Modeling Services to Construct Service-Oriented Healthcare Architecture for Digital Home-Care Business

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Abstract

Using Information and Communication Technologies (ICT) to enable the daily activities and interests such as dining, medicine, lifestyle, traffic, education and entertainment has recently become a world wide trend. Moreover, Service-Oriented Architecture (SOA) is nowadays one of the most important techniques to realize services in industry.

Therefore, we would attempt to give attention to what type of services ICT could realize for chronic patients and how this concept should contribute to their recovery. In this paper, we would like to share our experiences in creating innovative home-care business models. We first discuss the business modeling process, which contains generating care services concepts, investigating market, defining Key Services scenarios and cooperative policies. Second, we present the constructed SOA healthcare platform. Specifically, we explain the technical issues during the development of our business models. Finally, the business models and platform are evaluated using the Key Performance Indicators (KPI) developed in the study.

Keywords: business modeling, SOA design, KPI evaluation, digital home-care

1. Introduction

As information and communication technologies (ICT) has continued to advance, the application of ICT has evolved in the different aspects of our lives such as work and entertainment. In fact, ICT has been gradually infused into our daily lives. Through network techniques, computers could provide many remote services. Interestingly, a large number of innovative service models, such as YouTube, WRETCH, Google, Amazon, etc. are continuously emerging. Using ICT to create innovative services models, many have become famous enterprises worldwide. One of their identical characteristics is that they have applied specific information techniques to integrate network techniques. Also, these models have successfully provided content services to promote business values.

The application of ICT has become a worldwide trend. Infusing Service-Oriented Architecture (SOA) to provide common activities and interests such as dining, medicine, lifestyle, traffic, education and entertainment has also become an objective of industry. Through the SOA platform, we could integrate individual providers into similar service processes. Modeling distinct business providers may also be interesting work. Through this process, researchers would be able to communicate with various stakeholders as well as design systematic platforms.

In this paper, we focus on the domain of patient-centered healthcare in digital home. We then construct the SOA healthcare platform and its application system which provide innovative business models. In the following sections, we will describe the progress of its construction and at the same time share our experiences from this study.

2. Related Works

2.1 SOA principles

Service-Oriented Architecture (SOA) is a software architectural style for realizing and constructing business processes, which are packaged as software services during their life cycle ([1], [2]). SOA defines and reserves IT infrastructure to allow various applications that exchange data in business processes. SOA also separates services into distinct units (components or modules), which can be deployed over the Internet, and can be combined and re-used for business applications. In clearly defined layers of SOA, requirements for business processes could be distinguished and identified. Business requirements are also implemented and combined by distinct software services. Typical layers for SOA are business process layer, business service layer, application integration layer, and technology layer.

Consequently, the general architectural principles [3] point out the ground rules of SOA for its development, maintenance, and use. These are the following:

- Usability - Components or modules would be re-used in various business processes, and even mobile services.
- Compliance to standards - Data exchanges between platforms are important to SOA. These exchanges will extend significant issues for standardization, identification, authorization, etc.
- Service identification and categorization, deployment and delivery, monitoring and tracking, and KPI definition, etc.

One standardizing service could provide diverse and

innovative business processes. A typical example is the service of agential cash-receivers of 7-11 stores in Taiwan which has allowed payments by credit card, telephone, and on-line shopping, to name a few. In addition, the specific architectural principles for design and service definition are categorized into two types. The first type is the interaction between the service consumer and provider. The second type includes the design guidelines of service providers. They are described as:

- Service encapsulation - Various services in the Internet are consolidated with web services under the SOA platform.
- Service loose coupling - Services maintain a relationship that minimizes dependencies on one another.
- Service abstraction - Services are logically hidden from the outside world, beyond what is described in the service contract.
- Service contract - Services attached to the communicable agreements, and defined in service description documents.
- Service reusability – A service is divided into units with extended re-uses.
- Service composition - Collections of units of services can be coordinated and combined to create services.
- Service autonomy – Services have control over the business processes they encapsulated.
- Service optimization – High-quality services are generally considered more than low-quality ones.
- Service discoverability – Services are designed to be accessible to the public, therefore they can be found and assessed via available discovery mechanisms.

Constructing SOA is not only a technical but also a business challenge. In the visions of SOA, relationships between the service consumer and provider are not tightly stipulated. Their relations are loose coupling [4]. Thus, consumer services are not forcefully influenced by the changes made by the providers. Secondly, consumer service interacts with the service provider based on the service contract. Moreover, designing the Service Level Agreement (SLA) is an important task. SLA should also satisfy some general and specific principles.

2.2 CVA Market Demands

Apoplexy, also known as Cerebrovascular Accident (CVA), breaks out when the cerebrovascular suddenly oppilates or fractures. Some patients only experience slightly pathological changes. Others experience paraplegia, and others simply expire. Diseases are distinct based on the position and size of infarcts or hemorrhages. In developed countries [5], CVA is one of the main diseases which result in death or disability. Its occurrence rate is 1.2 - 2.5/1000 [6]. The survival rate is 2/3, but, most patients would suffer disability. Some apoplectics would be discharged from the hospital and taken cared of at home. According to the official statistical data in Taiwan [7], CVA is also included among the top ten causes of diseases. Apoplectics would not only be a difficult illness to manage for the patient, but also to the family and society. Patients with apoplectic diseases need long-term care to reduce pathologies. If they are hospitalized over a long period of time, it will pose financial and emotional burden on their families and will also be a waste of resources in hospitals. Therefore, one effective solution for this situation is to take care of chronic patients at home; this could be a challenge for the family. Because of these perceived needs, the research team poses the following questions:

- What could Information and Communication Technologies (ICT) do for apoplexy patients?
- How should ICT contribute to the apoplectics' recovery?

3. Business Modeling

Business modeling is a critical starting point when we would like to provide care-services on SOA. Before constructing the services platform in SOA, we should ensure our care business models, which include market demands, key services items, services scenarios, market prices, even more cooperative policies, etc. The research process of business modeling for cerebrovascular patients' home-care is described in following figure.

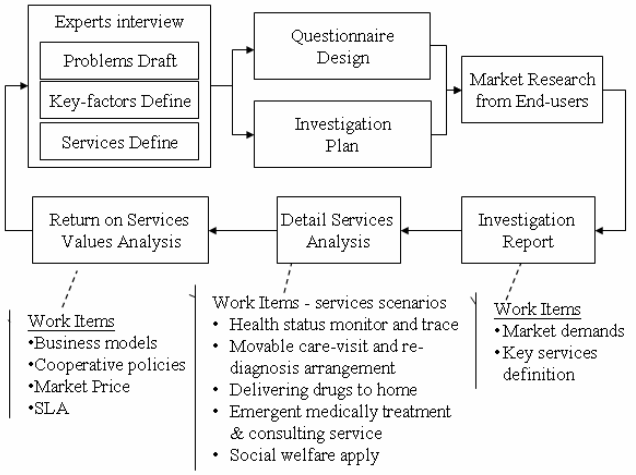

Figure 1. Business Modeling Process

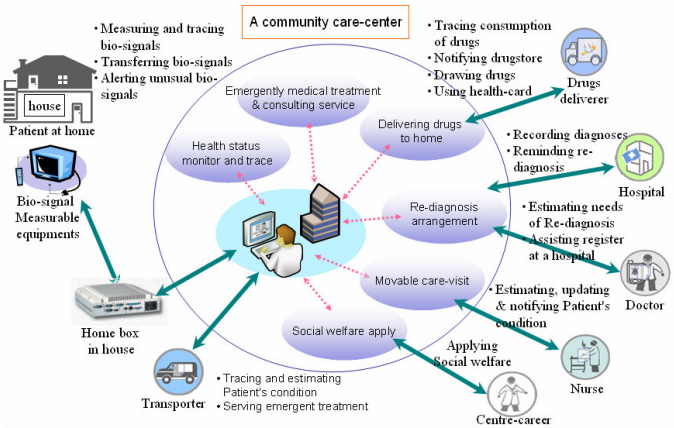

Figure 2. Services Concept

3.1 Services concept

First, researchers iteratively interviewed the domain

experts to draw out the services concept. This was a critical initial step in business modeling. The research efforts were really demanding as about 30% cost of whole project. The services concept is presented in figure 2. Particularly, there are services, roles, proprietors and devices that were included in the services concept.

3.2 Market Investigation

To obtain a good perspective of the market demands, a large-scale market investigation was carried out. The investigation focused on people who lived in Kaohsiung at southern Taiwan. Moreover, the patients' home-care is assumed as the research domain. In addition, the questionnaire was designed based on the services concept. Consequently, the investigation was divided into two parts namely the quantitative investigation and qualitative investigation, and were performed concurrently. Details of the investigation were recorded in the technical report [8]. Quantitative Investigation Results were significantly listed in table 1.

Table 1. Quantitative Investigation Results

Items	Demands of home-care	Percentage
1	health status inspection (Notify / Arrange / Trace)	61.2%
2	Health status monitoring, tracing and unusual alerting by medical equipments	56.2%
3	Assisting or accompanying to take medical treatment (register at a hospital / ambulance)	23.1%
4	Emergency medical treatment and notifying family members	48.5%
5	Consulting Medical treatment	47.7%
6	Providing supplementary instruments for home-care	49.2%
7	Serving routines at home	21.5%
8	Nutrition consulting	26.9%
9	Psychological consulting	26.2%
10	Assisting to call an ambulance	20.8%
11	Assisting to apply for social services	53.1%
12	Entertainment activities	21.5%

The results of the qualitative investigation are as follows:

1. For the cerebrovascular patients, restoring limbs at home has positive effects as they enhance the patients' movability.
2. The majority of the caregivers are female. When family members work during day time, caregivers who majorly come from overseas take care of the patients.
3. The major economic resources of the elders are their children as they depend on their previous savings.
4. Members of the family trend to drive their patients from their homes to the hospitals by themselves. However, when special equipment is needed, they choose to access the transportation services provided by the care centers.
5. Persons who have work hope that elders' day to day needs could be taken cared of by the hospitals or governments which are supported by community volunteers. Workers hope that care center could directly provide them more of the information about their volunteers.
6. There should be a higher provision of equipment to the patients who need them more, especially the equipment that regularly monitors the patients' status and alerts emergency situations. This is considered an innovative concept. Through the equipment, someone could efficiently take care of patients whose statuses were unusual.
7. Hospitals should charge a minimal fee for these types of services. The families would like to pay the services within the limit of their income. The maximum amount they would like to pay is 5,000 NT dollars per month.

3.3 Define Key Services to Develop

We would like to identify important services that should be developed from this investigation report. Based from our market analysis, we could first fund six items whose percentages are more than 40%. Their item numbers are 1, 2, 4, 5, 6 and 11. The other items, whose percentages are less than 40%, are filtered out. Second, we would only select item 1, 2, 4, 5 and 6 into key services group. The reasons are listed in last two columns of table 2. We filtered out item 11 since it could be supported without information techniques. Key service items in the group would be analyzed to form services scenarios for future development. Services scenarios were recorded into document [9].

3.4 Cooperative Policies and Market Prices

Home-care services are considered comprehensive solutions for patients at home because single service provider could not successfully provide these services. In addition, service providers should be organized into a virtual organization as they serve as care centers in the community, hospitals, IT companies, transporters, and insurance companies. Partnerships and agreements among these stakeholders have to be documented through contracts. Through this strategy, they could merge the services supply chains. Specifically, the insurance companies play a special role in the business models. During the services life cycle, service providers should review insurance policies, since there might be some risks in caring patients at home.

After planning the cooperative policies, we should also define the market prices for each service item. Care centers could sell services to end-users and enter into contracts with them based on the market prices of the combined services. In addition, market prices would be defined based on the previous investigation and the cost of different service scenarios. Thus, the cost of each service should be calculated. We listed the factors of each service's cost in the table 3.

Table 2. Select Services Items into Key Services Group

Discussion / Key Services Group	Investigation Results	Baseline to develop	Techniques / Business issues
Freelance care supervisors and re-diagnosis arrangement	health status inspection (Notify / Arrange / Trace) **61.2%**	In order to save medical resources for severe patients, doctor would suggest patients, who do not need much medical attention, to go to local clinics. This means that patients who only experience slight discomfort should just go to the clinics for medical. This system will make the distribution of patients in the hospitals even	To exchange diagnoses records
	Consulting Medical treatment **47.7%**		
Delivery of medicines to the patient's home	Providing supplementary instruments for home-care **49.2%**	By providing this innovative service, hospitals would have an increase in extra income. Patients could also get their medication more conveniently.	To integrate distinct industries
Health status monitor and trace	Health status monitoring, tracing and unusual alerting through modern medical facilities **56.2%**	Collecting bio-signals from patients at home and monitoring their variations are critical techniques. Hospitals could precisely get the patients' conditions.	To collect and to store bio-signals
	Emergency medical treatment and notification of the patients' condition to family members **48.5%**		

Table 3. Factors of Service Cost for Business Models

Factors	Price Unit
Expected number of centre-carer visiting	person-time/month
Human resources and qualifications	Person Quantity
Budget for human resources	dollars/year
Budget for IT systems and devices	dollars/month
Transporter's fee	dollars/month
Total budget	Dollars/year
Fees to be charged against user for their remaining balance	dollars/one person a month

4. Architecture Constructing

Developing SOA services platform and its application is another important task in providing SOA business models. To support this initiative, we employed and adopted software lifecycles [10] to develop them. Development process and its work items are described in figure 3. In the high-level design phase, we designed the SOA healthcare platform based on the services demands. An application system was analyzed through knowledge engineering in the requirement phase, and was designed using the MVC methodology in detail design phase. The required functions of these application systems were divided into three parts - user interfaces, business logics, and data models. User interfaces would be implemented in the application level while business logics and data models would be supported by SOA services platform. More detailed functions for each module are categorized into functional, non-functional, interface, and security. The high-level modules of the application system are showed in figure 4.

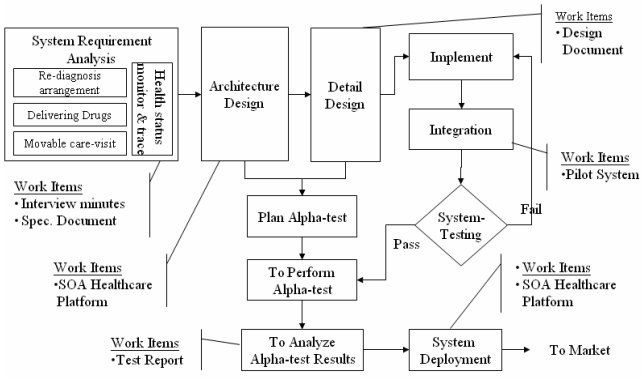

Figure 3. Developing Process of SOA Healthcare Platform

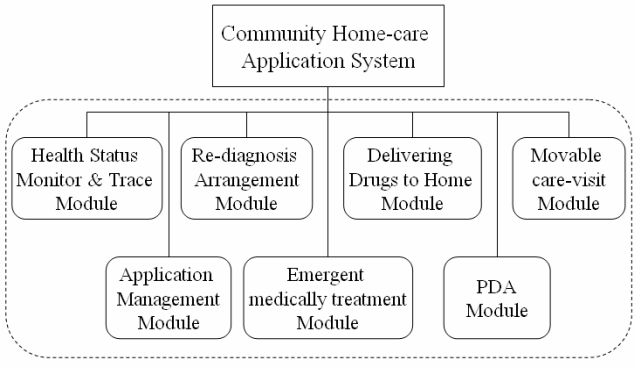

Figure 4. Functional Architecture of Application

4.1 SOA healthcare Platform

SOA healthcare platform was designed to provide executable environments which support standardized messages, various interfaces and flexible connections.

Different services techniques could cooperate with each others on this platform. In this platform, each module and component should be developed under MVC methodology. Business logics and data presentations should be separated into different independent components. Developing business services should focus on the design of business logics. The other technical components could be simply dealt through the SOA platform. SOA Healthcare Platform is showed in figure 5. Services-flow control tool contains three main modules, specifically the service executing engine, service process defining and services monitoring. The module of service process defining is used to identify service processes of application system. Moreover, the module of services monitoring is used to check the current statuses of service objects in the application system. Finally, the module of service executing engine is used to bind service objects and the other modules in platform. There are three healthcare tools that are used by patients in the platform. These include bio-signals management, messages management and end-users management. The module of bio-signals management is used to supervise patient's bio-signals from the homebox, an end-device installed in the patient's house. Meanwhile, the module of end-users management is used to handle users' profiles and personal descriptions. The module of messages management is used to handle messages passing between internal and external objects. In addition, the logger module is used to record the histories of the events while the module of exception handler is used for tracing run-time defects in platform. We would like to call these modules' components based on the coding style below:

```
try {
    // call regular components…
} catch {
    // call exception handler's components …
} finally {
     // call logger's components…
}
```

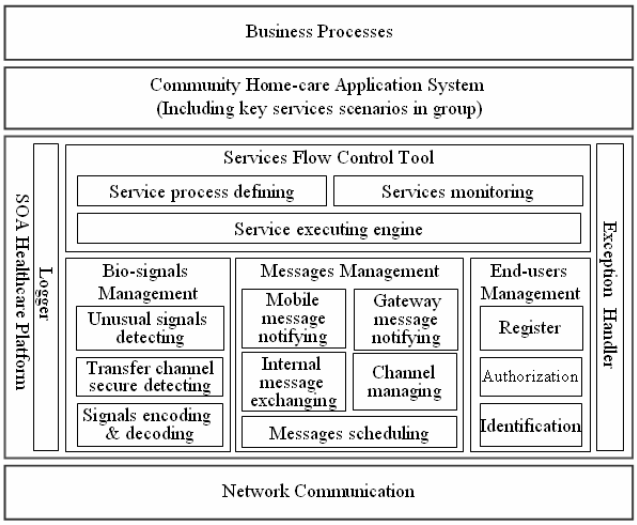

Figure 5. SOA Healthcare Platform

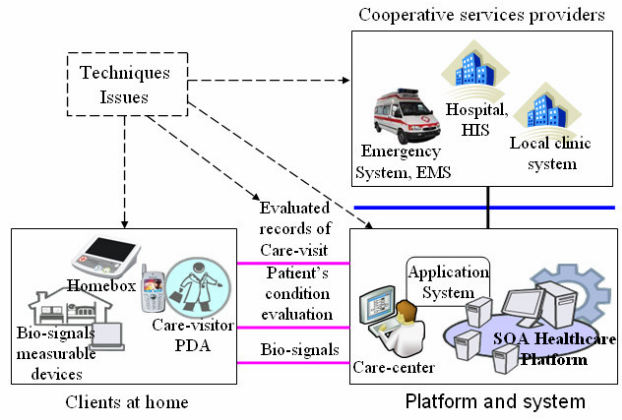

Figure 6. Deployment Overview of Systems

4.2 Surmounting Techniques Issues

We plan to deploy our systems in a real environment based on the services concept. The SOA healthcare platform was deployed to administer the services in the care center side and manage the homebox, bio-signal devices installed in the clients' house. The care center supervisor would regularly bring his/her PDA and visit the patients at their homes. Some cooperative services providers, such as hospitals HIS, local clinic system and emergency system, are also showed in figure 6. Since this is considered as a home-care solution really deployed in three sides, some technical issues about home-care will occur. By then, we will have to address these issues using the SOA platform. Furthermore, technical issues in home-care are addressed and shortly described as follows:

- Transferring bio-signals from clients to the application server in real-time
  - Transfer channels are always maintained by the platform which supports the message exchange.
  - Unusual bio-signals are monitored and handled by the platform through the application server.
  - End-users' profiles are managed by the platform. Private profiles should be shared in a secure way.
  - Messages and bio-signals should be standardized between systems through the platform.
- Integrating multiple bio-signals devices
  - Homebox would integrate multiple bio-signal devices. The condition of the homebox should be regularly checked by the platform, since it was registered there.
  - Within the homebox, user interfaces will simply be implemented to interact remotely. The interactions are executed through the platform.
  - If abnormal network occurs, homebox could detect and reconstruct by itself. After its reconnection, the homebox should pass exceptional logs to the platform.
- Integrating homogeneous providers
  - Business services processes should be composed and executed in an efficient way through the platform. The status of the executing services should also be monitored through the platform.
  - Caregivers should maintain terminal systems, which directly connect them to the platform.

Diagnostic records should be carefully shared using a standardized format between providers.

- Homogeneous systems should be integrated through the platform using for healthcare area.

Detailed specifications of this design are documented in technical report [11].

5. Key Performance Indicators Evaluation

The business models are evaluated using the Key Performance Indicators (KPI). We define our KPI by referring to the Balanced Scorecard (BSC) models [12]. For the SOA healthcare platform and business models, we planned to have four presentations of KPI. They are categorized as system quality, customers' satisfaction, business achievements and financial achievements. The measurements are described in the following.

1. System quality would be measured and analyzed according to its user-friendliness, level of security and privacy during the data transfer, the defects rates, the services response time and the used times.

2. Customers' satisfaction would be measured and analyzed according to the following criteria: marketing share, customers' continuity, increase in the number of customers, increase in customers' satisfaction, and stakeholders' satisfaction.

3. Business achievements would be measured and evaluated according to business quantity, number of customers, number of, transactions and profit growth.

4. Financial achievements would be measured and evaluated based on the profit growth and service packages, management performance and financial forecast that are based on the three phases, which are establishing phase, increasing phase and mature phase.

6. Conclusions

As information and communication technology (ICT) advances, the applications of ICT should provide convenience and business solutions to people. As revealed in our study, Service-Oriented Architecture (SOA) platforms could smoothly integrate business models and combine distinct services providers for innovative services. In this paper, we shared our experiences on creating innovative home-care business models. We presented how we created the SOA healthcare platform and addressed technical issues that emerged during its development. Finally, we demonstrated how we plan to evaluate the business models and platform using the four presentations of KPI. We believe that this is an interesting concept and a good case study on modeling services for the Service-Oriented Architecture in business processes.

7. Acknowledgements

This research was supported by the Applied Information Services Development and Integration project of the Institute for Information Industry (III) and sponsored by MOEA, Taiwan R.O.C.

Interviewed care-experts and investigated patients were supported by the Department of Medical Information, Chung-Ho Memorial Hospital in Kaohsing, Taiwan R.O.C.

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