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## Networkcentric healthcare: applying the tools, techniques and strategies of knowledge management to create superior healthcare operations

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**Abstract:** The proliferation of Information Computer and Communication Technologies (IC<sup>2</sup>T) throughout the business environment has led to exponentially increasing amounts of data and information. Although these technologies were implemented to enhance and facilitate superior decision-making, the reality is information overload. Knowledge Management (KM) is a recent management technique designed to make sense of this information chaos. Critical to knowledge management is the application of IC<sup>2</sup>T. This paper discusses how effective and efficient healthcare operations can ensue through the adoption of a networkcentric healthcare perspective that is grounded in process-oriented knowledge generation and enabled through World Healthcare Information Grid (WHIG).

**Keywords:** Knowledge Management (KM); healthcare management; healthcare operations; healthcare doctrine; e-health; networkcentric healthcare; healthcare technology; germane knowledge; information asymmetry.

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## 1 Introduction

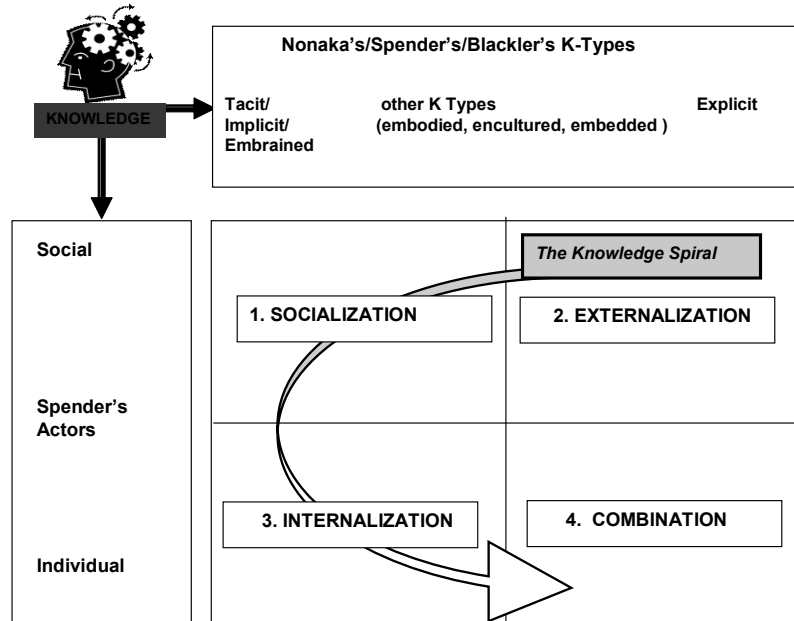
Healthcare is an information-rich, knowledge-intensive environment. In order to treat and diagnose even a simple condition, a physician must combine many varied data elements and information. Such multispectral data must be carefully integrated and synthesised to allow medically appropriate management of the disease. Given the need to combine data and information into a coherent whole and then disseminate these findings to decision-makers in a timely fashion, the benefits from IC<sup>2</sup>T to support the decision-making of the physician and other actors throughout the healthcare system are clear (Wickramasinghe *et al.*, 2005a). In fact, we see the proliferation of many technologies, such as Health Electronic Records (HER), Picture Archive Computerised Systems (PACS) and Clinical Decision Support Systems (CDSS). However, and paradoxically, the more investment in IC<sup>2</sup>T by healthcare, the more global healthcare appears to be hampered by information chaos, which in turn leads to inferior decision-making, ineffective and inefficient operations, exponentially increasing costs and even loss of life (Wickramasinghe *et al.*, 2005a). We believe the reason for this lies in the essentially platformcentric application of IC<sup>2</sup>T within healthcare to date, which at the micro level does indeed bring some benefits but, at the macro level, only adds to the problem by creating islands of automation and information silos that hinder, rather than enable and facilitate, the smooth and seamless flow of relevant information to any decision-maker when and where such information is required.

To remedy this problem and maximise the potential afforded by IC<sup>2</sup>T and consequently alleviate the current problems faced by healthcare, we suggest the adoption of a networkcentric approach to healthcare operations. Such a networkcentric approach is grounded in a process-oriented view of knowledge generation and the pioneering work of Boyd (von Lubitz and Wickramasinghe, 2006b; von Lubitz and Wickramasinghe, 2006c; von Lubitz and Wickramasinghe, 2006e; Boyd, 1987).

## 2 Process-oriented knowledge generation

Within Knowledge Management (KM), the two predominant approaches to knowledge generation are peoplecentric and technologycentric (Wickramasinghe, 2005; von Lubitz and Wickramasinghe, 2006d). A people-oriented perspective draws from the work of Nonaka as well as Blackler and Spender (von Lubitz and Wickramasinghe, 2006d; Nonaka and Nishiguchi, 2001; Nonaka, 1994; Newell *et al.*, 2002). Essential to this perspective of knowledge creation is that knowledge is created by people and that new knowledge or the increase of the extant knowledge base occurs as a result of human cognitive activities and the effecting of specific knowledge transformations (Wickramasinghe *et al.*, 2005a, Figure 1). A technology-driven perspective to knowledge creation is centred on the computerised technique of data mining and the many mathematical and statistical methods available to transform data into information and then meaningful knowledge (von Lubitz and Wickramasinghe, 2006d; Adriaans and Zantinge, 1996; Cabena *et al.*, 1998; Bendoly, 2003; Fayyad *et al.*, 1996; Holsapple and Joshi, 2002; Choi and Lee, 2003; Chung and Gray, 1999; Becerra-Fernandez and Sabherwal, 2001; Yen *et al.*, 2004; Award and Ghaziri, 2004; Wickramasinghe and von Lubitz, 2006; Figure 2).

**Figure 1** People perspective of knowledge generation



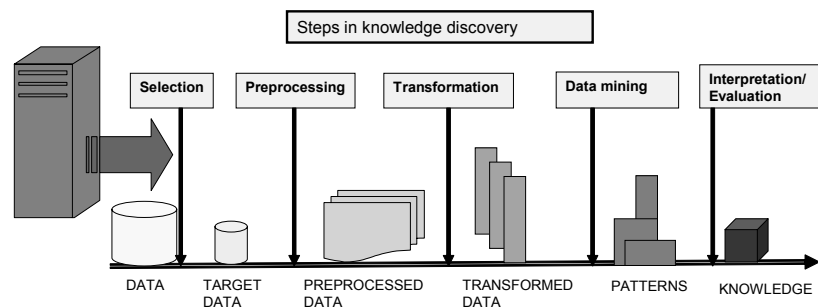
Source: Adapted from Wickramasinghe *et al.* (2005a)

The processes of creating and capturing knowledge, irrespective of the specific philosophical orientation (*i.e.* Lockean/Leibnizian versus Hegelian/Kantian), is the central focus of both the psycho-social (people) and algorithmic (technology) theories of knowledge creation. However, to date knowledge creation has tended to be approached from one or the other perspective, rather than an holistic, combined perspective (Wickramasinghe, 2005). Figure 1 highlights the essential aspects of the three well known psycho-social knowledge creation theories; namely, Nonaka's Knowledge Spiral,

Spender's and Blackler's respective frameworks into one integrative framework by showing that it is possible to change the form of knowledge; *i.e.*, transform existing tacit knowledge into new explicit knowledge and existing explicit knowledge into new tacit knowledge or to transform the subjective form of knowledge into the objective form of knowledge (Wickramasinghe, 2005; Wickramasinghe, 2003; Newell *et al.*, 2002). In effecting such transformations the extant knowledge base as well as the amount and utilisation of the knowledge within the organisation increases. According to Nonaka (1994): 1) Tacit to tacit (socialisation) knowledge transformation usually occurs through apprenticeship type relations where the teacher or master passes on the skill to the apprentice. 2) Explicit to explicit (transformation) knowledge transformation usually occurs via formal learning of facts. 3) Tacit to explicit (externalisation) knowledge transformation usually occurs when there is an articulation of nuances; for example, as in healthcare if a renowned surgeon is questioned as to why he does a particular procedure in a certain manner, by his articulation of the steps the tacit knowledge becomes explicit and 4) Explicit to tacit (internalisation) knowledge transformation usually occurs as new explicit knowledge is internalised it can then be used to broaden, reframe and extend one's tacit knowledge.

The two other primarily people driven theories that focus on knowledge creation as a central theme are Spender's and Blackler's respective frameworks (Wickramasinghe, 2005; Wickramasinghe, 2003; Newell *et al.*, 2002). Spender draws a distinction between individual knowledge and social knowledge, each of which he claims can be implicit or explicit (Newell *et al.*, 2002; Wickramasinghe, 2005; Wickramasinghe, 2003). Spender's definition of implicit knowledge corresponds to Nonaka's tacit knowledge. However, unlike Spender, Nonaka does not differentiate between individual and social dimensions of knowledge; rather he just focuses on the nature and types of the knowledge itself. In contrast, Blackler (Newell *et al.*, 2002; Wickramasinghe, 2005; Wickramasinghe, 2003) views knowledge creation from an organisational perspective, noting that knowledge can exist as encoded, embedded, embodied, encultured and/or embrained. In addition, Blackler emphasised that for different organisational types, different types of knowledge predominate and highlighted the connection between knowledge and organisational processes (Newell *et al.*, 2002).

**Figure 2** Technical perspective of knowledge generation



Source: Adapted from Wickramasinghe *et al.* (2005a)

In contrast to the above primarily people oriented frameworks pertaining to knowledge creation, Knowledge Discovery in Databases (KDD), and more specifically data mining, approaches knowledge creation from a primarily technology driven perspective. In particular, the KDD process focuses on how data is transformed into knowledge by identifying valid, novel, potentially useful, and ultimately understandable patterns in data (Adriaans and Zantinge, 1996; Cabena *et al.*, 1998; Bendoly, 2003; Fayyad *et al.*, 1996; Holsapple and Joshi, 2002; Choi and Lee, 2003; Chung and Gray, 1999; Becerra-Fernandez and Sabherwal, 2001; Yen *et al.*, 2004; Award and Ghaziri, 2004; Wickramasinghe and von Lubitz, 2006). KDD is primarily used on data sets for creating

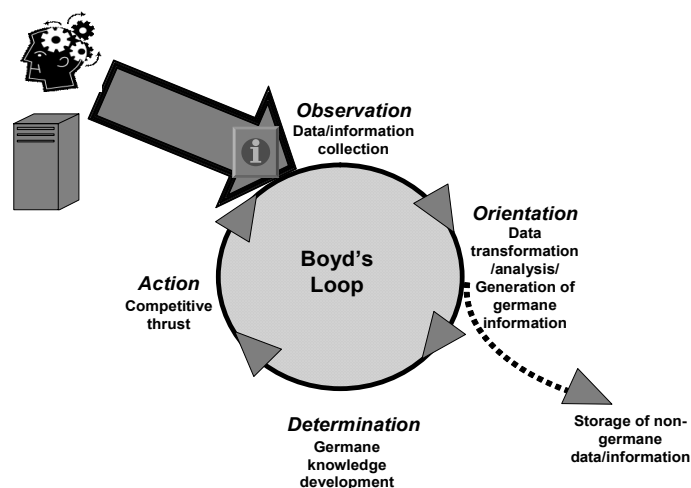
knowledge through model building, or by finding patterns and relationships in data using various techniques drawn from computer science, statistics and mathematics. From an application perspective, data mining and KDD are often used interchangeably. Figure 2 presents a generic representation of a typical knowledge discovery process. Knowledge creation in a KDD project usually starts with data collection or data selection, covering almost all steps in the KDD process; the first three steps of the KDD process (*i.e.*, selection, preprocessing and transformation) are considered exploratory data mining, whereas the last two steps (*i.e.*, data mining and interpretation/evaluation) in the KDD process are considered predictive data mining.

In contrast to both these approaches, a process-centric approach to knowledge creation not only combines the essentials of both the peoplecentric and technologycentric perspectives but also emphasises the dynamic and ongoing nature of the process. Process-centred knowledge generation is grounded in the pioneering work of Boyd and his OODA Loop, a conceptual framework that maps out the critical process required to support rapid decision-making and extraction of critical and germane knowledge (von Lubitz and Wickramasinghe, 2006d; Boyd, 1987).

The Loop is based on a cycle of four interrelated stages essential to supporting critical analysis and rapid decision-making that revolve in both time and space: Observation followed by Orientation, then by Decision, and finally Action (OODA). At the Observation and Orientation stages, implicit and explicit inputs are gathered or extracted from the environment (Observation) and converted into coherent information (Orientation). The latter determines the sequential Determination (knowledge generation) and Action (practical implementation of knowledge) steps (von Lubitz and Wickramasinghe, 2006d; Boyd, 1987, Figure 3). The outcome of the Action stage then affects, in turn, the character of the starting point (Observation) of the next revolution in the forward progression of the rolling loop.

Given that healthcare is such a knowledge-rich environment that requires rapid decision-making that has far-reaching consequences to take place, a process-centred approach to knowledge generation is most relevant and forms the conceptual framework for networkcentric healthcare operations.

**Figure 3** Process perspective to knowledge generation



A process-centric perspective view of knowledge creation is found in Boyd's OODA Loop model (Figure 3). The Loop is based on a cycle of four interrelated stages essential to the extraction of germane knowledge necessary to support critical analysis and rapid decision-making: Observation followed by Orientation, then by Decision and finally Action (OODA). At the Observation and Orientation stages, implicit and explicit inputs are gathered or extracted from the environment (Observation) and converted into coherent information (Orientation). The latter determines the sequential Determination (knowledge generation) and Action (practical implementation of knowledge) steps (von Lubitz and Wickramasinghe, 2006d). The outcome of the Action stage then affects, in turn, the character of the starting point (Observation) of the next revolution in the forward progression of the rolling loop. In Figure 3, this is represented by the arrow indicating the removal of nongermane data/information/ knowledge before continuing to the next step. It is important to note that at all stages within the OODA loop, both people and technology perspectives are supported and required to enable and facilitate germane knowledge extraction.

### 3 Networkcentric healthcare operations

Healthcare, like all activities conducted in complex operational space, both affects and requires the functioning of three distinct entities, *i.e.*, people, process and technology. To capture this dynamic triad that continually impacts all healthcare operations, the doctrine of networkcentric healthcare operations is built around the three entities, which form mutually interconnected and functionally related domains. Specifically, these domains include (von Lubitz and Wickramasinghe, 2006b; von Lubitz and Wickramasinghe, 2006c; von Lubitz and Wickramasinghe, 2006e):

#### 1 A physical domain

- that represents the current state of healthcare reality
- that encompasses the structure of the entire environment healthcare operations intend to influence directly or indirectly, *e.g.*, elimination of disease, fiscal operations, political environment, and patient and personnel education
- that has data within it that are the easiest to collect and analyse, and, especially, that relate to the *present* rather than the future state
- that is also the territory where all physical assets (platforms) such as hospitals, clinics, administrative entities, data management facilities, and all other physical subcomponents (including people) reside.

#### 2 An information domain

- that contains all elements required for generation, storage, manipulation, dissemination/sharing of information, and its transformation and dissemination/sharing as knowledge in all its forms
- within which all aspects of command and control are communicated and all sensory inputs gathered
- while the information existing within this domain may or may not adequately represent the current state of reality, all our knowledge about that state emerges, nonetheless, from and through the interaction with the information domain

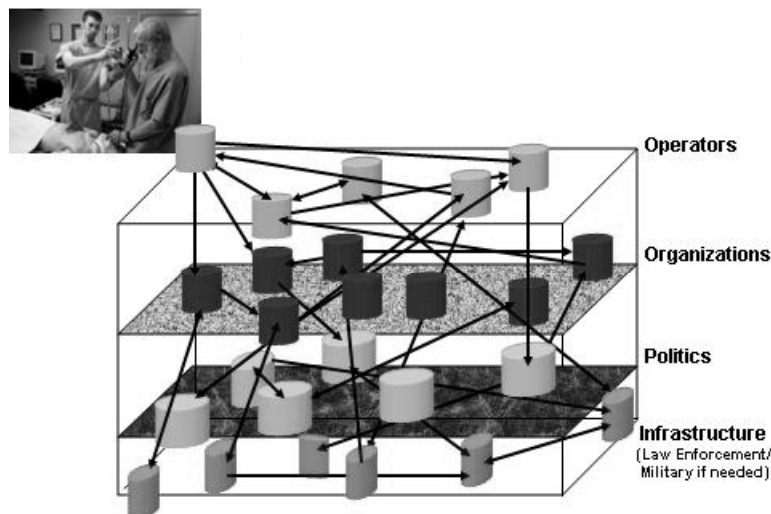
- within which all communications about the state of healthcare take place through interactions
  - that is particularly sensitive and must be protected against intrusions that may affect the quality of information contained within it.
- 3 A cognitive domain
- that constitutes all human factors that affect operations
  - within which that deep situational awareness is created, judgements made, and decisions and their alternatives are formulated
  - that also contains elements of social attributes (*e.g.*, behaviours, peer interactions) that further affect and complicate interaction with and among other actors within the operational sphere.

In essence, these domains cumulatively serve to capture and then process all data and information from the environment. Given the dynamic nature of the environment, new information and data must always be uploaded. Thus, the process is continuous in time and space, captured by the ‘rolling nature’ of Boyd’s OODA Loop; *i.e.*, it is grounded in the process-oriented perspective of knowledge generation.

#### *IC<sup>2</sup>T use in healthcare networkcentric operations*

The critical technologies for supporting networkcentric healthcare operations are not new; rather, they are reconfigurations of existing technologies, including web and internet technologies. The backbone of the network is provided by World Healthcare Information Grid (WHIG) (von Lubitz and Wickramasinghe, 2006b; von Lubitz and Wickramasinghe, 2006c; von Lubitz and Wickramasinghe, 2006e). WHIG consists of three distinct domains that are each made up of multiple grids, all interconnecting to enable complete and seamless information and data exchange throughout the system. Figure 4 depicts the WHIG with its distinct yet interconnected domains, each made up of interconnecting grids.

**Figure 4** WHIG, networkcentric operations and the complexity of modern healthcare delivery



Although ultimately directed at the individual patient, delivery of modern healthcare is an exceedingly complex operation involving several layers, many of which are not directly related to healthcare itself. In most extreme cases (*e.g.*, smallpox), treatment of a single patient may trigger a cascade of events affecting several countries that may be separated by very large distances. Rapid containment of the consequences of such events may require highly specialised knowledge, a high degree of dynamic and environment-sensitive multispectral information/knowledge coordination, analysis and transformation into a multidimensional picture of the 'operational space' characterising the event. Presently, owing to the mutual incompatibility of the existing information/knowledge resources (platformcentricity), inefficiency of knowledge management organisations, and lack of coordination among national and international bodies either directly or indirectly involved in healthcare delivery, the efficiency of the 'operators', *i.e.*, healthcare delivery personnel and their parent organisations (ambulance units, ambulatory clinics, hospitals, *etc.*) is significantly reduced, particularly during cataclysmic events when the need reaches its peak.

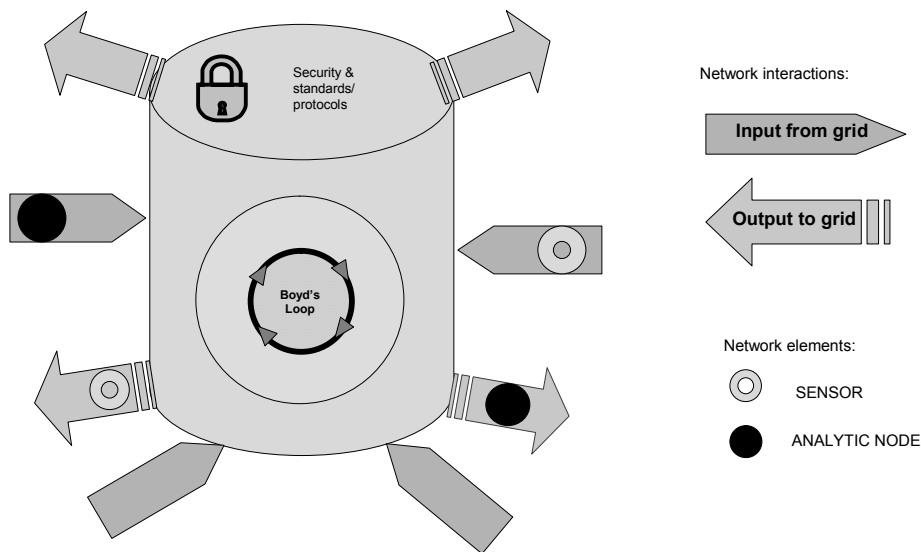
The concept of networkcentricity in healthcare operations reduces the current deficiencies by assuring continuous, unimpeded and polydirectional flow of information among the nodes (depicted as cylinders) populating the WHIG. At the level of the operators, each node constitutes an efficient knowledge management organisation (*e.g.*, medical library attached to a major medical centre – see ref. XX (HICS paper). Operator layer nodes interact with the nodes within other networks, such as Organisations' Network (national and international governmental organisations, NGOs, insurers, *etc.*), Politics Network (such as ministerial level organisations, judicial or parliamentary elements), Infrastructure Network (communication facilities, transportation, power grids, *etc.*), which, at times, may also be linked to law enforcement/military nodes (particularly during humanitarian/disaster relief healthcare operations). Commonality and compatibility of standards determining extraction, analysis, storage and dissemination of the information/knowledge within WHIG are mandatory in networkcentric operations. The power of WHIG is directly proportional to the square of the number of the populating nodes, while adherence to the Application Software Provider (ASP) concept and the development of intelligent WHIG access portals will assure accessibility even to those entities whose technology base is less than optimal.

The three essential elements of the grid architecture are the smart portal, which provides the entry point to the network, the analytic node and the intelligent sensors (von Lubitz and Wickramasinghe, 2006b; von Lubitz and Wickramasinghe, 2006c; von Lubitz and Wickramasinghe, 2006d; von Lubitz and Wickramasinghe, 2006e). Taken together, these elements make up the knowledge-enabling technologies to support and effect critical data, information and knowledge exchanges that in turn serve to ensure effective and efficient healthcare operations.

In networkcentric healthcare operations, the entry point or smart portal must provide the decision-maker with pertinent information and germane knowledge constructed through the synthesis and integration of a multiplicity of data points, *i.e.*, it must support and enable OODA thinking. Unlike current web pages in general and especially current medical web portals and online databases, such as MedLine, which provide the decision-maker with large amounts of information that he/she must then synthesise and whose relative and general relevance he/she must determine (*i.e.*, they are passive in nature), the smart portal enables the possibility of accessing the critical information required to formulate the Action (practical implementation) stage of Boyd's Loop. In addition, the smart portal includes the ability to navigate well through the grid system; *i.e.*, the smart portal must have a well-structured grid map to identify what information is coming from where (or what information is being uploaded to where). In order to support

the ability of the smart portal to bring all relevant information and knowledge located throughout the grid system to the decision-maker, there must be universal standards and protocols that ensure the free flow and seamless transfer of information and data throughout WHIG, the ultimate in shared services. Finally, given the total access to WHIG provided by the smart portal to the decision-maker, it is vital that the highest level of security protocols is maintained at all times, thereby ensuring the integrity of WHIG. Figure 5 captures all these key elements of the smart portal.

**Figure 5** The node and its associated smart portal—entry point to WHIG



The entry point to WHIG is a 'smart' portal (Figure 5). Unlike a traditional portal, the smart portal is active or dynamic. It provides the decision-maker or effector access to relevant data, pertinent information and germane knowledge required for a specific query (von Lubitz and Wickramasinghe, 2006e). This is achieved by the interaction of the decision-maker via the smart portal in conjunction with the analytic nodes. It is in fact the intelligence capabilities and knowledge management technologies of the analytic nodes throughout WHIG, which support process-centric knowledge management, that make the smart portal 'smart'. The analytic nodes obtain and process all multispectral data throughout and process it into pertinent information and germane knowledge that is assimilated and synthesised at the smart portal and then made available to the decision-maker. Other design elements unique to the smart portal include the ability to navigate well through the grid system, sophisticated security protocols and the existence of sensors in the network that detect erroneous or critical data.

The analytic nodes of the WHIG perform all the major intelligence and analysis functions and must incorporate the many tools and technologies of artificial intelligence and business analytics, including Online Analytic Processing (OLAP), genetic algorithms, neural networks and intelligent agents, in order to continually assimilate and analyse critical data and information throughout the grid system and/or within a particular

domain. The primary role of these analytic nodes is to enable the systematic and objective process of integrating and sorting information, or support the Orientation stage of Boyd's Loop. Although we discuss the functional elements of the analytic node separately, it is important to stress that the analytic node is in fact part of the smart portal. In fact, the presence of the analytic node is one of the primary reasons that the smart portal is indeed 'smart' or active rather than its more passive distant cousin, the integrated e-portal, which dominates many intranet and extranet sites of e-businesses today.

The final important technology element of WHIG is the intelligent sensors. These sensors are essentially expert systems or other intelligent detectors programmed to identify changes to WHIG and data and/or information within a narrow and well-defined spectrum, such as an unusually high outbreak of anthrax in a localised geographic region, which would send a message of a possible bioterrorism attack warning to the analytic node, or perhaps the possibility of spurious or corrupt data entering the WHIG system. The sensors are not necessarily part of the smart portal and can be located throughout WHIG independent of the analytic nodes and smart portals. Figure 5 depicts the three essential technical components of WHIG.

#### **4 Knowledge development, support and dissemination**

In our earlier paper (von Lubitz and Wickramasinghe, 2006c), we pointed out that healthcare information quality depends inversely on its range, *i.e.*, the shorter the distance between the source and recipient, and the lesser the degree of information content manipulation, the higher the quality. Similar observations have been made by other authors in the context of military activities whose complexity closely matches that of healthcare (Alberts *et al.*, 2000). At the moment, and even more so in the future, the highest quality of healthcare information reposes within medical libraries associated with major medical centres around the globe. However, despite over a 20-year-long history of Integrated Advanced Information Management System (IAIMS) initiative (Matheson, 1995) and the increasing need for a drastic change of operational philosophy (Kronenfeld, 1995; Blansit and Connor, 1999), the majority of medical libraries continue to function as the repositories of print-based knowledge (or its electronically disseminated substitute), whose participation in healthcare operations is driven by customer demand (essentially passive), rather than operating as dynamic, knowledge-developing and disseminating entities capable of *actively shaping* the healthcare world. As pointed out by several authors (Blansit and Connor, 1999; DuVal, 1967; Fuller *et al.*, 1999), future medical libraries must "filter, focus, and interpret information" (Stead, 1998), and "distribution of information, not control, is key to establishing, and maintaining power" (Martin, 1997). In the context of networkcentric healthcare operations, the role of medical libraries transforms even further: the library becomes a node.

At present, major strides are being made towards the practical incorporation of the IAIMS concept into reality (McGowan *et al.*, 2004; Guard *et al.*, 2004). However, global-scale networkcentricity demands capabilities extending beyond "reliable, secure access to information that is filtered, organised, and highly relevant to specific tasks and needs ..." (McGowan *et al.*, 2004). In addition to these essential requirements, networkcentric operations demand the merging of multispectral information streams into

coherent, operation-centred knowledge bases, development of real-time or near real-time operational space awareness, and predictive capabilities that are beyond the current scope of medical library operational profiles. Thus, contrary to the technologically advanced library of today, the library node of tomorrow must adopt Boyd's Loop principles of interaction with the environment as the principal philosophy of its interaction with the information world within which it functions (von Lubitz and Wickramasinghe, 2006c). Adaptation of such philosophy is also the critical step in transforming the operational profile of the existing medical libraries from essentially passive repositories which, with varying degrees of efficiency and reliability, transform the reposing information into coherent knowledge-based blocks, into active information-seeking entities (nodes) that conduct their exploratory work not only within their predetermined domain of healthcare, but also within all other domains whose content may be potentially relevant to healthcare itself. There is no doubt that the proposed change is fundamental. On the other hand, it is the change that moves the medical library beyond its current notion of the institutional 'networked biomedical enterprise' (Stead, 1998) into a global-level knowledge development, management and dissemination centre. More significantly, aligning such centres within the WHIG structure will lead to a massive enhancement of their overall operational power which (von Lubitz and Wickramasinghe, 2006e), according to Metcalf's law, increases in proportion to the square of the nodes connected to the network.

The proposed transformation of the medical library into a fully capable healthcare knowledge management and dissemination node will require major changes in the profile of the employed personnel. Today's librarian, exquisitely skilled in client-mandated database searches and information retrieval, will become a powerful knowledge worker intimately familiar with the processes of actively seeking new information, converting often unrelated information into coherent knowledge streams, and, ultimately, unifying individual streams and fusing them into the body of the general healthcare knowledge base. The new breed of healthcare knowledge workers will be essential in the development of CDSS, identification of new disease patterns, creation of new administrative tools and positioning of global healthcare systems towards 'just-in-time' responses to crises. Thus, the currently subordinate role of a librarian, operating as a support element in healthcare delivery, will shift to that of an equal partner to a physician and an administrator. In some situations, particularly those involving large-area events, healthcare knowledge workers may even assume the subordinate role of countermeasure effort coordinators and leaders. The widened scope of their importance in global healthcare operations imposes the need for rapid change in the education of the new generation of 'librarians' who, particularly in the context of networkcentric healthcare operations, will need to function as integral members of large, multidisciplinary management teams and be intimately familiar with several disciplines stretching beyond the classical realm of medicine and its affiliates. The rapidly approaching need for new skills is evidenced by the increasing number of papers devoted to this subject and the introduction of new training programmes aimed at the creation of 'new generation' specialists (Stead, 1998; Martin, 1997; McGowan *et al.*, 2004; Guard *et al.*, 2004; Moore *et al.*, 2004; Florance *et al.*, 2002; Keeling and Lambert, 2000; NHS Regional Librarians Group evidence to the Functions and Manpower Review (1993–1994); Aronow *et al.*, 1991). There is thus no doubt that, in similarity to military activities (from which the concept of networkcentricity also evolved), healthcare

operations will need to adopt the philosophy of ‘jointness’, wherein many currently independent disciplines will need to combine and interact in order to attain the stated overall goal – maintenance of global health.

## 5 Discussion

At its most fundamental (and maybe also the most naïve), healthcare is about assuring and maintaining an individual’s adequate level of health necessary for functioning as a fully capable member of society. In reality, healthcare, particularly in its global context, has become a business growing at an unprecedented rate, where global disparities in healthcare delivery become increasingly more apparent, where technology emphasises them rather than assists in their obliteration, and where the current expenditure of trillions of dollars yearly appears to have no impact at all. Part of the problem rests in the fact that the majority (if not all) of solutions to the healthcare crisis are, essentially, platformcentric, *i.e.*, concentrates on the highly specific needs of a speciality (*e.g.*, molecular biology), an organisation (*e.g.*, hospital) or a politically defined region (*e.g.*, the USA or EU). Hence, most of the technology-based solutions, while highly functional and of unquestionable benefit to their users, fail to act as collaborative tools assisting in the unification rather than subdivision of effort. Highly useful information generated within individual systems is lost, for all practical purposes, since it is inaccessible to others either because of its incompatibility with different operational platforms or simply because others are not even aware of its existence! The latter issue becomes particularly significant when relevant information exists within healthcare-unrelated domains. A particularly apt and very recent example of such a failure were the recovery efforts after the tsunami disaster of 2004, when the world dispatched badly needed medical supplies to the affected regions but failed to relate the transport to on-site distribution. The supplies piled up at major airports while healthcare workers in the field were short of the most basic commodities. The currently practised approach to healthcare informatics supports reoccurrence of similar events: for all practical purposes, healthcare informatics limits its sphere of activity only to subjects *strictly related to medicine, its practise and administration at the healthcare organisation level*. Yet, healthcare relates to a number of other elements of life – political structure of the region, its stability, its economy, even its weather. Failure to incorporate these seemingly irrelevant domains of information results in the emergence of medical ‘earthquakes’ such as the discovery that, contrary to the assumptions of the West, cardiovascular disease is the predominant killer among the populations of the underdeveloped world (Leeder *et al.*, 2004).

In order to support the seamless and efficient flow of data and information throughout WHIG, naturally, universal standards and protocols must be developed. Moreover, governments and policymakers must work together to address critical issues, as we have alluded to in our previous work, including building human capital and providing necessary resources, fostering trust, creating synergies between national and regional economic blocks and ensuring the privacy and confidentiality of sensitive information (Cebrowski and Garstka, 1998; von Lubitz and Wickramasinghe, 2006a). Naturally, a full range of wired and wireless telecommunications platforms to support all communications between and within the domains encompassed by the grids referred to earlier must be developed, and requires careful design considerations (von Lubitz *et al.*, 2005). However, another important consideration is that of knowledge governance (Weill and Woodham,

2002; Wenger, 1996). Knowledge governance serves to establish policies in alignment with the overall goals and objectives of WHIG and then delegate responsibility and accountability of KM activities to appropriate levels, manage the risks and continuously evaluate the information generated throughout WHIG against objective criteria to ensure that only pertinent information and germane knowledge flow seamlessly through the network. Without such KM governance, the information/knowledge management in a networkcentric environment will soon become cumbersome and most likely unmanageable as the information generated grows exponentially.

## 6 Conclusion

We believe that the adoption of the networkcentric approach, which is integrally connected to the process perspective of knowledge management, may provide at least part of the solution, especially at the worldwide level of healthcare. The concept is not new. In 1994, DA Lindberg described a vision of a global information infrastructure based on extensive implementation and exploitation of US leadership in high-performance computing, networking and communications in developing a large-scale, technology-based approach to healthcare. During the same decade, the US Department of Defense, followed by military establishments around the world, adopted the notion of networkcentric operations as the most viable solution to the ever-increasing complexity of military operations (Alberts *et al.*, 2000). Similar concepts are brought to life in multilayered, dynamic business activities (Cebrowski and Garstka, 1998). Healthcare operations are equally complex, if not more so, to either business or military ones. Their information/knowledge needs are equally multispectral and intense. And while healthcare is, indeed, about providing an individual with easy access to healthcare providers, and providing the provider with tools to provide adequate healthcare, it all takes place in a vastly more complicated environment of economies, policies and politics, and, far too frequently, conflicts. We believe, therefore, that similarly to the two other fields of human activity to which healthcare is (maybe unfortunately) also related – business and war – healthcare needs to expand its incursion into the world of IC<sup>2</sup>T to the concept of networkcentricity and pursue it with utmost vigour. As already demonstrated in practice (Cebrowski and Garstka, 1998), networkcentric operations increase efficiency, reduce cost, and increase the chances of success. All of these are of critical importance to the conduct of a single, most expensive and yet significantly inefficient activity known to humankind – the conduct of global healthcare operations.

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