Using ANT to Understand Key Issues for Successful e-Health Solutions

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Abstract
Faced by a confluence of onerous challenges including escalating healthcare costs, ageing populations and the advance of technology as well as the need to provide effective and efficient healthcare services, OECD countries today are turning to e-health as the silver bullet or panacea. However, despite the initial euphoria and notwithstanding the significant investments made, to date, many of these e-health solutions have yet to prove their success. This paper presents the findings from an exploratory study that examined e-health initiatives in five countries Australia, China, Germany, UK and US to understand why these e-health solutions have not as yet delivered the promised results. A key aspect from this study was the need to have a robust and rich theory so it is possible to more fully understand all the implications, barriers and facilitators of the respective e-health solutions. Hence, the paper proffers Actor Network Theory (ANT) as such a candidate theory and illustrates how it can help to identify and support an in depth understanding of key success factors.

1. Introduction

Today all OECD countries are investing heavily in health information technology in general and e-health in particular [1-3]. This is in response to immense pressures in various areas including changing patient demographics, financial implications, work force shortages, advancements in medical technologies and the need to provide efficient and effective patient centric healthcare delivery [3-4]. However, the benefits from such investments are yet to be realized.

Healthcare is a data and information rich industry [3, 5]. Its processes are complex and more often than not require the extraction of multi-spectral data and information to make unstructured and intricate decisions in compressed time periods; which if erroneous can lead to unpleasant outcomes such as the death of the patient (ibid). The underlying assumption in support of the introduction of IT (information technology) generally, and e-health in particular, into healthcare service delivery is that by improving the ways of accessing and sharing information across healthcare systems and moving away from pen, paper and human memory towards a new environment, where key stakeholders (for example: service providers, consumers, government agencies and healthcare managers) can reliably and securely share information electronically, it will be possible to realize significant improvements in health outcomes and quality of care [4, 6], help with cost savings, improve patient involvement and produce useable secondary data for further research and training [4, 7]. However, such a transformation is not a straightforward proposition especially given the complex and multifaceted environment of healthcare service delivery not to mention the inherent complexities of healthcare operations [5, 8-12]. Furthermore, it is because of the complex and dynamic nature of healthcare that makes the uses of technology mediated collaborations in healthcare both unique and challenging.

Wickramasinghe and Schaffer [3], among others, have argued that these kinds of interventions are intricate and far from simple and thus need to be evaluated with robust and rich theoretically informed techniques [4, 11-12]. Ramaprasad and Paul [13] developed an ontology to help understand the existence of the various IS/IT initiatives in healthcare and the consequent technology mediated collaborations that ensued. Specifically, their ontology includes five key areas; namely: 1. Technology – which is made up of architecture, system and strategy; 2. Partners – which is made up of the web of healthcare players such as providers, healthcare administrators, patients and regulators and their interactions with each other; 3. Content – which consists of data, analysis, diagnosis and treatment; 4. Media – which has the key components of personal e.g., face to face versus an electronic medical record system, social e.g., blogs or chat groups, mass which includes the radio or TV and institutional which includes HIE (health information
2. E-health initiatives

Yin [16]. surveys as discussed by Kvale [14], Boyatzis [15] and semi-structured and unstructured interviews and established techniques including archival analysis, gathered from multiple sources using various well Australia, China, Germany, UK and US. Data was benefits. The countries examined in the study include Australia, China, Germany, UK and US. Data was gathered from multiple sources using various well established techniques including archival analysis, semi-structured and unstructured interviews and surveys as discussed by Kvale [14], Boyatzis [15] and Yin [16].

2. E-health initiatives

This section summarizes the key issues and developments to date in each country’s respective e-health solution(s). It is important to note that healthcare delivery is fundamentally affected by the type of healthcare system adopted by a country [3, 17]. Further, the type of healthcare system is essentially a continuum that is impacted by whether the funding is predominately public or private. Hence, some countries lie at one end of this spectrum with an essentially public/government funded healthcare system such as the UK, while others lie on the opposite end with an essentially private (or non government) funded system such as US and China, while the vast majority exhibit two-tier systems that have a mix of public and private funding. This includes countries like Australia and Germany. The difference being that Australia has an inclusive system; i.e. private healthcare insurance does not preclude citizens from access to public healthcare possibilities while Germany has a substitute system; i.e. private healthcare insurance precludes the insuree from public healthcare funding. In order to have a representative set of cases that span all these possibilities we chose to focus on the five countries that are currently implementing e-health solutions: Australia, China, Germany, UK and US.

2.1 Case 1: Australia

In Australia, work on a nationally coordinated electronic health record was initiated in 1993 with the creation of National Health Information Agreement (NHIA) [18]. Between this time and 2009 several stages of government programs were set up and charged with the task. Finally, responsibilities of the development of the national e-health project were shifted to the National E-Health Transition Authority (NEHTA). Their responsibility was to develop standard clinical terminologies and identifiers for providers and patient services by 2009. Changes in government had the impact of affecting the pace of IT (information technology) initiatives and thus the target of having provider/patient identifiers was not met by 2009. In 2009 the new government announced the introduction of Health Identifiers and the introduction of the Health Identifiers Act 2010 served to strengthen their position on this e-health approach. It is now expected that by July 2012 with the help of 446.7 million dollars Healthcare Identifies (HI) services for all Australians will be available. HI services are essential for the chosen e-health solution for Australia; the PCEHR (Personally Controlled Electronic Health Record).

2.1.1 What is a PCEHR? The Australian government made the decision after much discussion to embark upon an e-health solution for all Australian residents and citizens called a Personally Controlled Electronic Health Record (PCEHR). The PCEHR is a unique solution that sits between an individually controlled health record and a healthcare provider e-health record. In addition, the PCEHR has a shared use and mixed governance model [4, 18].

The Personally Controlled Electronic Health Record (PCEHR) is thus a person-centric secure repository of the electronic health and medical records of an individual’s medical history that would act as a hub for linking hospital, medical and pharmaceutical systems using a patient unique identifier [18-19]. It can capture information from different systems and present this in a single view to consumers and authorized service providers for better decision making about health and service delivery [19-21]. This is a hybrid electronic health information system that integrates web based personal health records with a clinical
electronic health record system and allows shared access to both consumers and providers based on a shared responsibility and mixed governance model [19].

Key features of the PCEHR include [19]:
- Patients health information including medication, medical history referrals, lab test results, prescriptions, discharge summaries, allergies and immunizations will be provided.
- Rigorous governance and privacy procedures will be in place.
- Fast and reliable access of patient’s health information for both consumers and service providers remotely via fast internet connection to enhance decision making for diagnoses and treatments and preventive actions.
- High quality data for policy development as well as research and planning to government bodies will be provided.
- All activity history of any actions preformed on the PCEHR by a service provider and consumer will be provided.
- Individuals can make enquires and complaints about the management of their information.
- Easy access to health literacy information via direct link.
- Can collect information from consumer devices such as blood pressure monitors, blood glucose monitors.

This system will operate on the principal of an opt-in model; entirely voluntary basis without any obligation so a user can opt-in or opt-out and can even withdraw at any time. Further, individuals can also create lists of service providers in two different categories to grant access and exclude/deny access to any service provider or organization [19-21].

2.2 Case 2: China

While China is not an OECD country, with its very large population, large land mass and rise as an emerging economy it too is facing many challenges in trying to deliver quality healthcare for all its citizens. Interestingly, China’s healthcare system is very similar to the US. E-health in China is aimed at trying to improve traditional healthcare services. Key goals include removing the inequities, inefficiencies, poor quality, shortage of health resources, and improper distribution of health resources. The Ministry of Health in China has included e-health in the national long-term scientific and technological development plans, and it is the main objective of the "The Eleventh Five-Year Plan" of China's health information (2005) [22].

In 2009, China published policy documents focusing the medical and health information technology on establishing a unified electronic health record (EHR) and national health information data dictionary. In summary, the following three goals for China's e-health include [ibid]:

1. Every citizen holds a safe and effective e-health record. EHR is a necessary clinical information resource that modern medical institutions require to develop efficient, high-quality clinical practice and medical management. EHR can improve the quality and efficiency of medical and health services, prevent and reduce medical errors, control and reduce medical and health costs.

2. Every citizen has a right to the disease prevention (immunization), healthcare and health counseling services, which can be multi-agency, cross-regional, inter-departmental and cross-ownership. The development of health information technology should support sharing of health information to improve healthcare efficiency and quality, to improve healthcare access, to reduce healthcare costs, and to reduce medical risks [23]. Health information sharing depends on the computer and network technology in place. Overall, when compared to other industries e-health is still fragile in this regard. E-health information is inevitably forming a large number of silos, which significantly slows down the information sharing process of the health sector. It is essential to improve healthcare structures so that they are multi-agency, cross-regional, and inter-departmental and cross-ownership which will in turn enable health information to flow more seamlessly with the end result being that every citizen can enjoy the disease prevention (immunization), healthcare and health counseling services.

3. Every citizen gains the corresponding food security and health insurance. E-health must be connected to the national information database. It will become an efficient management and monitoring information platform in the market and knowledge-based economy.

2.2.1 Key challenges for e-health in China. To develop optimal partnerships between consumers and other groups of healthcare stakeholders, the key challenges for China with regard to its e-health solution are summarized as follows [22]: a) focus on meaningful collaboration with healthcare recipients;
b) develop efficient strategies and techniques to monitor patterns of Internet use among consumers; c) prepare for upcoming technological developments; d) balance between connectivity and privacy; e) develop a better understanding of the balance between face-to-face and virtual interactions; f) ensure equitable access to technology and information across the globe.

2.3 Case 3: Germany

Facing the same challenges as all OECD countries, Germany has decided to pursue an e-health solution based on an e-health card (eHC). Similar to Australia, the idea of an e-health card solution has existed for some years now and during the last years Germany’s strategy has changed. The gematik (Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH) an organization founded on January 11th, 2005 has been charged with the goal to implement this eHC and the necessary telematics infrastructure [24].

2.3.1 Initial Implementation Plan. The initial implementation plan consisted of four key steps. Each step consisted of key e-health functions which are then divided into two category groups. The first group included the administrative functions, which were compulsory for all card owners. The second group was focused on the medical functions, which were optional for the eHC holders. Both groups had two key steps [25].

- In the first implementation step of the eHC there was the implementation of the administrative functions planned (compulsory). Within this first implementation step personal information of the enrollee, information about the insurance agreement and the necessity of additional payments and data about the care provider were planned to be stored. The data was intended to be stored on the e-health card respectively on a server. In addition, it was planned that each enrollee will become a lifelong valid insurance number, which will be printed on the e-health card. Moreover, the plan had also included that each eHC will be equipped with a photo of the enrollee. Based on this lifelong valid insurance number and the enrollee’s photo the eHC would be well protected against misusage [26]. Furthermore, the first implementation step included a European Health Insurance Card (EHIC) on the reverse side of the eHC, which should give enrollees “access to medically necessary, state-provided healthcare services during a temporary stay in any of the 27 EU countries, Iceland, Lichtenstein, Norway and Switzerland” [27].
- For the second step of the administrative functions the implementation of electronic prescriptions (e-prescription) were planned for Germany (compulsory). The idea was to remove the approximately 700 million paper-based prescriptions and to process these transactions electronically [28].
- In the third step the implementation of the medical functions were planned. Because this involves personal health information Germany decided that these functions are voluntary, which means that the enrollees can decide if they want to use these additional functions or not. Examples, which were planned, are the documentation of medicine, which an enrollee has used or the storage of an emergency data record [29].
- The fourth step of the eHC implementation included, among other things, the electronic health record (EHR), which is also voluntary. With this EHR the idea was to have access to the entire patient’s data. For example, an EHR can include information about medications, radiology reports and past medical history. But it is not important, if the data are stored at one place or at different places, because the data of the patient can be accepted, processed and attended centrally [30].

2.3.2 Germany’s Current Strategy. In October 2011, the basic rollout of the German eHC began. Due to numerous debates pertaining to costs, functionality and security, as well as the correct strategy to move forward and appropriate timing, the start has been delayed for five years [31]. In addition, the four-step implementation plan seems to be invalid. The gematik now just mentions the difference between compulsory and voluntary functions [29] and functions available and functions in preparation.

The eHC, which is currently rolled out, is equipped with a photo of the enrollee and the lifelong valid insurance number. In addition, personal information of the enrollee and the necessity of additional payments can be stored while the European Health Insurance Card is located on the reverse side of the eHC [32]. All these details are equivalent to the first step of the old implementation plan.

In addition, five additional functions are in preparation [33]:

- Possibility to check and update enrollee data on the eHC online.
• Emergency data record: Enrollees can decide if an emergency data record, which includes allergies or incompatibility of medicine, etc., should be stored. This emergency data record will help the emergency doctor for his/her treatment, because the doctor can use this information without the contribution of the patient.
• Secure data exchange/communication between medical practitioners (e.g. discharge summaries).
• Electronic case file: Exchange of patient data between e.g. medical practitioners, which belongs to the same case.
• Documentation of medicine: The risk that patients will get/use drugs that will have interdependencies to other used drugs can be reduced.

The emergency data record and the documentation of medicine is equivalent to step three of the old implementation plan and the electronic case file can be seen as a lower version of an electronic health record, which refers to step four of the old implementation plan. Additionally, the secure data exchange/communication between medical practitioners (e.g. discharge summaries) refers also to step four of the old implementation plan. But the electronic prescription is not mentioned anymore (step two of the old implementation plan) and also, as mentioned above, the step by step approach is not valid anymore. In addition, it is unclear to date if the electronic health record will be implemented in the future.

2.4 Case 4: UK

The UK has also opted for a national e-health solution known as National Program for IT (NPfIT). To understand this solution it is first necessary to understand key aspects of healthcare delivery in the UK. The UK has a predominantly public or government funded healthcare system known as the National Health Service (NHS). This system was founded in 1948 as an integral part of British society, culture and everyday life. Private healthcare has continued in parallel to the NHS, largely paid for by private insurance (used by a small percentage of the population – generally as a top-up to NHS services) [34].

NHS Connecting for Health is the agency of the Department of Health launched in April 2005 charged with the responsibility for delivering the National Program for IT as well as business critical systems to support the national e-health solution [35]. The solution itself includes dividing the UK into five key regions and developing IT systems and services on a local level for these five regional clusters (Figure 1) of strategic health authorities supply and integrate systems across clusters so that systems will be common to all users [34-35]. Currently, this very large and ambitious project is over budget and yet to deliver on promised benefits [34].

![Figure 1. The five regional clusters (adapted from [34])](image)

2.5 Case 5: US

The US in direct contrast to the UK has a predominantly private model for healthcare delivery [3]. As such it has chosen an approach through healthcare reform and government policy not to define a particular national e-health solution per se but rather outline the parameters to which potential e-health solutions should subscribe [3]. One of the current key issues is the need to be compliant with the statute of meaningful use of technology [36] while a key structure in the e-health solutions to be developed and currently developing in the US will be related to supporting health information exchange [37]. “Health Information Exchange (HIE) refers to the process of reliable and interoperable electronic health-related information sharing conducted in a manner that protects the confidentiality, privacy, and security of the information. The development of widespread HIEs is quickly becoming a reality” [37]. In addition, Health Information Organizations (HIOs), the organizations that oversee HIEs are being designed and developed (ibid). For HIOs to function, they must have the capability to employ nationally recognized standards to enable interoperability, security and confidentiality, and to ensure authorization of those who access the information and it is these issues specifically the design, development and agreement of these standards that is currently a key priority [37].

3. Mapping the Ontology with Case Studies

By its very nature healthcare delivery is made up of a complex set of operations that include a web of healthcare players (or partners as per the ontology in
section 1). Thus, it should be of no surprise that all the e-health solutions presented in the proceeding section are large, complex projects. While some of the projects are at different stages of completion to others without exception all the initiatives, irrespective of the type of healthcare system are experiencing numerous challenges and none to date has delivered the promised results.

In terms of the five categories of the ontology presented earlier (Technology, Partners, Content, Media and Purpose) problems and challenges exist in all categories in each case study. For example with the PCEHR (the Australian solution) differing levels of technology infrastructure, adoption and diffusion throughout the country both in clinicians offices as well as citizens’ homes impact the possibility for its uptake and use; i.e., a Technology level issue. Further, there is contentious debate between the provider groups as to the level of consultation before the implementation which post implementation means that some clinicians are less well represented by the system than others i.e., a challenge at the Partners level. At the Content level two critical challenge exist as follows: the first is connected with the issue of opt-in versus opt-out, i.e. an individual is assumed to be part of the system unless they deliberately choose to opt-out versus an individual must specifically request to be a part of the system, the second is centered around the fact that the patient can select who has access to what in their complete medical record. Meanwhile, at the Media level various groups in the community such as the old and disabled as well as less computer savvy are at a distinct disadvantage with the PCEHR solution over a face to face context. For this solution Purpose, while not without its challenges is the least contentious and problematic area since, most are agreed that research, administration, care and education are the key areas for healthcare data and information stored in the PCEHR what is yet to be agreed upon is how this will be used and accessed for these various activities.

What we see then if we continue to map the case study data onto the ontology is that at all levels there are numerous challenges and impediments and a rich and robust theoretical framework or analytic lens is required to help identify key success factors barriers and facilitators to support a systematic and comprehensive analysis. We propose Actor Network Theory (ANT) as such a theoretical framework/lens and illustrate its benefits in the next sections.

4. Actor Network Theory

Actor Network Theory (ANT) is a sociological theory developed by French sociologist Bruno Latour and Michel Callon and British sociologist John Law [38-41]. The essence of this theory is that the world is constructed of hybrid entities [38] consisting of both human and non-human elements e.g. people, objects and organizations know as actors or sometime actants, and these elements cannot be studied in isolation or separately [42].

ANT tries to bridge the gap between a socio-technical divide by denying the existence of purely social or technical relations. In doing so, it takes a relatively radical stand and assumes that things (such as technologies) are actors and therefore have the potential to transform and mediate social relationships. Moreover, emphasis is also placed on the concept of heterogeneous networks because of the non-similar nature of elements and their relationship in network. This makes them open and evolving systems [43]. Therefore, Actor Networks are highly dynamic and inherently unstable in their nature; and a better understanding of how alignment between people, technology, their roles, routines, values, training and incentives as well as understanding of the role of technology and how it can facilitate or negatively impact the work process and tasks in an organization, and/or can stabilize the network to some extent can be better understood [44-45]. Thus, ANT can provide a material-semiotic approach and hence be an appropriately rich lens to study the ordering of scientific, technological, social, and organizational processes and events [45]. And it is for precisely these reasons ANT is proffered in this paper to facilitate a better understanding of e-health solution success.

4.1 Key Constructs of ANT

In order to apply ANT appropriately, it is first necessary to become familiar with the following key constructs and map them with the discussed case studies.

1. Actor/Actant: Actors are the web of participants in the network including all human and non-human entities. Because of the strong biased interpretation of the word actor towards human; a word actant is commonly used to refer both human and non-human actors [45]. Examples include humans, organizations, technology, technical artifacts and graphical representations.

2. Heterogeneous Network: is a network of aligned interests formed by the actors. This is a network of materially different 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" [45].
3. **Tokens/Quasi Objects**: are created through the successful interaction of actors/actants in a network and are passed between actors within the network. As the token is increasingly transmitted or passed through the network, it becomes increasingly punctualised and also increasingly reified especially when the token is decreasingly transmitted, or when an actor fails to transmit the token [45].

4. **Punctualisation**: is central to ANT. Within the domain of ANT, every actor in the web of relations is connected to others and as a whole it will be considered as a single object or concept in the same way as the concept of abstraction is treated in Object Oriented Programming. These sub-actors are sometimes hidden from normal view and can only be viewed in the case of a network break-down; this concept is often referred as a depunctualisation. Because ANT requires all actors or sections of a network to perform required tasks and therefore maintain the web of relations this becomes more focused when a break-down in the network occurs. In case any actor ceases to operate or maintain its link, the entire Actor Network would break down resulting in ending the punctualisation. Punctualisation is thus a process and cannot be achieved indefinitely rather it is a relational effect and is recursive in nature [40, 46].

5. **Obligatory Passage Point (OOP)**: 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 [42].

6. **Irreversibility**: Callon [42] 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 [38]. Given the very complex nature of healthcare operations [5] irreversibility is generally not likely to occur. However, it is vital that chains of events are continuously analyzed in order that future events can be addressed as effectively and efficiently as possible.

### 4.2 Three Stages of ANT

In addition to the afore mentioned it is also necessary to be aware of the three key stages of ANT as follows:

1. **Inscription**: is a process of creating technical text and communication artifacts to protect an actor’s interests in a network [38, 41, 47]. This is a term used for all texts and communications in different media including but not limited to (journal articles, conference papers and presentations, grants proposals and patents). Given the functions of an e-health record in general, the inscription stage is most beneficial to facilitate an in depth analysis regarding the content of the record and how this is communicated.

2. **Translation**: is used to explain the process of creation of Actor Networks and formation of ordering effects [39, 42]. At this stage all actors decide to be part of this network if it is worth building [41]. A good example here is the formation of NEHTA in the Australian case study and the identification of GPs as primary actors in the case of PCEHR adoption and implementation.

3. **Framing**: is an operation that can help to define actors and distinguish different actors and goods from each other [48]; i.e. in the German context for example, the various functions of the eHC are able to be analyzed in detail from the perspective of framing. Such an analysis in the ANT process can help the network to stabilize or the e-health solution to be suitable and thereby successful.

The next sections maps the key ANT constructs to the critical issues in the respective e-health case studies. In this research we have subscribed to the directives of Kvale [14], Boyatzis [15] and Yin [16] regarding conducting of rigorous qualitative research and construction of appropriate themes for thematic analysis. Moreover, triangulation of data gathered has been achieved through site visits, ethnographic analysis at key data sites in the respective countries and extensive use of secondary data and published reports.

### 5. Findings

As noted, the five case studies represent different types of healthcare systems spanning from essentially public (UK), to two-tier (Australia and Germany) to essentially private (US), as well as a healthcare system from an emerging economy; China. However, what is interesting is that faced with the same external challenges all these countries have opted for some type of national e-health solution in most cases, or in the case of the US the development of structures and policies to support several best of breed e-health solutions.

By analyzing these respective solutions using the rich and robust lens of ANT it becomes possible to understand what is required for successful e-health solutions to ensue; the important barriers, enablers and facilitators. Table 1 summarizes these findings.

The usefulness of ANT however, has even more far reaching benefits. In all the case studies discussed major delays to roll out of the specific solution has been due to lack of understanding and/or engagement of key stakeholders. By using ANT to frame and
analyze the specific e-health solutions as well as incorporating the three stages of ANT to examine more closely the processes that have/are ensuing, it becomes very clear who the key stakeholders are and how they will need to interact in order for success to ensue a priori. This will then serve to develop a shared vision in all stakeholders’ minds and thereby get a clearer concept of what is exactly needed and the key steps to achieve this. If such an analysis had been done in both the Australian and German instances, for example, it would be possible to have avoided many of the delays, which have amounted to years, while in the context of the NHS connect it would have been possible to avoid many of the key cost over runs, which have to date amount to order of magnitude millions of pounds. In the context of the US case study such an analysis would be especially helpful to identify the specific function of the various healthcare solutions as well as how they might need to interact to transfer data across and within systems.

Finally, it is also possible from such an in depth analysis enabled by ANT to identify the key considerations and factors important for the successful implementation and adoption of e-health solutions and begin to model these as depicted in Figure 2. This figure serves to depict key flows of information necessary for the quality of health outcomes. Moreover, it should be noted that such an analysis is indeed consistent with the ontology as describe in section 1, but without ANT it would not have been possible to systematically isolate all these components.

6. Discussion and Conclusion

By their very nature, e-health solutions are complex, large scale projects. Moreover, the technology mediated collaborations that ensue from these e-health solutions are numerous and have far reaching consequences; thus, it is of paramount importance that the underlying e-health solutions are successful. To date however current techniques, tools and analyses have failed to adequately capture the complexities and/or key nuances for a myriad of reasons but mostly because they have not been flexible, rich or robust enough. In addition, current approaches tend to view e-health solutions in terms of the adoption and implementation of a technology and fail to capture the critical interactions by key stakeholders such as providers and patients. Thus, the social and socio technical interactions must be analyzed systematically and with a robust and rich lens and hence we have suggested ANT. To illustrate the power of ANT in facilitating such analyses we have presented five case studies and provided respective ANT analyses for each. It is important to note that yet another beauty of ANT in this context is that it is as useful irrespective of the healthcare system (e.g. private, two-tier or public) or type of government system. This ensures that an objective framework can be used at all times. Finally, it is important to note that a mapping of ANT proffered in this paper is indeed consistent and in fact supports the proposed ontology by Ramaprasad and Paul [13].

Healthcare globally is at a cross roads. E-health is being seen as a vital necessity to address escalating costs and yet provide quality healthcare. This in turn means that the successful assimilation of these e-health solutions into their respective healthcare contexts is vital so that the technology mediated collaborations in healthcare which serve to provide quality patient care and life saving treatments must not only be understood but also facilitated and supported by these e-health solutions. ANT provides such an in depth appreciation by concurrently looking at people and technology issues and their interactions. Healthcare globally is at a cross roads. Thus, we close by calling for more research into the application of ANT in e-health solution analysis as we are confident this is an important area for investigation.

7. References


Figure 2. Schematic of ANT analysis
<table>
<thead>
<tr>
<th>Key Concept</th>
<th>Public (Case 4)</th>
<th>Private (Case 2 and Case 5)</th>
<th>Two-tier (Case 1 and Case 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actor/Actant</strong></td>
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<td>Technology: Web 2.0, databases, Graphical User Interfaces, HiE, computer hardware and software. People: service providers, healthcare funders, healthcare service recipients, healthcare organizations, suppliers and private health insurers.</td>
<td>Technology: Web 2.0, databases, Graphical User Interfaces, HiE, PCEHR, Hi, eHC and other computer hardware and software. People: service providers, healthcare funders, healthcare service recipients, healthcare organizations, suppliers and private health insurers.</td>
</tr>
<tr>
<td><strong>Heterogeneous Network</strong></td>
<td>NPHIT concept is not just an innovative solution in conjunction with several new functions; it will also result in a better information exchange between five key regions and between the healthcare actors.</td>
<td>No one particular e-health solution is defined, clearly a network of different applications and e-health solutions. To overcome the fragmentation US is developing a policy to support health information exchange (HiE).</td>
<td>The PCEHR technology here is clearly a network of different applications in this context. On the other hand the German e-health card concept will lead to a more connected and centralized healthcare system in Germany.</td>
</tr>
<tr>
<td><strong>Tokens/Quasi Objects</strong></td>
<td>This translates to successful healthcare delivery, such as treating a patient 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.</td>
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<td><strong>Obligatory Passage Point (OPP)</strong></td>
<td>The OPP for UK system is to develop a protocol for five regional clusters of strategic health authorities to help them to supply and integrate systems across clusters and make it sure that systems will be common to all users.</td>
<td>Nationally recognized standards and protocols are OPP for the successful e-health initiative in China and US.</td>
<td>In Australian context NEHTA is still developing this component. Whereas in the case of Germany the eHC includes all the protocols for accessing medical data during a patient consult.</td>
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<td><strong>Irreversibility</strong></td>
<td>Given the very complex nature of healthcare operations, it is generally not likely to occur. However, it is vital that chains of events are continuously analyzed in order that future events can be addressed as effectively and efficiently as possible.</td>
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