

## The Critical Issues about Deploying RFID in Healthcare Industry by service perspective

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### Abstract

*Although the Hospital Information Systems (HIS) have been rapidly deployed in hospital and clinical management, there are still some obstacles existed in integrating object flow and information flow within HIS architecture. Deploying Radio Frequency Identification (RFID) technology could provide advantages indentifying, tracking and tracing objects to provide high medical quality service and promote value-added operation efficiency.*

*Taiwan government has heavily advocated and even taken the initiates for the RFID deployment in healthcare industry. Over years, there are hospitals have deployed pilot projects with an intent to verify and evaluate the potential of RFID applications in healthcare service. However, some of the pilot sites were terminated due to resource shortage; some manages to more to the next phases. Case study methodology was applied in this study by interviewing ten experts who have actively participated in different projects. The results indicate that the critical key factors on RFID deployment in healthcare applications are not only technological concern, but also the value-added service perspective on the technology, in particular the value proposition on RFID adoption, diffusion and system integration.*

### 1. Introduction

A service process can be viewed as value co-production by service consumer and service provider. Service makes changes not only in core body, but also mind, and possessions [1]. The economics of globalization and the demand of across industrial integration have speeded up the trend of service oriented innovation [2].

Healthcare is one of the crucial sectors in service industry. Healthcare service is life-critical, so that any mistakes may cause irremediable regret. This sector has exploring how information and communication technology might improve patient safety for the past 50 years [3].

The major applications of information communication technology (ICT) for hospitals include paperless electronic health record (EHR) system for patient safety and medical errors reductions, electronic certification, authentication, and data security protection mechanism that abides by government regulation [4].

However, there are obstacles in existing "Hospital Information Systems (HIS)" which limited the integration of information flow and object flow for identifying, tracking, and tracing object in hospital [5]. With such limitations, it is difficult to make real-time decision and management.

Radio Frequency Identification (RFID) is an emerging technology that had been utilized for automatic identification in many supply chain management, and current practice is to increase the usage of such advanced, mobile IS/IT solutions for supply chain processes instead of barcode technology. RFID technology usage is creating new competitive environment transforming the manner in which business is conducted.

Taiwan government has paid strong attention with RFID related industries. There are some pilot projects funded by government to drive the RFID industry development, and related industry upgrading; and healthcare is one of the funded industries.

Unfortunately, not all of these projects are successfully implemented. The gap between the actual and expected outcomes would either positively or negatively influence the organization's decision to continue or abandon RFID adoption.

Reports forecasted that it could take another 10-20 years for generally RFID adoption [6]. The contradictory views about the potential contribution of RFID and its slow adoption pose theoretical and practical research agenda to understand the "why" and "how" of shortening the lead-time.

However, knowledge about the RFID deployment is limited due to the facts of inter-organizational manners. The study attempts to gather valuable deployment experience.

By addressing the critical issues about deploying RFID in healthcare industry, in particular, the service perspective of RFID applications for healthcare will be explored in details.

## 2. The development of RFID in Healthcare

### 2.1 RFID Deployment in Healthcare

"Patient safety" is one of the most important issues in healthcare field. The World Healthcare Organization (WHO) and other organizations all pay much attention to reducing medical errors for creating a patient safety medical environment. The organization, Institute of Medicine (IOM), reported that many medical errors occur because of human carelessness [7].

The survey from HIMSS (Healthcare Information and Management Systems Society) indicates there is more potential benefit to decrease medical errors in implementing "Computerized Provider Order Entry" (CPOE) systems, like bar code or RFID systems [8].

The guideline published by Food and Drug Administration (FDA) indicates that automatic data collection, enhanced communication, and coordination partnerships with other entities, including: government agencies; healthcare providers; and payer organizations, are the important issues for healthcare information management field with patient safety, and RFID can provide capability to promote visibility in healthcare management to ensure patient safety [9].

The deployment of RFID has resulted in ensuring accurate delivery and medical process in medications. The direct benefits that can be ensued including decrease medical errors, promoting medical operation and resource management efficiency, and also higher medical quality resulting from fewer incidences of clinical errors.

For pharmaceutical factories, deploying RFID can provide benefit in

supply chain management, competing counterfeit, easily for re-call process, tracing the drug pedigree, and can contact more sale information and customer demand from customer (clinical) side [10].

The RFID applications in healthcare value-chain from industry up-stream to down-stream are including: biotechnical lab and pharmaceutical factory, medical related supply chain management internal hospital management, and external healthcare service [11].

## 2.2 RFID development for healthcare industry in Taiwan

Healthcare provides treatment service for human health, and it is an important apart in every nations. Taiwan government also pays much attention to encourage hospitals implement ICT technology to provide more completely healthcare service.

The medical environment in Taiwan nowadays, almost all of hospitals have already implemented HIS for clinical treatment and operation management, because they are not only facing acute business competition for overabundant medical hospitals, but also need to declare their medical expense to the monopolistic insurance organization, "National Health Insurance" (NHI) for online declaration.

As so, a robust Health Information Network (HIN) was in place, so most of the physicians, nurses, and staffs are skilled in using IT/IS in clinical side.

Furthermore, the service accounts in Taiwan is already more than 70% of GDP (73.6% in 2005), but its contributor to economic growth is still less than 1% [12].

From government's perspective, it is crucial to encourage the high-technology

industry and healthcare industry to advance innovation to become high value-added service industry.

As the following industry: semi-conductor, hardware manufacturer, software and system integration, and healthcare service providers were selected as the promotion site for RFID deployment. With the support from the government, many hospitals are actively involved innovated innovation of RFID applications.

## 2.3 The trigger of RFID in healthcare

The report of ID TechEx estimates the market size in America healthcare industry will reach US\$ 86.3 billion in 2010 [13]. There are two main forces, industrial demand and government regulation, to drive the RFID industry glowing up.

From industrial view, Wal-Mart took the head in requesting hundred pharmaceutical goods suppliers to deploy RFID, compatible with EPC standard, at package level. Accenture help in building the IT platform for eleven pharmaceutical manufacturers, distributions and hospitals [14].

From regulation view, "Healthcare Distribution Management Association (HDMA)", an institution to regular healthcare product logistics standard, regulate all of the pharmaceutical transportations should paste RFID labels to case level in 2007 [15]. FDA in US even extends the legislation further to item level for competing counterfeit [10].

When most of the pharmaceutical factories, in upstream of supply chain, have already labeled RFID tag on their products, it would trigger more industrial applications to downstream, like hospitals or related medical institutions.

### 3. The Expert Interview

To have a deeper empirical understanding of this phenomenon would be crucial to helping healthcare organizations respond to the technological implications and strategy management when implement.

Today, deploying RFID in healthcare is still at the initial stage. Current empirical work seems to lag behind the diffusion projections of the mobile technology among practitioners.

To further explore the RFID deployment related issue, quality research methodology was applied to gather more in depth understanding on the issues.

Interview was conducted with ten experts including: vice-president and directors from information department in hospitals, managers from hardware/software providers, system integrators, project manager, end-user, and consultant, who had participated in these healthcare projects before.

The four hospitals included in our study are: Taipei Medical University Hospital, Taipei Wan-fang Hospital, Show-Chwan Hospital, and Chang Gung Memorial Hospital (Keelung).

### 4. The Critical issues about deployment

In analysis critical issues on RFID deployment, four dimensions are engaged:

#### 4.1 Technological Dimension

The operators prove RFID technology start at the process from client side for: data capture, data management, data analysis, data access; and the last is information responds.

To ensure the complete and integrity of data process, the following issues are identified:

#### 4.1.1 System readable rate

Currently, the readable rate of RFID system is under 100%, and it becomes one of the major obstacles on RFID adoption.

One of the important features such as RFID is “non-line of sight”. Radio frequency convey by air-interface, which needs better channel coding and modulation to reduce the signal broken and confused noise.

There are various primary factors that influence the system readable rate: the direction of transmission, locality of air-interface, the characteristic of product, and the operation environment.

Firstly, the electronic received and reflection between RFID tag and electrical reader is directivity-oriented, so there is a serious limitation on reading angle. The horizontal angle is much better than the vertical or oblique ones.

The next, air-interface in hospital, such as the temperature, humidity, and local electromagnetic interference (EMI), should be avoided to ensure the data readability.

The carrier tag should avoid the usage of metal and liquid. Some medical objects, like medical appliances, medicine bottle, test tube, and blood bags, should use special design tags to lift the limitation.

The operation environment such as indoor or outside environment, distance between operations, and object moving speed compose another challenges. Others like: reader wave strength, or the reader deploying position also influence the data readability about deployment.

#### 4.1.2 Frequency limitation

Frequency selection is influenced by the demand of applications in the field. The characteristic of lower frequency RFID has lower price, better penetration, but it drawbacks at shorten transmission distance, slower data transmission rate, and larger superficial area of antenna. Contrarily, the vantage of high frequency RFID is contrasted with lower frequency.

Base on the regulation from “International Telecommunication Union (ITU)”, there are seven frequency bands of RFID usage. The conventional application in healthcare is 13.56Hz (HF passive tag) and 900MHz (UHF active/passive tag).

In many countries, the channel of air-interface is public wealth, and its allocation is regulated by each local government, except for some industrial, scientific and medical (ISM) radio bands, which RF electromagnetic fields can be free of charge for medical usages under an international standard.

HF frequency (13.56MHz) is one of ISM radio bands, so the applications about HF RFID can develop permissively. Though, the usage of UHF band is restricted with different local government that is also a big deployment problem for applications in cross nations supply chain.

Fortunately, most applications of UHF in healthcare have territoriality that has less demand about data exchange cross different countries.

In Taiwan, HF tag is applied for large amount objects tracing in supply chain management, and it is also adapted to assist medical operation management. In the contrast between passive, active UHF tag is for recycle application, like tracking patient and staffs, or location-based management.

#### 4.1.3 Electronic interference & Patient healthy influence

There are two misgiving issues about deploying wireless technology into healthcare environment. First one is about electronic interfered between RFID wave and a medical instrument, the others is the influenced of wreck patient health from radio frequency to chronic injure.

Firstly, there are some demonstrations in the implement projects which have already measured whether the influence or not to two quantification indicators, “bit error rate (BER)” and “electromagnetism mutual interference (EMI)”, between HF wave and Electric Shock Machines, Electrocardiogram (EKG), Breath Machines, and IV Pumps at work field in internal hospital environment. The result of these experiments shows there is no obvious influenced and interference.

Secondly, the power of passive HF reader is below 500m watt, it just similar to Wireless-Lan or Bluetooth that has already deployed into hospital indoor environment. The reports from US Federal Communication Commission (FCC) and IEEE organization did not find out the obvious evidence about lower frequency RFID, “Non-Ionization Radiation”, would hurt the health of faintness patient.

Nevertheless, if choosing active UHF RFID, especially for long distance usage, which reader’s power is constantly more than 3 watt. It should be doubted about the interference with the instruments and patient health.

Medical care service is related with human’s life. For the more conscientious experiment and counterdemonstration is necessary. There should be more through research by impartial institutions to ensure the safety about the implement.

In the brief conclusion from technological dimension, for observing these obstacles, it is important to draw up the implement plan and re-engineer the clinical path to make it suitable for RFID technology.

## 4.2 Economical Dimension

For the decision maker, implement cost and ROI evaluation are the core consideration factors [16]. In additions, the following factors engaged:

### 4.2.1 Network Effect

Innovation diffusion theory asserts that the number of organizations adopting an innovation roughly follows an S-shaped curve over time (Rogers, 1983). Mapping the S-shaped curve to RFID technology indicates that the adoption now is just in the early stages. It would be led first by a few mega buyers in the retail industry, military, and government.

Although the cost of implement still influences the diffusion velocity about RFID adoption. The cost of system deployment is high in this stage, but the sustainability tag cost is another vast expense to maintain the mechanism.

The price of tag is composed about chip, antenna, attach, testing and convert. The cost reduction about tag is strongly influence from the amount of purchase. How to achieve the critical mass amount to come into being network effect is the key issue about the diffusion, and that should rely on some government or industrial development strategy to impetus it.

Auto-ID Lab estimates the industry would be detonated growing up when the tag price redundant under US\$0.05. The market scale and the production amount of RFID tag are the critical

about cost reduction. However, it is a difficult circular dilemma, just like the controversial theme about which chicken or egg is first existence in the world.

### 4.2.2 Implement Cost

According to the survey of the Yankee Group [17], RFID spending falls into four categories: hardware (29%), software (27%), internal labor (23%), and consulting services (21%) with a total cost ranging from US\$9 million to 25 million for a large-scale manufacturer in consumer goods industry [18].

The budget of these projects in healthcare in Taiwan is only about NT\$ 12~20 million (US\$ 0.3~0.6 million). The visible cost includes: Hardware (RFID tags, reader, and related IT system), software, network infrastructure, system integration (SI), organization change, project labor cost, education, and a few consultant services fee.

Unfortunately, there is still some hidden cost, just like iceberg hidden most parts below the water, which is strongly influence the successful of the implement.

To perform better system quality of the circular process mechanism, there are still some system implement issues, including: usability, scalability, availability, integration, interoperability, security, authorization, and sustainability maintenance expense.

For the successful project implement, the richness consultant, project manager, programmer and plentiful project labors are important, but most of the projects in Taiwan did not pay much attention to these parts. It is the reason why some of these pilot projects cannot keep going to the next step further.

#### 4.2.3 Revenue of Investment (ROI)

Steve Banker, one senior director for SCM at the ARC Advisory Group, surveyed 24 companies that actively implementing RFID and find out it should take at least ten years to leverage the investment and turn back the positive revenue after already more than US\$10 million of implementation [6].

Recently there are few germination hampers in RFID industry development, one main reason is higher cost. The slow rate of ROI, a major economic reason, is one of reason why companies hesitate to adopt RFID technology.

Most of the successful RFID applications occurred where the cost of the tag was insignificant when compared with the cost of the tagged item or else value added, such as electronic products, or automobiles. RFID tag cost becomes a much more concern when the cost of product being tagged is lower, especially in item level implement.

Furthermore, health care service is one part of public welfare in nations. Medical care has strong relationship with persons' life, and any mistake or medical errors may cause irretrievable regret to patients. Medical errors could even impact the fame of hospital, and it is easy to result huge indemnify.

The government and public hospitals should consider how to value add-on to the society, instead of just evaluate ROI. Patient safety issue is significant for the value of the life. So medical institutions need to spend their efforts about how to promote medical quality, and decrease medical errors.

### 4.3 Industrial Dimension

The common industrial standard is a serious influence to speed up the diffusion of market application and

development. The deployment of infrastructure and Network Platform are two assistant trigger engines for whole industrial implement to conduce less cost and higher ROI.

#### 4.3.1 Industrial Standard

The industrial standard is necessary for promoting industry development. The standardization of RFID technology has been evolving progressively. The standard in RFID system can be separated into three parts, data structure, air-interface, and local-interface.

There are already some famous local RFID standards during this century, like ISO, ANSI, EAN, and UCC. Electronic Product Code (EPC) standard and International Organization for Standardization (ISO) are the most prevailing standards among them.

Latest, it gradually integrates and classifies into two mainly groups, International Organization for Standardization (ISO) and Electronic Product Code (EPC) standard. ISO standard is the famous in Europe system, and it accentuates on air-interface. The other one is EPC standard, which is expanded from US system. It emphasis on data structure, extended to network architecture, information system, data filter, and storage mechanism.

However, the common industrial standard is all-important for industry to achieve the network effect as soon as possible. So EPC-global organization led efforts to merge EPC and ISO standard to facilitate the wider adoption of RFID.

In healthcare industry, "Health Industry Business Communications Council (HIBCC)" works on establishing common standard for healthcare system specialization, which is inherited from existence medical standard, ANSI, CEN, and HIBC.

Except pharmacy and medical instrument industry which are connected with worldwide supply chain, medical care service has territoriality for each country. Furthermore, each hospital has their organizational culture and clinical path. So it is important for a regional country to purpose his appropriative standard for domestic usage.

#### 4.3.2 System Network Architecture

Network infrastructure and information system architecture are the key to make “Health Information Network” (HIN) reality. The complete information system composed and network infrastructure are also the cornerstone for successful deployment.

By the view of system value, the simple close loop (CL) system, the deployment of sole application, department, or singular organization, just produces limited benefit for the restricted value added.

Although building up an open loop (OL) system should result more deployment scope, time, system complexity, and it needs more budget for investment. It should build up an OL system to connect with other organizations for data exchange and integration in industrial supply chain in order to perform complete RFID characteristic and to acquire the better beneficial result after deployment.

The network infrastructure and system component in healthcare industry can refer the specification in “EPC Network”, which is announced from EPC-global and Auto-Id Lab. The design of distributed computing system and operation mechanism can be advisably revised for the demand of healthcare.

Except basic network infrastructure, there are still several information systems composed a whole RFID

operation mechanism, which includes ONS (Object Name Service) Server, Discovery Server, PML (Physical Markup Language) Server, Trust Server, and RFID Information Server (IS).

The superintendent in government and healthcare department may draw up a clear blue-map for RFID HIN architecture. There should be some technical guidelines about system framework, communicate protocol, and some open API components to easily communicate with other information system in coordination institutions.

#### 4.3.3 Network Exchange Platform

Undoubtedly, there are real obvious benefits when we implement RFID system. However in the conclusion of our interview, it is hard to convince hospital to budge more funding for only single application when we evaluate the ROI, the limitation of CL system implement.

In order to obtain plentiful ROI, it should be stringing up the whole applications and systems. It means to integrate the real objects flow and information flow with related organizations at real time.

The mechanism should be designed to decrease duplicated key-in and save related effort by some automatic mechanism and extra-organizations communication. So the demands of RFID data exchanges are not only between vertical levels (organization inside), but also cross horizontal organizations (healthcare supply chain).

To summarize the interview, RFID Network Platform stands on the key position to communicate and coordinate information exchange and operation synchronization to value added the industrial deployment.



The pedigree of patients or drugs can be exchanged by the platform, and person who is authorized legally can take the latest information in anytime at anywhere.

#### 4.4 Social Dimension

RFID tags can capture huge data from client side more than barcode system in the past. For minutely catches your data for system for tracing pedigree and tracking position even at real time, privacy arguments and the trust issue is the major controversy from social dimension.

##### 4.4.1 Privacy Argument & Data Security

Privacy argument comprehends with person's attribute; person's data, communications, and anonymity right. The right of privacy here can be divided into medical staff, visitor and patient. Medical institutions control the whole durative position and movement for human in hospital by RFID, even more detail to process, but it also may cause the disputation about human right and personal privacy

Medical care environment has its feature which needs to consideration the maximum benefit for whole society instead of single human right. Hence patient privacy is not the first priority when privacy argument is conflict with patient safety and social welfare.

The raising of concerns about the human basic right of privacy argument and data security should severely lash to the emerging technology. For example, sensitive and identifying information, such as names, ID number, credit card numbers and medical history, could be transferred by RFID Network Platform at every minute and at every moment.

When there is abundant of ICT deploying into our life, there should be regulation with law protecting. It is important to leverage the balance of development between "life convenient", "patient safety" and "personal privacy" to secure the confident right.

How to deploy RFID system to follow the Health Insurance Portability and Accountability Act (HIPAA) regulations should be further research to depth discussion the privacy and data security issues about implementing.

##### 4.4.2 Trust Issue

Trust is another important issue influencing the internal-organization relationship with external-organization partnership. When the degree of integration between business partners is increased, partners could access people's data that was inaccessible previously.

Trust is also an important determination of a successful new technology implement. Trusting organizations are more willing to invest in RFID and share information with their business partners.

In other words, when trusting business partners propose adopting RFID to facilitate their transactions, the partners are more likely to reach consensus in terms of the benefits they can each realize.

## 5. Conclusion

Deploying ICT in healthcare industry for promoting patient safety is a complexity issue, but it also is an unavoidable problem for each nations. Conventional wisdom tends to focus on the economic value of IT deployment from the view about how to enhance the efficiency, effectiveness, comparative advantage, and productivity.

However, implement RFID technology is not only the question about technological or system deployment issues, but it is also including multiple-dimensions about economic, society and management. For achieving successful implementing, it is important to use the service oriented perspective for the value added thinking. To building up the common industrial standard, privacy argument and data security, and the trust from the staff and customer is the key about the implement.

There should be evolutionary new business model and variety opportunity in deploying RFID in healthcare. To develop the service science, management and engineering (SSME) methodology is our future research to more clarify analysis and systematized discussion the critical issues for ICT deployment in healthcare industry.

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