The need for rich theory to realize the vision of healthcare network centric operations: the case for combining ANT and social network analysis

AUTHOR(S)

Nilmini Wickramasinghe, R Bali

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Chapter 3

The Need for Rich Theory to Realize the Vision of Healthcare Network Centric Operations:

The Case for Combining ANT and Social Network Analysis

Nimini Wickramasinghe
RMIT University, Australia

Rajeev Bali
Coventry University, UK

ABSTRACT

In a dynamic and complex global environment traditional approaches to healthcare delivery are becoming more and more inadequate. To address this von Lubitz and Wickramasinghe (2006e) proffered the need for a network-centric approach that allows free and rapid sharing of information and effective knowledge building required for the development of coherent objectives and their rapid attainment. However, to realize this vision it is essential to have rich theory and robust approaches to analyse the levels of complexity of modern healthcare delivery. This paper discusses how this might be done by drawing upon the strong rich analysis tools and techniques of Social Network Analysis combined with Actor Network Theory.

INTRODUCTION

Environmental complexity of healthcare operations is often magnified by the presence of multiple actors (agencies, governmental bodies, global organizations, etc.) who perform within the same space, but use a wide variety of independent and non-intercommunicating platformcentric tools. As a consequence of the resulting chaos, the attainment (mission) of healthcare goals (objectives) is uncertainty- rather than information-driven (von Lubitz and Wickramasinghe, 2005; 2006e). In response to the inefficiency of the highly fragmented programs to address even the most urgent aspects of healthcare across the globe, a demand for the development of a new rule set (Barnett, 2004; Onen, 2004; Olutimayin, 2002; Banjeri, 2004)

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governing the future actions began to emerge – the quest for the "doctrine of global health."

In response to this void von Lubitz and Wickramasinghe (2006b-e) proffered the doctrine of network-centric healthcare. This doctrine finds its operational predecessor in the military application of information and decision support system networks based on uniform and widely distributed access, collection, processing, and dissemination standards (Cebrowski and Garstka, 1998). The doctrine calls for the development of interconnected information grids that, together, constitute a powerful and well-structured network that facilitates information sharing among all participants within the operational continuum (space, see Cebrowski and Garstka, 1998; Stein, 1998). Consequent to improved information sharing is the enhancement of its quality and integrity which, in turn, escalates the level of situational awareness that is the foundation for efficient, real-time collaboration among the involved entities, their self-synchronization, and operational sustainability. The overall operational effect of network-centricity is a dramatic increase in mission effectiveness (Cebrowski and Garstka, 1998) whose success, even at the earliest trial stages, led to its adaptation of network-centric concept by several armed forces across the globe. For the same reason, the doctrine begins to find its place in the modern, ICT-driven business world (ibid).

THE CONCEPTUAL BASIS FOR NETWORK-CENTRIC OPERATIONS

The cardinal details of the network-centric doctrine of healthcare operations have been described in detail by von Lubitz and Wickramasinghe (2006b-e). The doctrine is rooted in the pioneering work of Boyd (1987, see also von Lubitz and Wickramasinghe, 2006b-ed-e) who analyzed the process of decision making and the fundamental principles of interaction with- and control of- a fast paced and dynamic environment. Critical research-based projects (as applicable in the area of information systems and health) have a growing tradition of qualitative inquiry. Despite its relativist ontology, actor network theory places a strong emphasis on empirical inquiry and actor network theory, is ideally suited to the generation of detailed and contextual empirical knowledge (Doolin B and Lowe A, 2002). Following its initial military applications, Boyd's OODA Loop as it is presently known, found many adherents and practical uses in a wide variety of civilian applications including medicine (von Lubitz et al., 2004von Lubitz and Wickramasinghe, 2006a-e).

THE NATURE AND DEFINITION OF THE DOCTRINE OF NETWORK-CENTRIC HEALTHCARE

Following the essential nature of actor network theory, the intricate and mutually constitutive character of the human and technology (in the processes and relationships of illness and health) has been demonstrated (Prout, 1996). In addition to this "micro" example, successful interaction with complex sets of macro-environments (macro-environment galaxies) such as global healthcare (which comprises a vast array of independently identifiable macro-environments, *c.f.* 1) presents an insurmountable task *unless assisted by a highly sophisticated, multilayered network of ICT that incorporates a full range of telecommunication platforms, sensors, data storage elements, analytical nodes, and dispersed access points, the operation of which provides flexible command and control and rapid response capabilities*.

The doctrine of network-centric healthcare has its roots in network-centric computing (von Lubitz and Wickramasinghe, 2006b-e) whose practical development has been greatly facilitated by the rapid progress of various areas of ICTs (e.g., HTML, TCP/IP, Web, JAVA, XTML, etc – refs Hironaka, 1992, Valdes et al., 2003). The principal task of network-centricity in healthcare operations is to develop the state of *information superiority*.

The state of information superiority provides the actor(-s) with the critical *operational advantage* that allows to determine and dictate the direction and tempo of all activities in a collaborative, highly coordinated manner which, in turn, reduces the time needed to reach the preset objectives in the most effective and economical manner. Even the sketchy and largely anecdotal reports of the events surrounding Hurricane Katrina operations indicate quite clearly that the absence of the state of information superiority was one of the principal culprits in the resultant leadership failures, absence of coordination, and a number of avoidable post-hurricane fatalities (e.g., CNN News, a,b,c)

Unsurprisingly, in order to be executed efficiently, healthcare operations must be conducted within the intersecting territory of three mutually interconnected and functionally related domains (von Lubitz and Wickramasinghe, 2006b-e; Garstka, 2000):

- The *physical domain* which encompasses the structure of the entire environment healthcare operations intend to influence directly or indirectly, e.g., elimination of disease, fiscal operations, political environment, patient and personnel education, etc. Information within this domain is the easiest to collect, analyze, and disseminate
- The *information domain* contains all elements required for generation, storage, manipulation, dissemination/sharing of information, and its transformation and dissemination/sharing as knowledge in all its forms. It is here that all aspects of command and control are communicated and all sensory inputs gathered.
- The *cognitive domain* relates to all human factors that affect operations, such as education, training, experience, political inclinations, personal engagement (motivation), "open-mindedness," or even intuition of individuals involved in the relevant activities. Difficulties in metrics relevant to the cognitive domain notwithstanding, a body of experimental studies begins to emerge that will, ultimately, provide close quantitative relationships to other domains that govern healthcare operations space e.g., (Bodner et al., 1986; Roberts and Clifton, 1992; Back and Oppenheim, 2001; Newby, 2001; Wetherell et al., 2002; Abel-Smith, 1989).

Hence, fundamental to the doctrine of network-centric healthcare operations (HNCO) is "*unhindered networking operations within and among all three domains that govern all activities conducted in healthcare space and are based on free, multidirectional flow and exchange of information without regard to the involved platforms or platform-systems and utilizing all available means of ICTs to facilitate such operations.*

THE PHYSICAL CONSTITUENTS OF THE HEALTHCARE NETWORK

The essential and enabling element of HNCO is the Healthcare Information Grid that allows full and hindrance-free sharing of information among individual domains, their constituents, and among constituents across the domains. In order to perform such a function, the Healthcare Information Grid must consist of an interconnected matrix of ICT systems and capabilities (including communication platforms, data collection, storage, manipulation/dissemination, and sharing), associated processes (such as information and knowledge storage and retrieval, management and their dissemination/sharing), people (e.g., healthcare providers/investigators, administrators, economists, politicians, lawyers, ICT personnel), and agencies (governmental and NGOs (Non-

Governmental Organizations) at local/national/international level.)

The required technology (von Lubitz et al., 2005) and individual components of such a grid already exist (von Lubitz and Wickramasinghe, 2006b-e), and their role and interactions in the context of network-centric operations described in a greater detail elsewhere (von Lubitz and Wickramasinghe, 2006b-e), the grid itself needs yet to be constructed based on universally accepted and shared operational and security standards and protocols that will allow free and unfettered access to all actors within the healthcare space Once developed, the Grid will facilitate information sharing and enable joint development of objectives, precise characterization of missions necessary to attain these objectives, allocation of adequate resources, and continuing monitoring of progress. The latter will, in turn, permit not only timely intra-operational interventions (e.g., modifications of the mission profile, changes in resource allocation) but, even more significantly, assist in the development of the unified command structure necessary for the synchronization of currently non-related and often disorganized and discordant efforts conducted within the same segment of healthcare space. That such controls are required in very large scale operations is demonstrated by several studies showing that, in the developing countries in particular, the currently disorganized conditions of healthcare aid often result in inefficiency and inappropriate application of the available resources (Abel-Smith, 1989; Howard, 1991; Collins and Green, 1994; Schneider and Gilson, 1999; Buse, 1999).

Access to the Healthcare Information Grid is facilitated through "smart" portals (described in detail in von Lubitz and Wickramasinghe, 2006b-e) that provide the gateway to all operationally pertinent information existing within the network. Operational (pertinent) knowledge support is derived through a semi- or fully automated search of the grid by the information processing capabilities and decision support capabilities of the smart portal, followed by the equally semi- or fully automated assembly, analysis, and pertinent knowledge derivation. Based on agent technologies, and contrary to the majority of the existing portal systems, the "smart portal" is fully active, and its operations provide relevant data, information, and knowledge based on cross-domain objective analysis of all relevant facts rather than those that may be, often erroneously and subjectively, classified as relevant by the human operator.

Many of the complexities of network-centric operations are invariable linked to the issues of security and data/information integrity and, given the total access to the Healthcare Information Grid provided by the smart portal to all actors within the operational space, it is vital that the highest level of security protocols are maintained at all times.

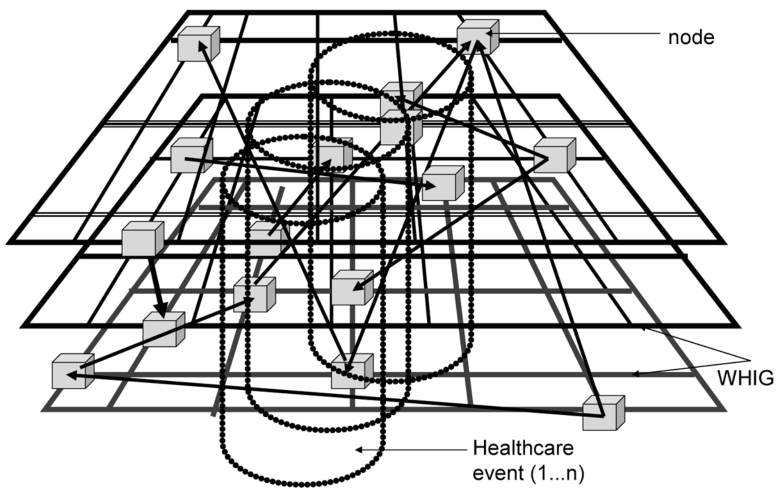
RICH ANALYSIS TOOLS AND TECHNIQUES

In order to design, develop and thereby successfully realize the vision of network-centric healthcare it is vital that rich analysis tools and techniques are fully utilized. In general the social theory literature is peppered with various theories that are both complex and rich. Within this body of the literature two appropriate candidates that are particularly relevant in the context of HNCO include Social Network Analysis (SNA) and Actor Network Theory (ANT).

Social Network Analysis (SNA)

SNA is a technique that facilitates the mapping and measuring of relationships and flows between people, groups, organizations, systems as well as all information/knowledge processing organizations and thereby enhances metacognition with respect to the representation of organizational knowledge in networks (Wasserman and Faust,

Figure 1. Healthcare information grid



1994; Niessen 2007). People and groups are represented as nodes while the relationships or flows are represented by links. Taken together this analysis of nodes and links builds the network under consideration. The location of actors in such a network is critical to a deeper understanding of the network as a whole and the participation and position of individual actors (Wellman and Gulia, 1999). Location is measured by finding the centrality of the node.

In terms of centrality three considerations become important in any SNA; degree of centrality – in other words how many people connect with you, betweenness – or whether or not you are located between 2 key actors in the network and thus may play a "broker" role, and closeness – or ones position relative to others (especially key players) in the network. In addition, it is important to note if there exist boundary spanners -actors who bridge or overlap into different networks, or peripheral players – actors who are perceived as unimportant.

One way to improve the current state-of-the-art in SNA is to develop new ways to produce interval/ratio measures of relations between the various individuals in the organization to determine the strength of their ties (Liebowitz, 2005). Analysts of social networks are interested in how the individual is embedded within a structure and how the structure emerges from the micro-relations between individual parts (Hanneman, 2002).

To illustrate the value for SNA within HNCO let us look at Figure 1. Within the Healthcare Information Grid structure various healthcare events (denoted by cylinders labeled healthcare event 1…n) have been highlighted. In the case of an emergency and disaster scenario such as Hurricane Katrina, it is possible to think of one of these events as Hurricane Katrina. In this context the nodes (cubes on Healthcare Information Grid) represent various actors. What becomes of crucial importance in the emergency and disaster state of Hurricane Katrina is the distance or centrality of key actors since the key actors are the important decision makers and in such a context rapid prudent decision making can save lives. Clearly, in such a context the understanding of who/ where the boundary spanners are as well as the betweenness and closeness constructs are key in designing a superior network that will enable at all times appropriate and speedy decision making to ensue. It is also useful to note that SNA can be used in post facto analysis to facilitate necessary lessons learnt that can be applied to the future state. Thus the incorporation of SNA into the continuous design and development of HNCO is going to facilitate the realization of a well structured network that will indeed support all the complex and dynamic operations in healthcare.

Actor Network Theory (ANT)

As noted earlier healthcare is a complex domain. Specifically, the roles of different healthcare players including payers, providers, healthcare organizations and regulators as well as their respective interactions with Healthcare Information Grid and how Healthcare Information Grid in turn might facilitate, modify or even impede their tasks. To facilitate a superior understanding a sufficiently rich and dynamic lens of analysis can be found from the application of Actor Network Theory (ANT).

ANT embraces the idea of an organizational identity and assumes that organizations, much like humans, possess and exhibit specific traits (Brown, 1997). Although labeled a "theory", ANT is more of a framework based upon the principle of generalized symmetry, which rules that human and non-human objects/subjects are treated with the same vocabulary. Both the human and non-human counterparts are integrated into the same conceptual framework.

ANT was developed by British sociologist, John Law and two French social sciences and technology scholars Bruno Latour and Michel Callon (Latour, 1987, 2005; Law and Hassard, 1999; Law, 1992, 1987; Callon, 1986. It is an interdisciplinary approach that tries to facilitate an understanding of the role of technology in specific settings, including how technology might facilitate, mediate or even negatively impact organizational activities and tasks performed. Hence, ANT is a material-semiotic approach for describing the ordering of scientific, technological, social, and organizational processes or events.

Concepts of Actor Network Theory

Table 1 presents the key concepts of ANT and their relevance to network-centric healthcare operations.

DISCUSSION

The suggested approach is a hybrid approach that combines the respective strengths of SNA and ANT in order to facilitate the realization of HNCO. Such an approach requires the identification and tracing of specific healthcare events and networks to "follow the actors" (Latour, 1996) and investigate all the relevant leads each new actor suggests. The first step is thus to identify these actors (or actants), remembering that an actor is someone or something that can make its presence individually felt and can make a difference to the situation under investigation. Thus, in HNCO the actors would include: medical practitioners, nurses, medical instruments, healthcare organizations, regulators, patients, equipment suppliers, medical administrators, administrative computer systems, medical researchers, and so on. In a particular operation (or event) it is important to identify all relevant actors before proceeding further.

The next step is to 'interview' the actors. With human actors this is, of course, quite straightforward, but with non-humans it is necessary to find someone (or something) to speak on their behalf. For an item of medical technology this might be its designer or user, or it might just be the instruction manual. The aim of this step is to see how these actors relate to each other and the associations they create – to identify how they interact, how they negotiate, and how they form alliances and networks with each other. These 'heterogeneous networks' consists of the aligned interests held by each of the actors.

Human actors, such as medical practitioners, can 'negotiate' with non-human actors such as X-Ray or dialysis machines by seeing what these

Table 1. Key Concepts of ANT

Concept	Relevance to HNCO
Actor/Actant: Typically actors are the participants in the network which include both the human and non-human objects and/or subjects. However, in order to avoid the strong bias towards human interpretation of Actor, the neologism ACTANT is commonly used to refer to both human and non-human actors. Examples include humans, electronic instruments, technical artifacts, or graphical representations.	In HNCO this includes the web of healthcare players such as provides, healthcare organizations, regulators, payers, suppliers and the patient as well as the clinical and administrative technologies that support and facilitate healthcare delivery.
Heterogeneous Network: is a network of aligned interests formed by the actors. This is a network of materially heterogeneous actors that is achieved by a great deal of work that both shapes those various social and non-social elements, and "disciplines" them so that they work together, instead of "making off on their own" (Latour, 2005).	Healthcare Information Grid is clearly the technology network for HNCO. However it is important to conceptualise the heterogeneous network not as Healthcare Information Grid alone but as the aligning of the actors with Healthcare Information Grid so that it is possible to represent all interests and thereby provide the patient with superior healthcare delivery. Given the scope of healthcare operations and the global nature of HNCO there will be numerous power dynamics within and between groups of actors. This will be a critical barrier to enabling the well functioning of network-centric operations. The key is to carefully align goals so that healthcare delivery is truly patient centric at all times.
Tokens/Quasi Objects: are essentially the success outcomes or functioning of the Actors which are passed onto the other actors within the network. As the token is increasingly transmitted or passed through the network, it becomes increasingly punctualized and also increasingly reified. When the token is decreasingly transmitted, or when an actor fails to transmit the token (e.g., the oil pump breaks), punctualization and reification are decreased as well.	In HNCO this translates to successful healthcare delivery, such as treating a patient in a remote location by having the capability to access critical information to enable the correct decisions to be made. Conversely, and importantly, if incorrect information is passed throughout the network errors will multiply and propagate quickly hence it is a critical success factor that the integrity of the network is maintained at all times.
Punctualization: is similar to the concept of abstraction in Object Oriented Programming. A combination of actors can together be viewed as one single actor. These sub actors are hidden from the normal view. This concept is referred to as Punctualization. An incorrect or failure of passage of a token to an actor will result in the breakdown of a network. When the network breaks down, it results in breakdown of punctualization and the viewers will now be able to view the sub actors of the actor. This concept is often referred to as depunctualization.	For example, an automobile is often referred to as an unit. Only when it breaks down, is it seen as a combination of several machine parts. Or in HNCO the uploading task of one key actor, be it a provider or a regulator is in reality a consequence of the interaction and co-ordination of several sub-tasks. This only becomes visible when a breakdown at this point occurs and special attention is given to analyse why and how the problem resulted and hence all sub tasks must be examined carefully.
Obligatory Passage Point: broadly refers to a situation that has to occur in order for all the actors to satisfy the interests that have been attributed to them by the focal actor. The focal actor defines the OPP through which the other actors must pass through and by which the focal actor becomes indispensable (Callon, 1986).	In HNCO we can illustrate this by examining the occurrence of a disease or catastrophe. A recent pertinent example is SARS which caused a major epidemic crisis and required a united, co-ordinated global response to focus on finding a cure and treating affected victims. A similar co-ordianted immediate response was required in the aftermath of Hurricane Katrina or the Tsunami that struck the countries of the Indian ocean in December 2004. Such incidents form the catalyst for developing shared goals and united focus of effort so necessary to effect superior healthcare delivery.
Irreversibility: Callon (1986) states that the degree of irreversibility depends on (i) the extent to which it is subsequently impossible to go back to a point where that translation was only one amongst others and (ii) the extent to which it shapes and determines subsequent translations.	Given the very complex nature of healthcare operations (von Lubitz and Wickramasinghe, 2006b-e) irreversibility is generally not likely to occur. However it is vital that chains of events are continuously analysed in order that future events can be addressed as effectively and efficiently as possible. This is at the very essence of HNCO.

machines can do for them, how easy they are to use, what they cost to use, and how flexible they are in performing the tasks required. If negotiations are successfully completed then an association between the medical practitioner and the machine is created and the machine is used to advantage – the network has become durable. If the negotiations are unsuccessful then the machine is either not used at all, or not used to full advantage.

Once this is developed it is then important to apply the techniques of SNA to map the flows of pertinent information and germane knowledge throughout this network and thereby not only enhancing the metacognition of the system but also the ability to rapidly extract and utilize the critical knowledge to support prudent decision making and at always a state of being prepared and ready (Wickramasinghe and von Lubitz, 2007; von Lubitz and Wickramasinghe, 2006 a;f)

The main advantage of this approach to considering HNCO is in being able to identify and explore the real complexity involved. Other approaches to technological innovation, Innovation Diffusion for example, put much stress on the properties of the technology or organisation themselves, at the expense of looking at how these interact. Unfortunately in doing this they often tend to oversimplify very complex situations and so miss out on a real understanding. The ANT approach of investigating networks and associations provides a useful means to identify and explain these complexities as well as track germane knowledge and pertinent information. This is paramount if the doctrine of network-centric healthcare is to be successfully realised.

CONCLUSION

Healthcare reform is being embarked upon by most if not all OECD countries in one form or another. This is as a result of the presently disorganized state of global healthcare coupled with predicated exponentially increasing costs required to support and sustain current healthcare practices. In 2006 von Lubitz and Wickramasinghe (2006e) proffered HNCO as a solution as a remedy to the problems plaguing healthcare delivery.. This doctrine has several advantages: first, a similar concept is already implemented with significant success by the military establishment. Hence, the "lessons learned" can be readily adopted into the civilian environment. More importantly, however, by permitting free flow of information among currently disconnected entities and fields of healthcare operations, the network-centric doctrine allows vast improvement in information management and use in all activities related to healthcare. In addition, network-centricity permits generation of the currently absent comprehensive, multifaceted, and unified body of knowledge necessary to conduct healthcare activities in a manner addressing present inequalities through a consistent knowledge-based effort rather than, as it is presently done, through the erratic application of ever increasing funds.

Sadly, still today most healthcare operations are at best platform centric and efforts to transition to a network centric approach are in general not occurring. We believe that network-centric healthcare offers the most tangible and obtainable means of such transformation, and that, in similarity to science, business, and warfare (Smarr, 1999) every effort should be made to pursue the tenets of the doctrine in changing the face of the global healthcare. However, and most importantly, if HNCO is to become the new paradigm for healthcare delivery in the 21st century it is vital that a rich set of analysis tools and techniques be employed. To this regard we have presented a hybrid analysis which draws together the strengths of two well established social theory techniques; namely social network analysis (SNA) and actor network theory (ANT). We contend that the richness of such an approach is essential if the true potential of HNCO operations are to ensue. In closing we not only call for more research in this area but also for more research into the value of using such hybrid approaches in various areas of dynamic and complex operations.

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