance quality care with low program costs for low-income patients. The problem was that patients often went to emergency rooms and clinics for treatment. They seldom saw the same doctor more than once or twice. Therefore, doctors had to start new and basic examinations each time a new patient entered the clinic for treatment. This procedure added unnecessary costs, wasted time, and would also potentially reduce the effectiveness of health care.

Arkansas DMS officials recognized that doctors had the opportunity of serving patients best if they understood the medical history and treatments of each patient. As the Arkansas DMS was faced with the fact that service to low-income patients under the Medicaid program increased, the situation called for finding a way to forge lasting relationships between patients and primary care physicians.

Persons who are eligible for Medicaid belong to the following categories [30,45]:

- Persons receiving Supplemental Security Income (SSI), i.e. persons older than 64 and blind or disabled adults and children. The Social Security Administration determines SSI eligibility
- Participants in aid to families with dependent children
- Participants in the Under-18 Program
- Aged, blind, or disabled persons in nursing homes who meet state eligibility requirements for long-term care
- Children younger than 21 who are in foster care
- Individuals covered by the Supplemental Omnibus Budget Reconciliation Act, i.e. the pregnant women, infants and children program
- Infants born to Medicaid-eligible women
- Individuals eligible due to disregard of social security cost-of-living, earned-income, or child-support increases
- Qualified Medicare Beneficiary (limited to cost sharing of Medicare services)
- Specified Low Income Medicare Beneficiary (limited to payment of the Medicare Part B premium only)
- Persons receiving home and community-based services
- Disabled persons younger than 19 who are receiving care in their homes and would be eligible for Medicaid if they were in institutions
- Illegal aliens (emergency services only)

Persons who are not eligible for any of these programs may qualify for Medicaid through the Medically Needy program, depending on their incomes, resources and medical needs.

The Arkansas Medicaid Program covers 12 federally mandated services and several optional services. With more than 415,000 potential Medicaid recipients in the state, program administrators faced three mandatory tasks for each case: 1) confirm patient eligibility; 2) find a primary care physician to stay with; and 3) pay doctors, pharmacists and hospitals promptly. Failure to achieve any of these tasks could lead to untreated ailments, rising costs and reduction of the federal grants needed to fund the program.

5.2 The Medicaid Management Information System

The Medicaid Management Information System (MMIS) of the Arkansas Division of Medical Services as at the end of 1999 consists of two parts: a) a core data repository (called AEVCS), and b) a decision support technology (called MFADS). The AEVCS is a point-of-sale medical claims and data collection system. This system has been enhanced with advanced decision support capabilities. The MMIS is able to analyze trends, monitor results and improve the quality of health care for its beneficiaries: cf. Figure 1.

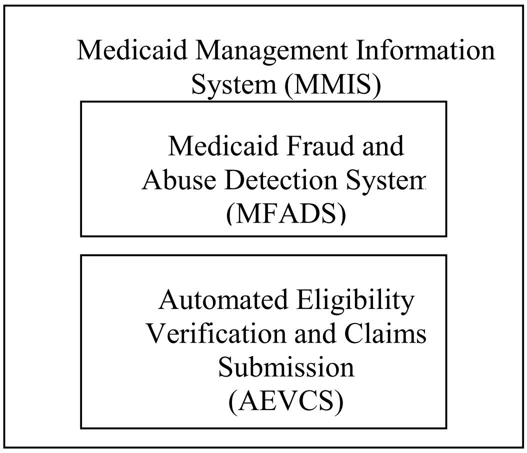

Figure 1: A Management Information System for Medicaid.

The two subsystems of the Medicaid MIS will be presented in the following sections.

5.3 The AEVCS System

Electronic Data Systems, EDS (1999), designed and built an electronic business system called Automated Eligibility Verification and Claims Submission (AEVCS). The key to accessing the system is a photo ID card with patient data on a magnetic strip.

The AEVCS system supports the processing of eligibility-verification and claims transactions through a network of point-of-sale devices or vendor systems [25]. Each transaction is processed in real time and a response is returned to the submitter immediately, noting whether the transaction has been accepted by Medicaid and informing the submitter of any errors.

The AEVCS system was developed jointly by the Arkansas Department of Human Services' Division of Medical Services and EDS, Arkansas Medicaid's fiscal agent. The AEVCS system, which was piloted in 1992 and implemented throughout Arkansas in June 1993, operates at more than 2,600 provider locations.

By using sophisticated VeriFone point-of-sale devices and a nationwide packet-switching network, AEVCS lets providers determine, in real time and in one simple operation, a patient's eligibility for Medicaid. If the patient is eligible for Medicaid, AEVCS delivers an authorization number to the provider, guaranteeing that any claim submitted for treatment on that date will not be denied because of ineligibility for benefits.

The system accepts most claim types used in the Arkansas Medicaid program, including HCFA-1500 medical; UB-92 hospital inpatient and outpatient; Early and Periodic Screening, Diagnosis and Treatment (EPSDT); pharmacy; vision; dental; and long-term care claims.

5.3.1 Technical Specifications

The technical specifications suggested and implemented by EDS [18], was a real-time SQL*® with an online transaction processing database to support the AEVCS system, processing 17.1 million transactions per year. The AEVCS system resides on a Tandem® platform in Auburn Hills, Michigan. The Tandem platform is averaging a 20 percent capacity and uses approximately 7.4 gigabytes of disk storage. The Medicaid Management Information System (MMIS) processes paper claims and performs all "back end" claim functions. The MMIS resides on an IBM platform in the Plano, Texas, EDS Service Management Center. It processes 2,470 million instructions per second of processing power and has 12,691 gigabytes of direct access storage. In addition to the Tandem and IBM platforms, EDS supports a decision support system in Little Rock, Arkansas, using the UNIX® operating system on a Sun™ platform.

5.3.2 Knowledge, Information and Data Exchange

AEVCS can be accessed through point-of-sale devices, vendor systems, PC's, and both intranet and Internet websites. Office staff members of Arkansas DMS use the websites to display statewide medical provider information and assign primary care physicians (PCP) to patients. This setup allows eligible recipients to quickly choose their PCP based on criteria important to them.

The patient's card is "swiped" through a terminal like the one used with credit cards at the doctor's office. The system then verifies patient eligibility and benefit use. AEVCS also confirms payment, which is deposited electronically into the physician's bank account.

This flow of data, information and knowledge is collected in the table below to provide an overview of the communication of the business relations.

From: To:	Arkansas DMS	Doctors	Patients
Arkansas DMS	Internal knowledge handling	Confirmation of patient payment Display medical provider information	Assign primary care physicians
Doctors	Verify patient eligibility and benefit use	Internal knowledge handling	Care, treatment, and advice
Patients	Request for payment status information	Patient medical history and treatment (patient card)	Internal knowledge handling

Table 4: The Knowledge Exchange Matrix for Arkansas Health Care - AEVCS.

Compared to the knowledge exchange model in previous studies, the state model of this study is the patient medical history and treatment record. [39,54] Instead of speaking about a Product State Model, we might therefore speak about another kind of PSM, i.e. a Patient State Model. In this case as well as in the case of an industrial product, the knowledge, information, and data carried by the PSM are the core of the distributed knowledge management network.

5.3.3 Business Impact of the AEVCS system

By implementing the AEVCS system, paper bills, checks, envelopes or postage stamps were eliminated. All status information, e.g. payments, had to be accessed using the website.

In 1998, Arkansas Governor Mike Huckabee noted [18] that the state "saved about $30 million in Medicaid costs as a result of the efficiency built into the system." That is a 17-month total drawn from achievements like the following. Governor Huckabee continues:

"Emergency room use by Medicaid patients dropped 60 percent - falling to 10 percent below the general population. Average claims processing time was reduced from 15 to 3.5 days. Collection expense, a fact of life for many care providers, is practically 'zero' on Medicaid claims. The AEVCS system dropped costly claim denials from 12 percent to 1 percent of the Medicaid outpatient caseload of a large children's hospital. Before EDS initiated a decision support system, programmers developed 130 reports from the database in a one-year period. After system installation, staff members generated reports at an annual rate of 1,140. That's well over an eight-fold increase."

Another significant impact of the AEVCS system according to Ray Hanley, Director, Medical Services for Arkansas Medicaid, was that "With AEVCS, we went from an error-prone paper claim system that took weeks or months to process a claim to an average turnaround time today of 3.8 days with an extremely high degree of accuracy" [20].

Also, denied claims fell from 33 percent to less than 4 percent because the new system instantly flags errors for providers. Providers all over the state are gladly accepting Medicaid patients, which has improved both the access and quality of health care across the state.

Simply in savings on postage fees that went with the old paper eligibility card system, the state saved $60,000 per month [21].

5.4 The MFADS System

The decision support part of the MMIS is called the Medicaid Fraud and Abuse Detection System (MFADS). The Arkansas Decision Support System (DSS) - developed jointly by the Arkansas Division of Medical Services, Arkansas Department of Human Services, and EDS - was implemented in February 1997. The system is designed to structure, store, retrieve, and analyze critical Medicaid management information more efficiently. "The new system uses more than just a relational, data-matching or algorithmic approach," said HHSC's Davis. "It's got the potential of looking at fraud patterns in both supervised and unsupervised models. You would have to build hundreds of individual queries (for a flat-file database) in order to generate the same patterns that you get with neural networks."

In the past, Medicaid Management Information System data could be retrieved only by printing predetermined reports or by viewing existing online screens. If the information needed was not already available through one of these methods, programmers had to modify the screens or generate new programs to produce the data. The Division of Medical Services needed an application that made the data available quickly and easily - a simple system that all levels of personnel could use to retrieve data without relying on programmers.

The Decision Support System provides that solution. It is an easy-to-use yet powerful tool for gathering, analyzing, and displaying information. DSS operates in a client/server environment that incorporates cutting-edge data-warehousing technologies. All pertinent MMIS information (such as recipient eligibility, provider, claims history, pricing, procedure, and diagnosis information) is extracted weekly from the mainframe computer and loaded into a database that users can query. Users access the database through a local area network. Security is maintained through the network and the application itself.

The most powerful feature of DSS is its drill-down capability, which lets users access deep levels of detail. For example, a report might list total pharmacy expenditures by county for the current state fiscal year. If one county seemed to have unusually high expenditures, the user could drill down into that county to see total amounts paid to each pharmacy in that county. Then, the user could drill down into each pharmacy's records to find out which drugs were ordered most often and which recipients received them. This feature is unusual because it lets the user define the information subject to drilling and the hierarchy that the drill follows. In the example, the drilling hierarchy was the county to pharmacy to drug to recipient. The user could change the hierarchy, drilling directly from county to drug to determine what drugs are used most often countywide. DSS also lets users drill up and across. Thus, users have unprecedented capabilities to capture, analyze, and present data.

In the year before Arkansas DSS was implemented, 130 ad hoc reports were generated by programmers at an average of 32 hours each. During the first week that Arkansas DSS was in production, 25 reports were produced by Division of Medical Services staff members with minimal assistance from one programmer and one business analyst. By the end of the first month, 95 reports had been produced - more than 70% of the total number produced the previous year. As more users become comfortable with DSS, we expect the use of DSS - and the overall productivity of DSS users - to increase further. The backlog of requests for ad hoc reports has been eliminated. Programmers' time can now be concentrated on maintaining MMIS, identifying and implementing other data processing innovations.

5.4.1 Technical Specifications

For many years, Medicaid information was housed in flat-file databases, and analysis was accomplished using peer groups, which might be faulty since their analysis was based on information furnished by a doctor or medical facility. Until the implementation of the new system, Medicaid information was scattered throughout a number of state agencies, making it problematic to create data sets and identifying trends.

The Medicaid Fraud and Abuse Detection System (MFADS) is a suite of products that incorporates learning technologies to detect aberrant patterns of provider and recipient behaviors and services. Fraud suspect identification is generated and supported with technology aids such as algorithms, neural networks, clustering identification techniques, case management, and web browser tools and applications. To support EDS in building up intelligent decision support, two technology partners were brought into the project [18]. HNC Software, San Diego, is a leader in the development and delivery of predictive software in client/server environments, and Intelligent Technologies Corp., Austin, Texas, is a leading developer of advanced fraud detection software for the health care, insurance, and financial industries.

For the data warehouse part of the MMIS, EDS as system integrator engaged with various suppliers. As the user interface, BusinessObjects from Business Objects was chosen due to its flexibility and user-friendliness, allowing non-data processing staff to extract information from the database. Business Objects' Document Agent provides batch execution and scheduling, and is further used to generate off-line analyst-defined reports [9]. BusinessObjects can transfer data to other business intelligence tools such as MapInfo and SPSS.

MapInfo by MapInfo Corporation is a spatial information management, and is a geographical mapping tool that lets users map information according to recipient or provider demographics. SPSS by SPSS, Inc., is a sophisticated statistical analysis tool [9].

Another decision support application is the Pandora Managed Care Information System by Codman Research Group, which provides population-based analytical information to health data researchers. Pandora MCIS is a managed-care software package that is used to study trending, expenditures, and service utilization among at-risk populations of Medicaid recipients.

In order to extract data from the mainframe, ETI EXTRACT by Evolutionary Technologies International was chosen. Oracle SQL Loader converts data to ASCII and further loads the data to the warehouse tables. As hardware, the Sun Sparc Center 2000E and Sun Ultra Sparc 6000 were used [9].

The MMIS generates and contains tremendous amounts of data. The total system will include more than 1 terabyte of information, including claims information and provider enrolment data, as well as tables and data tabs. Most of this data is fragmented among numerous systems. By integrating these various pieces, a comprehensive view of a provider's billing practices can be generated. And by using the advanced decision-support tools, patterns of care can be analyzed and payments that should not be made can be identified. For example, analyzing combined data will quickly expose providers who have billed for more hours than it is possible to work in a day. It can also identify providers whose billings are always just under the allowable threshold. All kinds of irregularities can be unearthed.

5.4.2 Knowledge, Information and Data Exchange

The knowledge, information, and data exchange of the MFADS has some extensions compared to the AEVCS. This is illustrated in Table 5.

From: To:	Arkansas DMS	Doctors	Patients
Arkansas DMS	Internal knowledge handling	Confirmation of patient payment. Display medical provider information. Previously excluded providers can be flagged in the database. Notification of previous fraudulent practices before a claim is paid. Display claims history.	Assign primary care physicians. Pricing information. Procedure information.
Doctors	Verify patient eligibility and benefit use.	Internal knowledge handling	Care, treatment, and advice. Diagnosis information.
Patients	Request for payment status information.	Patient medical history and treatment (patient card).	Internal knowledge handling

Table 5: The Knowledge Exchange Matrix for Arkansas Health Care - MFADS.

5.4.3 Business Impact of the MFADS system

In the first three months of operation, the MFADS system identified 244 probable cases of overpayment, totaling nearly $700,000. In the first 58 days of operation, the system met 20 percent of its annual goal and is projected to pay for itself within two years.

The system's "hit rate" in Phase I algorithms was between 81-100 percent, where every "hit" the system identified was indeed engaging in abusive, wasteful or fraudulent activities. The system reduces the work involved in identifying suspects, which translates into 68-100 percent increase in staff productivity for some tasks.

A benefit that came from reviewing patients' diagnoses and length of stay was that it was possible to identify key areas for educating health care providers and patients in preventive care maintenance.

MFADS is expected to generate no fewer than 2,000 additional suspects and recover an additional $7 million annually by the year 2000. Ray Hanley, Director of the Medical Services for Arkansas Medicaid states that "Decision support technology is giving us more access to information, so we can better serve our health care recipients" [19]. Furthermore, ""the system isn't just for fraud detection, but to identify waste and abuse as well, with an eventual goal of prevention," said Carol Meisel, project manager for Texas MFADS at integrator EDS Corp., Plano.

The state of Arkansas gained rapid access to accurate information and was further able to display it in a usable, understandable form as sophisticated decision support capabilities were added to the AEVCS system. And with the ability to quickly retrieve any type of information in the system, the Arkansas Medicaid staff can now create ad hoc reports within a couple of hours. According to Hanley, that is a quantum leap in the way information is compiled. "In the past, a system engineer would have to prepare the report, which could take as long as three weeks," Hanley explains [20]: "Now our own staff can access information in the data warehouse from their computers and can prepare reports that reflect information as current as the previous week. When enhanced by a medical director's knowledge and experience, this advanced technology system can extract more information than we ever imagined was buried there," says Hanley.

In addition to increasing productivity, access and accuracy, the decision support and eligibility verification systems have had other measurable effects on the Arkansas Medicaid program. From not being able to find enough physicians to participate in Arkansas's Connect Care managed care program, Hanley says they now have virtually every practicing primary care physician's participation. "Equally important is patient satisfaction. And feedback from surveys we have been conducting is extremely positive. Medicaid beneficiaries really value and appreciate the fact that they have the advantage of private sector care and the attention of a physician of their choosing. No other state in the country has the kind of access to mainstream medical care that our program does."

Government statistics estimate that states, Medicare and commercial health care providers could lose up to $100 billion to fraud, abuse, and waste a year. To help control this problem, some states are taking aggressive steps. The Texas Medicaid program is working to recover millions of dollars that otherwise would be lost, thanks to sophisticated new technologies and modeling techniques within its new Medicaid Fraud & Abuse Detection System (MFADS) developed in partnership with EDS.

Arkansas has more assignments planned for its MMIS and decision support system, including a program assisting in increasing physician accountability. For example, using information from the state's database, the state's peer review organization can now flag higher-than-normal emergency room usage. It can also identify abuses of certain procedure codes by comparing them to the physician's peer group. With this information, Arkansas will be able to police the system and take corrective action, saving money and insuring better patient care.

6. Applied Distributed Knowledge Management

The analysis follows the ideas presented in the theoretical presentation of DKM and PSM. We want to trace the knowledge management aspects in the case, including knowledge creation, sharing and exploitation. In terms of exploitation, we will look in particular into the intelligence and decision support associated with the AEVCS and MFADS, respectively.

In the case of the Arkansas Division of Medical Services, the product state model serves the purpose of having pertinent data about patients, providers and claims. These data are translated in the Medicaid Management Information System into valuable information to save the State of Arkansas's money and provide adequate, cost-effective health care to Medicaid beneficiaries.

The health care administration case was presented in terms of the knowledge management concept propounded in the previous section. Nonetheless, the information systems have not been designed or presented in the literature in terms of DKM. The case is thus independent of our propositions. Our interpretation of the case bridges the two worlds: the Medicaid systems already developed and operating, and our theoretical model of distributed knowledge management. Bridging without intent of a "proof" of the DKM concept, the case represents a very interesting and unique system. The system is an instance of an interorganizational health care system that surpasses electronic data interchange systems (EDI) [3]. Our interpretation structures the data in accordance with the multi-agency approach of DKM and traces the impact upon product state models, i.e. the Arkansas DMS, the physicians and the patients.

In the table below, we revisit the case study in terms of the three aspects of DKM.

In the table, we show the categories of DKM related to major aspects of the case. Combined with Tables 4 and 5, we are presented with the overall relation to distributed knowledge management. The creation, sharing and exploitation take advantage of different product state models, namely a model for the Arkansas DMS health care obligations, the physicians' and other providers' health care services and the patients' health care needs.

Distributed knowledge management model	**Knowledge Creation: Product State Models**	**Knowledge Sharing: Interorganizational network support of PSM**	**Knowledge Exploitation: Distributed decision support**
Arkansas Medicaid health care system	Arkansas DMS health provision Physicians' health care services Patients' health and satisfaction	AEVCS (automated eligibility verification and claims submission) Operated by doctors and other health service providers, issuing claims, medical provider information, patients' medical history and treatment records, using intra- and internet websites, request for report facilities.	MFADS (Medical Fraud and Abuse Detection System) Data retrieval and presentation system, neural network, drill-down and drill-up capability for users, applications generating spatial and population-based analytical information, fraud and waste detection, prevention and improved health service.

Table 6: Applied distributed knowledge management to Medicaid health care administration.

The distributed decision support can be tracked. First, data acquisition and sharing (AEVCS) and data exploitation applying decision support systems (MFADS) generate up-to-date health care reports for the Arkansas DMS. Secondly, the recurrent acquisition of physicians' and other health service providers' patient treatment data is made available as timely eligibility data accessed on-line by the very same health service providers when visited by patients. The eligibility is the knowledge exploitation outcome of the PSM of Arkansas DMS. The treatment offered patients is the knowledge exploitation outcome of providers' access to track patients' medical and treatment history across different providers. The patient health care satisfaction reflects the patients' use of a primary care physician and procedure information, helping to ease access to relevant health service provision.

Concluding on these observations from the case study, we find distributed knowledge management and distributed decision support to be promising concepts to explore in further research.

7. Conclusion and Perspectives

The distributed knowledge management concept merges specific knowledge with knowledge from other players into a decision support system specific for each player in the network in recognition of product state model (PSM) differences.

Traditionally, knowledge management is conceived in a bilateral model, where acquisition is separated from sharing and exploitation without specific conception of who will use the knowledge and when. In a distributed knowledge management (DKM) model, the acquisition usage and user are known. Furthermore, the idea of an organization-wide knowledge repository is replaced by a network of repositories, each exchanging specific knowledge giving and gaining value for the partners in the network.

The case showed that a distributed decision support system (DDSS) founded on PSMs generates a significantly higher efficiency in operations and planning. The pay-back time on investment was only a few years for a very large system. The distributed knowledge management model proved its efficiency in sharing and exploitation of data in decision support systems that pushed forward relevant knowledge to decision makers on a recurrent scheme. At the same time, the patient satisfaction increased, showing a higher service quality.

Like other network applications, the design of a distributed knowledge management network represents a challenge to business managers and public authorities. The case study proved the existence of sufficient incentives to pursue this kind of information systems, overcoming the risks and costs of development, maintenance and operations. A major obstacle to this kind of system is in the requirement definition phase of the system. Mutual trust to be open about critical operations and data is required at this stage. When the system is running, the results, we would expect, will be so persuasive as to support the continuous use and development of the system. We need more cases across different sectors and industries to test whether the principle of DKM is tenable in those conditions too.

Since knowledge management issues, interdependent technological systems, and information complementarity are the rule of the day, the opportunities for taking advantage of the distributed knowledge management model are prolific.

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