Facilitating the Adoption of Open Source Technologies for UK Health Care: An Ecosystem Framework

Ying Liao\textsuperscript{1}, Kiran Fernandes\textsuperscript{1}, Denise Downs\textsuperscript{2}, Gill Foley\textsuperscript{2}

\textsuperscript{1}The York Management School, Freboys Lane, York YO10 5GD, UK, \{yl705|kf501\}@york.ac.uk
\textsuperscript{2}UK Department of Health Informatics Directorate, \{denise.downs|gill.foley\}@nhs.net

Open source initiatives like the U.S. Veteran VistA has had a profound impact on how services can be delivered to patients. Despite the growing support for the use of open source technologies in general and healthcare in particular, the United Kingdom healthcare community has been slow to adopt these technologies. Key reasons cited for this has been the lack of government policy and initiatives to support business to operate commercially in this sector. This article proposes a framework for implementing a UK e-health open source ecosystem that can potentially foster the re-use of software components and promote interoperable software solutions in the National Health Service (NHS) to support improved patient-centred care.

Keywords
collaboration, ecosystem framework, health informatics, open source technologies, UK health care

1. Introduction

Many healthcare trusts in the United Kingdom, although discuss and advocate the appropriate use of technologies, seem to be relatively slow in terms of uptake of the technologies to support the day-to-day operation of their organizations. This is especially the case in respect of open-source technologies, where a number of stakeholders have to collaborate to develop patient-centric software solutions. There are a number of initiatives like Veterans Health Information Systems and Technology Architecture (VistA), which have proven to improve efficiency by 6% per year \cite{1} and achieve a pharmacy prescription accuracy rate of 99.997\% \cite{2}. However, these initiatives cannot be directly adopted within the UK healthcare system due to the centralised nature of healthcare delivery.

The NHS, which is the world’s largest publicly funded health service, is divided into primary and secondary care. In 2008/9 the NHS received more than £100billion budget from government \cite{3}. Since January 2004, £5.8billion has spent on the National Programme for IT with an aim to provide the NHS primary care with ‘a main and alternative system’ \cite{4}. Despite the growing support for adopting open source within government IT, there is a low level of public awareness of the proven merits of open source to meet the business requirement of the NHS \cite{5}.

The aim of this paper is to introduce a framework that is capable of facilitating the adoption of open source technologies within the UK healthcare system using an internet based ecosystem. This is achieved by providing the stakeholders the opportunity to collaborate and develop interactive solutions and dynamic online communities as part of the structure of UK National Healthcare System. Before addressing the central issues of facilitating such an ecosystem, we provide a brief introduction about existing initiatives in this area followed by a literature review. The framework is discussed in detail with emphasis on marketplace, governance, partnership and contribution. We use expert interviews and case studies to demonstrate the robustness of the proposed framework. Finally, we present our experiences of facilitating the ecosystem.
2. Literature Review

The health Information Technology (IT) has its own history to adopt open source technologies. The U.S Veterans Health Information Systems and Technology Architecture (VistA) has been distributed as source code at no cost for decades [6]; around VistA’s core code base developer communities were formed to provide more cost effective and widely available open source Electronic Health Record (EHR) solutions [7]. In 1990 the OpenGalen was formed to provide an open source route for disseminating the academic research results of medical terminology and tools as a framework for its future development [8]. OpenEHR [9], a non-profit organisation co-founded by the UK and Australian academics and health informatics, aim to develop specifications, open source software and tools for creating re-useable clinical models of content and process (known as archetypes) along with formal interfaces to terminology. Supplier-sponsored Mirth [10] is an open source cross-platform HL7 interface engine that enables bi-directional sending of HL7 messages between systems and applications over multiple transports.

Recently the U.S Department of Veterans Affairs projected an ecosystem vision of VistA with an aim of accelerating rate of innovation, easing component integration and creating a new market [11]. Large open source projects such as Apache, Eclipse and Mozilla, have demonstrated that both open source development and technology adoption can be facilitated in a mature ecosystem [12, 13]. This is becoming more and more important for sector linked with the public’s well-being, such as health care [14]. An ecosystem initiative was taken by the International Health Terminology Standards Development Organisation (IHTSDO) [15], with a purpose to improve the health of humankind by fostering the development and use of suitable standardized clinical terminologies (notably SNOMED CT), in order to support safe, accurate, and effective exchange of clinical and related health information. Open Health Tools (OHT) [16] which is collaboratively working with IHTSDO on an open source clinical terminology workbench, was established by international collaboration efforts with a vision of enabling a ubiquitous ecosystem where members of the Health and IT professions can collaborate to build open, standards-based interoperable systems that enable patients-centred health care.

Adopting open source technologies might be essential for making significant advances of health systems in the domains of personal health [17, 18], healthcare delivery [19] and population health [20, 21]. Researchers argued that lack of awareness and understanding of, and familiarity with open source technologies is a major barrier to the adoption of EHR [22] In the interest of interoperability, open source technologies could help to lower the price of the Health IT applications or components (particularly knowledge components), or pieces of the technology infrastructure for interoperability [23]; it also can help to reduce health IT suppliers’ internal development cost and mitigate risks of adopting standards [24]. Adopting open source technologies could also facilitate re-use of health IT tool components [25], which can potentially help prevent the health providers from re-creating the wheel and achieve long-term cost savings. In contrast to the proprietary solutions, open source technologies enable health providers to avoid being locked-in proprietary health IT systems and promote the use of open data [26]. Open source technologies can also help engage with front-line clinical staff who require for more innovative and flexible system features to help them get jobs done [27]. Health service performance could be improved by having a ‘vibrant and pervasive open source movement in medical informatics’ [28] as ‘user experience can potentially be improved’ [29] and ‘developers would have real-life test situations for their products’ [30]. Alternatively, Carnall [31] suggested within the context of the NHS, that open source may ‘provide security against specialist healthcare application providers going bankrupt and leaving the client (NHS) with problems, which may involve great cost to remedy’. However recent research has found that open source systems, supported by open source community, are in fact more secure than the expensive proprietary alternatives [32].

Compared to other developed countries, the NHS is one of the key laggards in term of the adoption of open source technologies [33]. An absence of open source reference implementations has led to an absence of successful open standards, and in turn an absence of competing implementations for health care systems [5]. Windley [34] notes that, over a long period of time, Government departments and the NHS have stopped developing their own systems and increasingly relied on IT consultants for this development. Very often these consultants are tied into software and hardware suppliers and this may create functional and suitability problems. The top-down approach of the National Programme for IT (NPfIT) has left little purchasing power between the NHS trusts and health IT SMEs [35]. Also the NHS
Previous open source studies propose different configurations of governance mechanisms [37, 38, 39,40]. Future research agenda could include ‘identify whether the presence, absence, or specific content of government rules is consequential for open source project effectiveness’ as suggested by Markus [41]. She further suggested a comparative study is needed to investigate ‘would these proposed configurations of open source governance mechanisms mesh with each other in an empirical study conducted with expanded set of governance categories and dimensions?’ [41]. Other potential research areas include: how leadership and control sharing across organisations and individuals in and between communities [42], what is the role of non-profit foundations in an open source ecosystem [43], and how to mitigate free riding in the open source model [44]. Recently the U.S Department of Veterans Affairs requested empirical evidence in the domain of open source governance to address various critical challenges of enabling an open source ecosystem such as ‘how to transition from passive software users to active open source participants’, ‘what are new governance elements’, ‘what factors will most impact the ecosystem’s ability to significantly contribute to the codebase?’, and ‘what is the degree of central control in an open source ecosystem’ [11] Future studies can also explore the empirical case of how ownership structure, market competition, and prior buyer–seller connections can support the market sustainability where not all buyers or all sellers participate in a biased e-market [45]

3. Research Question

The European Communities’ guideline on public procurement has adopted a view that standard-based open source alternatives and ‘technology-neutral’ regulation are vital to meet the public sector’s needs of interoperability, transparency and flexibility, as well as economical use of public funds [46]. In the United Kingdom it is part of the government’s ICT strategy to ‘create a level playing field for the use of innovative ICT solutions’ and ‘to educate, promote and facilitate the technical and cultural change needed to increase the use of open source across government’ [47].

The failure of NPfIT has transformed NHS’s ICT strategy from ‘replace all existing systems’ to ‘connect all systems’ [35]. The UK Department of Health has recently revealed a long-term vision plan that ‘the NHS service outcomes will improve most rapidly when clinicians are engaged, and creativity, research participation and professionalism are allowed to flourish to enable patients to have more choices and control, helped by an information revolution’ [48]. Facilitating the adoption of open source technologies can potentially change the dynamics of the UK health IT market and help NHS to improve ‘productivity’ and ‘efficiency’ and eventually improve patient’s care and safety [49].

The challenging economic climate is another driver for accelerating open source adoption for UK health care. The UK Leeds Teaching Hospitals NHS Trust is working with consultancy to develop an open source portal to give clinicians a single view of data held in its PAS and departmental systems [50]. Due to steep budget cuts for NHS trust, the idea of ‘share, re-use and recycle’ could be more likely to engage with NHS senior executives, ICT managers and procurement staff who are under pressure to deliver cost efficiency. This study can potentially contribute to the reflection of social dynamics over e-communities [51] in a context of health care; how relationship and power could shift between community members in a very different pattern from what we know [52].

4. Framework

This proposed ecosystem framework is made of four different models (i.e. a marketplace model, a contribution model, a governance model and a partnership model), which are inter-connected with each other to ensure the ecosystem’s long-term sustainability. These four models can potentially demonstrate merits of collaborative development and re-use of software application, component tools and knowledge artefacts within the NHS, uplift the counter-productive technology discrimination in UK health IT market, provide a level playing field for Small and Medium Enterprises (SMEs) and transform the dynamics of UK health care community.
4.1 A Marketplace Model

The UK Government recently set out proposals for putting local consortia of General Practitioner (GP) practices in charge of commissioning services to best meet the needs of local people, supported by an independent NHS Commissioning Board [53]. This means that the purchasing power will be devolved from central government to consortia of local GPs that will carry both budgets and governance responsibilities to ensure that appropriate and necessary healthcare services are commissioned in an area. The proposed marketplace model describes potentially how GP consortia and other NHS organisations could aggregate their purchasing power by participating in a buyer-biased e-market in which open source suppliers could reach a large number of buyers with only a single connection.

4.1.1 A community owned e-market

At any given point of time, it is assumed that the marketplace, where NHS organisations and its partners can list and share business requirements, can provide collaboration facilitates for a number of major health IT projects (i.e. p1, p2, p3..., pk); meanwhile there are a number of health IT suppliers operating in this ecosystem (i.e. m1, m2, m3... mk), with different combinations of skills and expertises (i.e. c1, c2, c3..., ck). A massive health IT project P1 (assembly requiring for a mix of business competences c1, c2, c3 and c4) is most likely to be outsourced to a major health IT supplier m5 because of its financial safety and 'full capability'; alternatively project P1 would be more likely to be outsourced to another more efficient and effective group of suppliers (i.e. m1, m2 and m3) in the proposed e-market as it would be easier for NHS to negotiate functionality, control budget and mange delivery time when large health IT projects could be cut into smaller and more manageable slots. Furthermore, developed software applications, component tools and knowledge artefacts can potentially be shared, reused and recycled within NHS under appropriate license arrangements.

The proposed e-market infrastructure is open-source-technology based, communally owned, communally governed and communally maintained. It would mitigate the future risks of the platform to be taken over by one player’s interest, lock into proprietary technologies or a single supplier, and lack of maintenance resource. It also provides potentially opportunities for all market players to build their own business model and interface with the e-market.

4.1.2 Virtual team(s)

A e-tendering system has been adopted by the proposed marketplace model. The selection of a virtual team can provide a mechanism to engage with open source solutions and open source suppliers (most of them known as health IT SMEs) into NHS’s procurement process for large health IT projects. Introducing business competence would also reduce the overall complexity of each single IT project. The NHS can potentially get better system functionality and features by integrating more innovative solutions and business models from small companies. A virtual team could be selected from both organisational and individual participants, which potentially allows independent consultants, clinicians and other individuals who understand the needs of NHS to get involved in the system development.
4.2 A Contribution Model

This contribution model demonstrates how health IT suppliers, health providers, clinicians, research institutions and other stakeholders can potentially collaborate together to develop health systems, populate ecosystem assets, re-use software components and share knowledge artefacts across the UK health care community. This contribution model is based on a hybrid scenario where supplier-sponsored projects and community-driven projects exist in parallel at the same time. But this article focuses on explaining how the supplier-sponsored projects can function in this ecosystem.

At any given point of time, this UK e-health open source ecosystem is consisted of a number of health IT suppliers (m1, m2, m3…,mk), code consumers (N1, N2, N3…, Nk) and a network of clinicians, researchers and individual developers (A1, A2, A3…, Ak). Normally a code consumer N1 (e.g. an NHS Trust) will look for a fully-functioned health system (e.g. Lorenzo) from the marketplace. However in an open source ecosystem, a health IT supplier (M1) can only develop a number of software components upfront (c1, c2, c3, test it with the market and leverage resource from collaboration with other community members, e.g. the other suppliers, NHS trusts and research institutions.

For example, if a health IT supplier (M1) has developed their own project roadmap and lists a number of software components (c1, c2, c3) in the ecosystem under an open source license, the code consumer (N1) could find that these components are useful, but they also need other components to build a fully-functioned system. In such circumstances, code consumer (N1) can approach the health IT supplier (M1) in the marketplace and co-fund an ecosystem project (e1). The development is strongly directed and co-ordinated by the supplier (M1), which potentially ensures the timeliness and functionalities to meet the code consumer’s (N1) business requirement.

In another case, the supplier (M1) can collaborate with research institutions who possess expertise within developing algorithms and concept, but lack resources required for implementation in the real world. Research institutions can be driven by the ‘proof of concept’, suppliers-sponsored funding and the greater good to the public; the health IT supplier (M1) can reserve their own resource and shift activities to build on other components or projects that are more commercially attractive.

If the open source components are of good quality, potentially other suppliers (e.g. M2) might tend to adopt these components into their own systems. Supplier, M1, can apply a non-permissive open source licence that will stop supplier, M2, from taking out software components to integrate them into their own proprietary system. In other circumstances, supplier, M1, will encourage the wider adoption of their components (particularly for interoperability infrastructure components) in order to gain the advantage of future interoperability. The emergence of communities with commonly used infrastructure components and open sourced system APIs can potentially promote the long-term systems interoperability for the health care.
4.3 A Governance Model

The proposed governance model consists of three elements: legal entity, membership and community self-regulation.

4.3.1 Legal entity

A legal entity is required to establish in order to own the ecosystem assets (including both tangible and intangible assets) on behalf of the community. The legal entity serves to protect the using of ecosystem assets in an appropriate way not against the open source concept and community interests. It upholds copyright, trademark and brand name, deals with external organisations and carries legal liability. A chair and a board of directors are usually recruited to execute operation.

4.3.2 Membership

A successful ecosystem approach allows any individual or organisation to freely access, use, contribute and disseminate useful outputs out of the community according to community’s license arrangement and terms of reference. Membership is applied to help community to facilitate and get the best out of its most invaluable asset which is ‘people’.

Benefits and commitments of membership should be carefully defined to keep the community attractive to join and at the same time avoid free-riding participants. Individual members are expected to facilitate group discussion, generate user feedback and actively participate in ecosystem events. Before community reaches the point of self-sustaining, organisational members can offer free service, donate codes and sometimes bring in cash to help the community take off the ground. However in the long-run, individuals and organisations should be given equal representation so as to reflect the voices from the grass-root of community.

4.3.3 Community self-regulation

A bottom-up community self-regulation is recommended. In the long-run, members will automatically be falling into different groups (e.g. open source development group, open source implementation group, requirement sharing group and standard group). Leaders and champions will be spotted on and be acknowledged by community. Representatives voted by community should sit in the steering group to shape the long-term strategy of the ecosystem.

4.4 A Partnership Model

The partnership model enables ecosystem members to collaborate on at different levels so as to think globally, lead nationally and act locally. Five groups of strategic partners for the UK e-health open source ecosystem are proposed as follows:

- Global open source communities

Figure 3 A Contribution Model.
Home country health care agencies
Open source suppliers representatives
International standards organisations
Research institutions

A successful regional ecosystem should co-operate with international communities rather than compete with them. Global connections enable ecosystem members to adopt ideas, share good practice, re-use existing tools and build project profile with international resource and talents; it also attracts open source suppliers in terms of the market size. At the national level, the ecosystem partnership with the Department of Health/NHS could help to buy-in senior executives of the NHS trusts and to influence the policy making. A regional approach could provide a national leadership to drive up the collaborative development and sharing between the NHS organisations to leverage resource more wisely and innovatively and to focus on the business needs of NHS. International standards organisations can play a vital role in the marketplace model by providing the ‘competence profile’ (i.e. standard compliance, engineering safety and license arrangement). Research institutions can always provide intelligence and resource support for open source development, which has been demonstrated in business model of successful open source supplier [54].

5. Evaluation of the Framework

In this study, the proposed framework was evaluated through expert interviews and case studies. They are discussed in detail in the following sections.

5.1. Expert Interviews

Expert interview was the first step of the evaluation process. Two sets of semi-structured interviews were carried out at the University of York. Thirty six interviewees (September 2009) mainly from the NHS trusts attended the first semi-structured interview session, while twenty five interviewees (June 2010) attended the second session.

Four experts in the area (academics and practitioners) were selected as interviewers. Among the sixty one interviewees, 27 represented NHS managers and leaders, 3 represented policy makers from the Department of Health, 24 represented commercial vendors and 7 represented the academic community and clinicians. The positions of these commercial experts included regional manager, supply chain manager, procurement manager, project manager, and so on. All of them had many years’ experience in the healthcare software development and service sector. The selection of interviewees provided a good representation of healthcare professionals. The key points of the experts’ comments are summarised below:

- The experts confirmed the appropriateness of the key models in the proposed framework. They were quite happy to see a systematic framework like this. The marketplace model, in particular, was of interest to the commercial interviewees, as the saw this as the basis of providing more flexibility to their existing portfolio of services and products. The experts felt that the proposed framework provides the UK healthcare community with a template that can be modified and refined at latter stages of the ecosystem.

- Majority of the experts agreed that the concept and principle of using a membership model can be used to develop a strong healthcare community and can be the basis of developing a robust collaboration network. Although they did not quite understand the difference between self-sustainability and membership based subscription, all of them suggested that the ecosystem could be sustained within two to three years.

- Some of the commercial experts suggested that independent moderators should be involved in the ecosystem management team. They believed that with the involvement of independent moderators the ecosystem would be perceived to be more independent and therefore marketable. However, they were also aware of that if external moderators are “employed” the management of the ecosystem will become more expensive.

- As for the contribution model, some experts worried about the biased judgment. On the contrary, other experts considered that it is a quick and easy way of getting developers to contribute to the
ecosystem. According to these experts, the development activity requires necessary resources. When resources are limited, our framework was useful.

- Competency scoring methods are developed in the proposed framework. Almost all of the experts preferred the competency scoring method to create virtual teams because it reflects the fact that some companies can perform better than other companies.
- According to the experts, the proposed framework can be used for different communities within the UK healthcare sector. The use of the framework for different communities highlights the importance of involving the “right-mix” of members to remove any unbalance of relationship development. This becomes a starting point of encouraging collaboration and integration throughout the ecosystem.

5.2. Case Studies

Two case studies were carried out. The purpose of case studies was to provide evidence for applying and examining the proposed framework in practice. The two case studies were two related projects in two large UK universities. One was on the use of Common User interface Reference Implementation Open source (CURIO). The other was a Clinical predictive tool, which was based on clinical predictive PARR model algorithm. They had two separate communities and two separate modes of delivery and development. Both these projects were funded under the auspices of UK grants. The main purpose of conducting these case studies was to understand the dynamics of the developed framework and validate the developed models. Our analysis shows that there is a relationship improvement in the aspects of ‘trust’, ‘collaboration’ from the first project, while aspects like ‘objectives’, ‘procurement’ and ‘community’ were key items seen in the second project. Starting with these two projects helped create a dynamic community on the ecosystem. Two parties (one US and one UK) have expressed a desire to establish a partnering relationship in a long-term programme.

6. Discussion

In this section, we primarily discuss our experiences of facilitating the adoption of open source technologies for UK health care from two perspectives: social and development dynamics. We conclude this section by synthesizing the main contributions of this paper towards the development of knowledge about ecosystem facilitation.

The role of a champion and project leader is central to the social dynamics of an ecosystem. Our observations were that most of the discussions and post messages that led to multiple branches were initiated by the champion and project leader(s). This finding echoes Mahendran’s results that highlight the importance of a champion and project leader and their authority over e-communities [49]. We observed that power is distributed between the project leader and the developer in such an ecosystem, as both parties take complementary roles in the ecosystem and often collaborate on issues related to project management. In our ecosystem we have seen that themes of discussion persist longer if they are clearly related to some central aspect of a live project or policy document. Single-theme design discussions are sometimes sustained for days. In these single-theme, multi-day discussions we have observed moments of interchange in which multiple messages are received from the same vendor. This often reflects their commercial interest in a particular topic. It is noted that concerns raised around what is the size of the marketplace, what makes it different and how does it work alongside the current business model of major health IT suppliers.

7. Conclusion

The proposed framework and associated models can serve as a useful guide for facilitating an ecosystem within the UK healthcare community and develop a research program aimed at understanding how the ecosystem impacts interaction and collaboration within a healthcare system. This section highlights these managerial implications and discusses research opportunities stemming from the conceptualization advanced in this paper.

NHS ICT Managers and commercial vendors can use the proposed framework to facilitate internal strategic discussions focusing on the evolution and potential impact of open source solutions within an ecosystem.
ecosystem. These discussions can be organized to correspond with the different models of the framework. First, vendors must develop a deep understanding of interactivity in the ecosystem – between clinicians and trusts, between trusts, and between academics. NHS ICT managers must carefully inspect their existing practices (particularly procurement) and industry-specific practices and evaluate their continued usefulness and relevance. Where appropriate, approaches for developing synergistic connections between existing communities within the ecosystem should be explored.

Finally, strategic discussions must take into account the multi-faceted nature of the ecosystem presented in this paper. Users like the clinicians may rely on the ecosystem not only to participate in projects, but also to search for information, facilitate projects and seek assistance on previously posted solutions. Developing solutions or projects to meet different needs is likely to have resource and business-process implications for a vendor. Therefore, after carefully considering technological and strategic factors, managers must chart, proactively, the most appropriate migration path for their different product-markets - that is, a trajectory of evolution toward collaborative development that is likely to be most beneficial for the firm.

Guided by the proposed framework, future research efforts can be developed in a number of related directions to explore the validity and robustness of the proposed framework. There is a need for research efforts focusing on empirically exploring the operational aspects of the ecosystem.

Finally, it should be noted that many of the ecosystem outcomes derived by the interaction between the stakeholders are linked to the acquisition and utilisation of information and knowledge. It is therefore imperative that this ecosystem takes into account the importance of transaction (not only monies) within the ecosystem. Overall, guided by the framework advanced in this paper, research efforts aimed at exploring issues like collaboration, interaction and development have the potential for significantly advancing our understanding of ecosystem facilitation and development.

The eHealthOpenSource.org ecosystem is in the transition process to take forward as a live community by ecosystem members. Our project has arranged ecosystem transition webinar and steering group meeting with wider community members to discuss about the long-term strategy of the ehealthOpenSource.org. A third party open source supplier has developed and donated a codeforge infrastructure to the ecosystem and we are in talking with local NHS trusts, universities and open source suppliers to finalize the transition proposal.

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References


