Understanding Technology Changes for ICT4D Projects through Modelling

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***Abstract*—ICT4D involves the study of design and development of ICT technology to the community. Based on our experience, most of the ICT4D projects are happening in one off solution. The projects will deliver with off the shelf products or services and hand over to the community upon the deployment and training. There is neither plan nor development to deal with changes. Hence, it may lead to the failure and unsustainable projects. We believe that dealing with technology changes is essential for sustaining the ICT4D projects. However, how to handle the changes in technology on ICT projects? This paper introduces a preliminary study on technique to handle the changes of technology through modelling. From the modelling, it showcases how the requirements have led to the technology change and how the business models affect the decision in designing the technology or solution for ICT4D projects. We adopt actor network theory to study the technology changes on ICT4D projects. We extend the actor network theory with networked actor modelling to study the actors' needs and the impact of cost (e.g. business models) to deal with the technology adoption, translation and development for ICT4D projects. The agent oriented modelling is introduced as the modelling process for actor network theory. The agent modelling consists of models based on the integration of agent models and e3Value model. In order to evaluate the work, we demonstrate how the model can understand the technology changes (e.g. adoption and adaptation) for an electronic health record system (EHR).**

***Index Terms*—EHR System; ICT4D; Modelling; Technology Changes.**

I. INTRODUCTION

ICT4D is the introduction of ICT to support the socio-economic development of the rural community. In Malaysia, ICT4D has been introduced almost a decade. The aim of the ICT4D is to bridge the digital gaps between the rural and urban; improve the digital literacy among the communities and promote the business development in the rural area for better livelihood. To date, various ICT4D projects have been introduced in Sarawak. Among them, telecenter or Pusat Internet 1 Malaysia (PI1M) is a platform to promote ICT among the rural community in Sarawak. The telecenter known as rural internet Centre (Pusat Internet Desa, PID), Mini RTC, Kedai Com, USP Communication Centre (UCC), Rural Broadband Library, Universal Service Provision (USP), and Bestari.Com [1].

The telecenter or PI1M is a place or one stop station that equip with ICT infrastructure like computer, the internet, printers, digital camera. Also, it can serve a multi purpose hall in which the training is conducted in the PI1M, meeting and other events. With PI1M, the community will attend various ICT or general training program (e.g. business training, talks), competition (e.g. drawing competition), and serve the Internet. They are a total of 1,945 telecentres are operational in Malaysia nowadays. From the review [1], the benefits of a telecentre in Malaysia are following.

i. community development in which the telecentre is served as a centre to embodiment and enrichment of social, physical, and spiritual aspects of the rural population [1].
ii. to increase ICT literacy of the rural community
iii. to improve access to computers and provide opportunities for online activities
iv. to promote the development of networking and telecommunication with outsider through email, SMS, etc
v. to access the government electronic system for services such as payment of taxes, registering complaints, etc
vi. to help students to obtain information online through telecentre programme in schools

As telecenter has much beneficial to the community, it has been suffered from the issues of sustainability. Based on our experience, most of the ICT4D projects are happening in one off solution. The projects will hand over to the community upon the deployment and training. There is neither nor plan or development to deal with changes. This may lead to the failure and unsustainable projects. We believe that dealing with technology changes is essential for sustaining the ICT4D projects. However, how to handle the changes in technology on ICT projects? We adopt actor network theory to study the technology changes on ICT4D projects. We extend the actor network theory with networked actor model in order to study the impact (e.g. cost) of technology changes for ICT4D. The agent oriented modelling is introduced as the modelling process for actor network theory. The agent modelling consists of models based on the integration of agent models and e3Value model. To evaluate the work, we demonstrate how the model can estimate the cost as the potential impact of electronic health record system (EHR), an EHR project for rural community Sarawak.

Section II presents the related works in dealing with technological change. It covers the adoption of ANT in the study the technology changes, and general usage of ANT. In addition, we present some of the issues of ANT in dealing with development studies. Section III presents the proposed modelling process to understand the technology changes for ICT4D studies. The section first elaborates the modelling process. This is followed by a run through an example of applying the modelling process to electronic health record system for the rural community of Sarawak. Section IV presents the lesson learnt and conclusion of this paper.

II. Related Works

Technology is one of the key elements for socio economic development for development. The technology has gone through a process of adoption, transfer, adaptation and innovation [6]. Although work [6] has been done to understand the process of technological change; the effect of technology change vs. social structure, there is a little detail on what happening during the technological change, what active role is played by both individual people and by the technology itself. In other words, studying the technical change from the actor or people perspective has not much addressed in the literature. Actor network theory (ANT) has been adopted to investigate the technical change in the Sri Lanka integrated financial management information system (IFMIS)[6]. The project provided new hardware, new software and a new procedure to five ministry's departments. It has been concluded that the ANT provides able to study the technological change processes for development. It can expose the formation and dissolution of the socio-technical structure; the active role (Asian development bank, PEM technology, government officers, private sectors consultant, MOF leadership) of technology and 'translation ' of interests during the changing processes. The Actor-network theory (ANT) is used as a framework for understanding the processes of implementing e-government in developing countries. ANT can identify what causes e-government implementations to success or fail [7]. Meanwhile, the ANT has been used to study the South African rural women's development organisation [23] and mobile learning for development [3]. From the review, we identify some of the issues of actor network practice:

i. The definition of actors is too broad. It covers human and non-human. As technology is listed as the example of non-human, it is not abstract, and maybe technology focus but not people focus.
ii. The intention of having models is good but not mature. [6] has presents a model during the problematization phase. The model shows the actors, transition and goal in a simple diagram. The paper presents the importance of multi-actor modelling and the notion of goal in actor-network theory. A good start on goal model.
iii. There is no work to explore on the actor-network to study the cost effectiveness of ICT4D projects.
iv. There is a lack of modelling technique to support the actor-network theory. The current practice is interviewing the actors [5]. Hence, the answer is subjective, and sometimes the answers are ambiguous.
v. The potential of actor-network theory is started to pay attention to development studies [5]. However, more works are needed to better position the actor-network theory for development studies e.g. how the networks lead to development, etc. -little works to understand what goes on during technological change; in particular the active role is played by people and by technology [5].

III. Actor-Network Modelling for ICT4D Projects

Inspired by [6], it has been reported that actor-network theory can study the technology changes of ICT projects. The actor network theory can analysis the actors and interconnection between actors, technology and society [5]. From the analysis, it can understand how ICTs can enhance the livelihoods of poor and marginalised communities [5]. The actor-network theory consists of two processes. First, the actor-network theory requires identifying the actors. Then, transition processes are conducted to analyse the actors. These involve activities to identify the problem (problematization) of the actors; the interest of the actors (interestness); the focus of the actors after negotiation of the interest among the actors (enrollment); the chosen representative to work on the focus within the group (mobilisation).

We introduce an actor network modelling to support the actor-network theory. The modelling process is adopted from agent oriented modelling (AOM) [11] and e3Value model [4]. The AOM is focused on modelling a complex socio-technical system. The AOM has been explored in various domains like sustainable software [13], collaborative learning application [14], eHealth [15], video surveillance system [8], information finding [10], environmental study [9], ICT4D [12][16]. On the other hand, the e3Value model is focused on financial or business modelling. As both models are based on actors, we believe that they are able to cover the various process of actor-network theory. Work like [4] has integrated agent model like Tropos with e3Value model [4] for web service development. The modelling is needed to enable the software engineers to understand e-service and reduce the short-lived business and bankruptcy of e-business [4]. The Tropos goal model and value-modelling are used to create, represent and analyse e-service business models. Also, it additional analysis for e-service.

Figure 1 shows the proposed modelling to support actor-network theory in dealing with technology change through agent modelling and e3Value modelling. The modelling process starts with Human Oriented Method Elicitation Requirement (HOMER). This is followed by ROADMAP goal modelling and role modelling and finally, i*goal modelling and e3Value modelling. On the other hand, the modelling is corresponding to support the actor-network theory process. The Agent Oriented Modeling (AOM) is adopted to identify the actors, problem and interest of the actors. The ROADMAP goal modelling and role modelling is related to enrollment process to finalise the needs of the actors. The i* modelling is to examine the strategic motivations and rationales behind a value constellation's network of relationships [4], which we believe it is an essential element during the mobilisation. Finally, the e3value modelling is to support the pre-development process. A process that has received a little pay attention in the actor-network theory [5].

To further elaborate the proposed modelling, we present how the modelling is able to deal with technology change for the EHR system. It showcases how the actor's requirements and business model have led to the design choice of EHR system. The models will first model the adoption, translation and innovation of the technology based on the actor study. The software engineers can look at the models to design and develop the suitable systems. On the other hand, from the study of the financial capability of actors, the project manager can plan for a right business model for the ICT4D projects. Finally, the software engineer can use the previous models to design and develop the ICT4D projects.

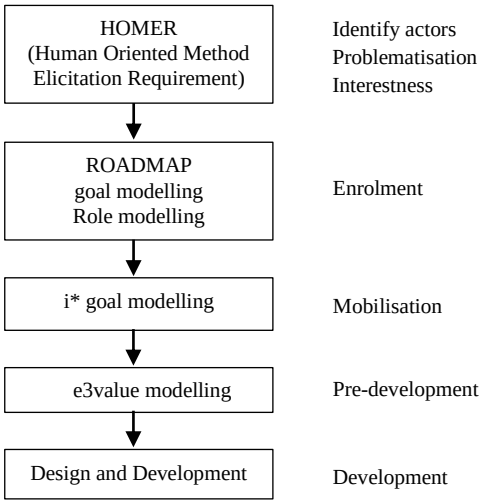

Figure 1: Exploring actor-network theory model through agent modelling and e3value

Agent elicitation through HOMER: As mentioned before, the modelling starts with HOMER. HOMER is a requirement elicitation technique for the agent based system. It is developed based on the organisation metaphor-hire a staff. During the elicitation, the interviewer will ask for several elicitation questions like who to hire in solving the entire problem? The job description, responsibility, dependency of the role, etc.

In the study, HOMER is used to understand how people adopt the technology. First, who will use the technology? What is the dependency of actors in using the technology? What is the purpose of having the technology? What is the knowledge that is required to use the technology? What are the rules or constraints in using the technology? The example of elicitation answers for EHR is following. We need to recruit project manager, provider (software provider, hardware provider, a network provider (e.g. mobile provider or satellite provider), power provider), community, medical officer, funder on EHR project. In general, the project manager will handle the project; the provider will deliver the EHR services; the community is the end user who will use the system and receive the benefits from the EHR system; the medical officer will consult and diagnose the community health records and the funder will fund the project.

A. ROADMAP Goal modelling

Figure 2 shows the ROADMAP goal model for EHR system. The goal model presents the purpose of the system. In general, the EHR system involves goals to 'capture health records', 'keep health records', 'send/alert health records', 'retrieve health records' and 'diagnose health records'. The community will involve in achieving the goal to 'capture health records' and 'retrieve health records'; the system provider is responsible for achieving the goal to keep the records, send the record to the community and alert the health status to the medical officer and community. Meanwhile, the medical officer is responsible for achieving the goal of 'retrieve health records' and 'diagnose health records'. The project manager is responsible to 'handle the main goal of 'handle health records' together with the funder. On the other hand, there exists quality goal of 'privacy' and 'literacy' in which those are the non-functional requirements for the system.

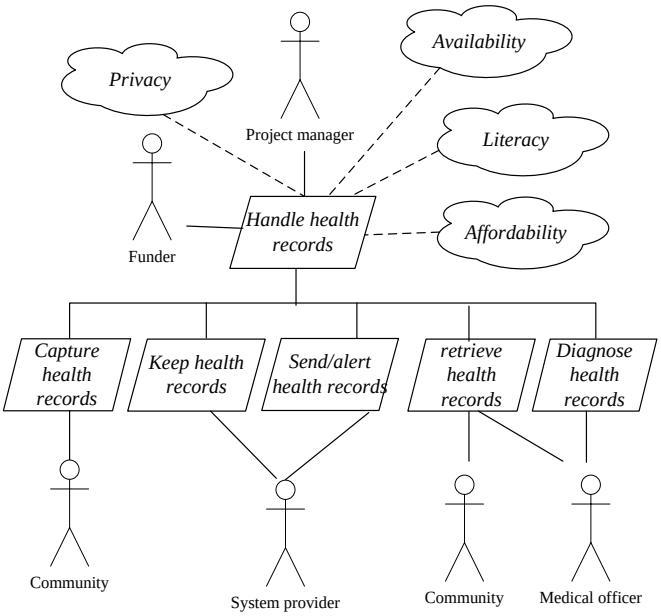

Figure 2: An overview ROADMAP goal model for EHR system

B. Role modelling

We can further understand the actors based on the role modelling. Table 1 shows the role model for an actor of funder. It models the interest of the actor in regard to the problem.

Table 1
Role model for funder

Role	Funder/NGO/Gov
Description	Provide funding to work on the community projects
Responsibility	Evaluate funding to the community
	Monitor the projects
	Receive reports on the project
	Call for proposal for the funding opportunities
	Pay the money project manager
	Working on the government policies (e.g. socio-economic policy)
	Enforce the policies
Constraints	Ensure the payment is on time
	Ensure the report submission is on time
	Ensure the project is executed according to the schedule
	Ensure the message is delivered and reach to the community

C. i goal modelling*

Figure 3 presents the dependency analysis of the actors through i* goal model. Here, the EHR system is depending on community, hardware provider, software provider, medical officer, funder/NGO/government; telecenter provider, network provider and power provider. The community depends on the telecenter provider for network access. Meanwhile, the community depends on the EHR system to 'keep records', 'retrieve records', alert health status; protect health data privacy and ensure literacy of the system. On the other hand, the EHR system depends on the community to capture health records; funder to provide funding; hardware provider to provide 'medical devices' and software provider to provide 'software development.

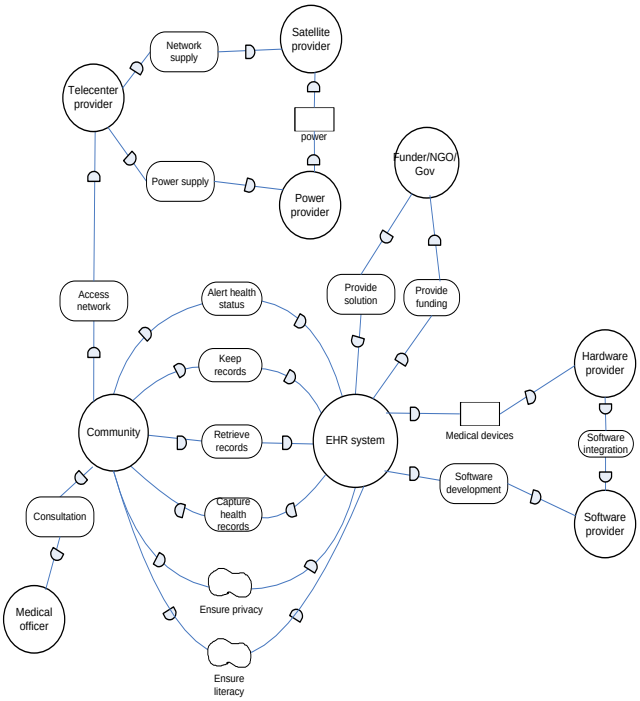

Figure 3: i*model for HER system

D. e3value modelling - pre-development

In this section, we present the study of the technology change from the financial perspective. The model showcase the technology change due to the different setting of business models. Figure 4 shows the e3value model for a telecentre based business model for EHR. The number of actors is based on the one to one mapping from the i* model in Figure 3. Altogether, they are ten actors in the e3value model. In general, the Funder will provide funding for the EHR system. From the funding, the EHR actor will transfer the money to recruit hardware provider, software provider, cloud provider and telecenter. Upon the payment, the hardware provider will supply the Bluetooth enable medical device and Bluetooth gateway to the EHR actor; the software provider will provide software to EHR actor; the cloud provider will provide data access, and repository to EHR actor and the telecenter actor will provide network access and computer facilities to the community. The medical officer will receive the health alert from the HER actor. Then, the medical officer will provide consultation to
the community. The community will access the EHR system. In order to access the system, the community needs internet access. The telecenter actor will provide the internet access to the community. It depends on satellite provider and energy provider on the internet facilities and power supply.

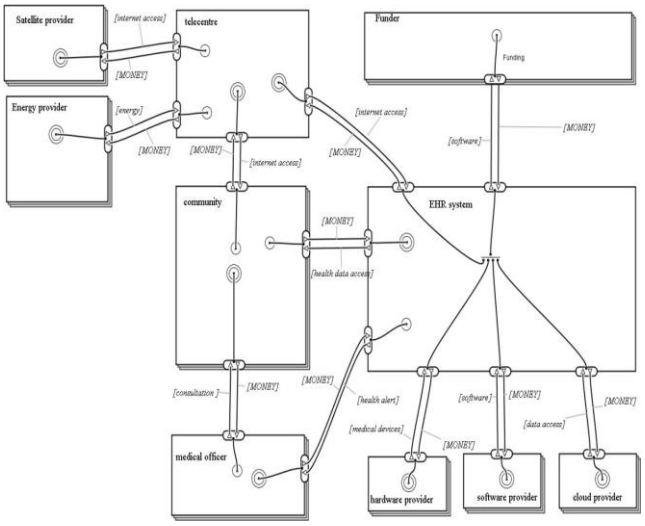

Figure 4: The e3value model for telecenter based business model for HER

From the e3value model, we can calculate the value transaction of each of the actors. The value transaction cover the revenue per actor based on provided product or services. Table 2 shows the sample of the cost calculation for telecenter actor. The results is generated automatically from the e3value tool. The table showcase the value transfer, value interface, occurrences, valuation, economic value and total value for each actor. The calculation is based on a yearly basic. Assume that the funder provide RM20000 on the funding to build the EHR system. The calculation is based on the estimation that the satellite network service is costed RM1300, energy service is costed RM2000; cloud service is costed RM250; hardware service is costed RM3000; software service is costed RM9000; telecenter service is costed RM5000. Meanwhile, the transaction to access the medical data by the community and medical officer is RM0 and the network access to telecenter is RM0 by the community. Table 3 compare the financial capability of two different business model for EHR system. The difference between this models is the community will pay for their mobile subscription within the mobile based business model for EHR. From the models, it's can become a platform to justify the technology changes. Here, the mobile based business model can save more allocation to the EHR actor. However, the community needs to pay RM360 on the mobile subscription.

Table 2
Sample of cost calculation for tele-center actor

Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
{internet access, MONEY}			1		-1300	
	in: internet access	(all transfers)	1	0	0	
	out: MONEY	MONEY	1	1300	-1300	
{energy, MONEY}			1		-2000	
	in: energy	(all transfers)	1	0	0	
	out: MONEY	MONEY	1	2000	-2000	
{MONEY, internet access}			1		5000	
	in: MONEY	MONEY	1	5000	5000	
	out: internet access	(all transfers)	1	0	0	
Total for actor						1700

Table 3
Cost table for telecenter business model vs. mobile based business model

Actors	Revenue of actor (RM)	
	Telecenter based business model	Mobile based business model
EHR system	2750	7750
Telecenter	1700	-
Cloud provider	250	250
Funder	-20000	-20000
Satellite provider	1300	-
Software provider	9000	9000
Hardware provider	3000	3000
Energy provider	2000	-
Medical officer	0	0
Community	0	-360
Mobile provider	-	360

E. Development

From the goal and role modelling, we can understand the problem, actor interest and focus. On the other hand, the pre-development allows the software developer to understand the reason behind the technology change based on the generated business models and find a suitable technology for the development process. Based on that information, we can design the EHR technology that suitable based on the study.

IV. Discussion and Conclusion

This paper describes how the technology changes for ICT4D projects. From the modelling, it can be reported that the technology changes because of the actor interests, focuses and is influenced by the networked of actors. Meanwhile, the technology changes is because of the changing of business model or cost effect for the entire solution. We introduced a modelling technique to understand the technology changes for ICT4D. The modelling technique is built upon the actor-network theory. In term of theoretical implication, this paper has extended the theory of actor-network theory with pre-development. With the pre-development and development process, the actor-network theory can cover the development phase in which those process are missing at the current stage. Meanwhile, we introduce the modelling process to actor-network theory and demonstrate the process to understand the technology changes for ICT4D. In future, more works are required to evaluate the modelling process empirically and through various case studies on two of the current community projects by the authors.

Acknowledgment

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