RFID Role in Efficient Management of Healthcare Systems: A System Thinking Perspective

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ABSTRACT

This paper presents an analysis toward understanding the business value components that a healthcare organization can drive by adopting RFID technology into its system. This researcher proposes some propositions and frameworks for evaluating the business value of RFID technology. Author illustrates the concepts drawing on the experience of nine case studies already presented on the healthcare topics and service industries. Thereafter, a framework as a set of propositions based upon relevant literature, case studies from the field, and expert's intuition, is formulated. The proposed propositions are validated through causal loop logic and systems thinking philosophy. To fully understand this topic some applications of radio frequency identification in healthcare management and other industries are briefly discussed.

1. Introduction

Today, the safety of working locations, products, transportations and customers are the main things to managers. In Pharmaceutical industry that is even more important. This is because the safety of the people and nations also must be taken into consideration. Refreshable goods often require strict control of storage / transportation environments such as high and low temperature. The expiration date must be taken into consideration as well. Tracking and tracing processes offer the documentation needed to ensure these safety requirements. Tracking and tracing are ineffective most often. This is because they are reactive instead of proactive. If we use EPC technology, products can be tracked and traced very easily. Any person who has access to information along the supply chain can find out the historical background on a particular drug, as well as its current location. EPC technology verifies information at every point along the supply chain helping to ensure product integrity (Anonymous, 2005).

Automatic identification and data collection (AIDC) had made large contributions to many companies bottom line. Radio Frequency Identification is one of the most wanted

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technologies in the today's large successful enterprise like Wal-Mart, Dell, Automobile Part makers, Food Stores, Computer Stores, Bookstores and so on with the hope that operating costs will decrease and products will get more accurate in both data collection and reporting. More organizations from manufacturers to government agencies, retailers to healthcare providers are introducing RFID technologies into their supply chains, for asset tracking and on time management, and for the security and regulatory purposes. However, as companies explore these significant advantages through pilot programs the impacts of RFID technologies on the company wide network must be considered.

This research analyzes the coupling of RFID with the health care management concepts to enhance the productivity of the system under study. Such a research is needed to determine the RFID value as far as its business value generation capability is questionable. Research is conducted using a descriptive type information gathering procedure and situation analysis having selected nine cases from the literature of RFID and health care management. This empowers us to look into more than one case study at a time and hence, to check the performance of each of cases in a tableau format for comparison purposes. In addition to that, the reader would be exposed to the facts that how practitioners and researchers all around the world are seeing RFID technology and its real role in health care management as a productivity improvement tool. A brief literature review on the subject matter is also presented.

The rest of this paper is organized as below: section 2 describes RFID tags, costs and its frequencies. Section 3 is about RFID applications in health care systems. Section 4 discusses the research methodology. In section 5, nine cases on health care topics are reviewed. Section 6 provides a comparison of reviewed cases as they are discussed in section 5. Research propositions are presented in section 6. Managerial implementation is given in section 7. Author's conclusion is given in section 8.

2. RFID Tags and Costs

RFID is not a new phenomenon. It has been around for decades. It was used initially for proximity access control. Thereafter, it was evolved to be used in supply chain tracking, toll barrier control, and even protecting automobiles (Potter, 2005). There are four types of tags in industry that are known as: (1) Passive tags; (2) Active tags; (3) Semi Passive tags; and (4) Semi Active tags. In a market study conducted by Venture Development Corporation in August 2004, it was found that Active RFID systems have a series of valuable characteristics including: (1) Enhanced dependability because of high performance; (2) Enhanced security/access control including theft reduction; (3) The ability to link tags together in software for custodianship; (4) The ability to automate identification and location by removing human intervention; (5) Improved data integrity because of accuracy and reliability; (6) Improved read accuracy and longer read ranges; and (7) Increased data transfer rate. The same study found that the reasons end users implement active RFID systems centers around increased productivity including: streamlined processes; labor reductions; increased visibility and automation; and the provision of real-time information. Additional capabilities unique to active tags were also cited by end users as being important including: sensor monitoring; automatically beaconing signals; and tamper resistance.

Passive tags get their energy from a remote RFID reader. An active tag uses a battery for both the chip and the transmission of data on the antenna. Semi-passive tags use a small onboard battery to power the chip. Semi-active tags use the battery for powering the antenna but the chip relies on the Radio Frequency (RF) energy from the reader (Potter, 2005). The life of active tags are limited while of passive tags are unlimited. Active tags are heavier than the passive tags and more costly as well. Table 2 identifies differences between active and passive RFID tags.

3. RFID Applications in Health Care

In May 2002 Massachusetts General Hospital installed its first trial of the iRIS RFID system, which was developed by Mobile Aspects. The purpose iRIS was to manage inventory and access to medical supplies and surgical parts throughout the hospital. By the end of 2002, Massachusetts General Hospital had installed six iRIS units in its operating rooms. According to the RFID Journal, with the assistance of iRIS over $500,000 worth of equipment and supplies were tracked. Additionally, iRIS has been integrated into the hospital's scheduling and billing system. As a result of the success of iRIS at the Massachusetts General Hospital, similar systems have been installed at the hospital of the University of Pennsylvania, the University of Pittsburgh Medical Center and the Carolinas Medical Center (Crayton, 2004).

It is important for business and social science researchers to understand RFID, because it is likely to have a profound impact on how firms compete globally, especially in terms of supply chain management. Ninety seven percents of pallets sent to Iraq have been shipped with RFID tags (Barlas, 2005). The largest area of adoption has been in the retail industry (IDTechEX, 2006a, 2006b), and approximately 1500 RFID patents have been issued since 1997 (Read, 2005). This technology can save billion of dollars for the world businesses specially the first world countries that are ready to use that. Various countries have started to use RFID in different forms and shapes.

In April 2004 Washington Hospital Center in Washington D.C. began a trial use of RFID tags focusing on RFID usage in hallways and in emergency rooms. Washington Hospital is using active UWB or ultra-wide band tags, developed by Parco Wireless, to track medical devices in the hospital. Washington Hospital Center has the staff and patients wear credit card sized RFID tags to obtain and maintain patient and healthcare provider information (Crayton, 2004).

The potential benefits to RFID technology in the food industry are enormous. Because each chip is unique to the specific box it is in, tracking the whereabouts of products becomes much simpler. If a manufacturer recalls a batch of products, the RFID tags for the containers affected can be flagged electronically. Eventually, grocery retailers will not be able to sell recalled products because the register will not allow it (Hall et al., 2004). Looking further into the future we can see other sort of RFID capability as such as: homes—equipped with "smart appliances"—will also be linked to the network. Refrigerators will inform homeowners that the milk is expired; the microwave will alert the consumer that the product about to be warmed was recalled 6 hours earlier by the manufacturer. Even the pantry, if equipped, could print a grocery list based on current inventory (Hall et al., 2004).

The future seems to point in the direction of full incorporation of RFID tagging with nearly all products, equipment, supplies, and people simply because of the wide range of use of these tags (Angeles, 2005; Chopra and Sodhi, 2007; Riggins, 2006; Sarma, 2004; Fish and Forrest, 2007).

Even though the distanced future for RFID technology seems very promising, the implementation of that and its uses in near future are uncertain. Researchers (Angeles, 2005; Schwirn, 2006b) pointed to the fact that the costs and ROI are too high for widespread implementation and that any product that is lower than $15 in price would be a poor use of resources.

What this means is that many medical supplies in certain portions of the supply chain are simply too low cost to justify using RFID technology. The article went further to say that upstream manufacturers are not going to incorporate RFID in anything but the palate level due to costs, leaving the down stream users without the RFID tags (Angeles, 2005; Schwirn, 2006b).

4. Research Methodology

This research attempts to study the impacts of radio frequency identification on the healthcare management system enhancement. To date, most of the research conducted on the RFID has been focused on the description

of its real-life applications in various settings. The number of researches conducted on the theoretical framework is limited.

Several modes of academic inquiry were used in this study, though usability context analyses were the focal means of research. These analyses are similar to case studies as they investigate ''a contemporary phenomenon within its real life context when the boundaries between phenomenon and context are not clearly evident'' (Yin, 1998). They also similarly use multiple sources of evidence, however are differentiated on the basis of the unit of analysis.

In a usability context analysis methodology, units are not individuals, groups or organizations but are applications or application areas for a product, where 'product' is defined as ''any interactive system or device designed to support the performance of users' tasks'' (Thomas, 1996).

The results of multiple analyses are more convincing than a singular study and the broad themes identified cover the major fields of current healthcare management RFID-based systems (Masters and Michael (2007). As such, this is a largely qualitative study that uses some elements of descriptive research to enhance the central usability context analyses. Research to assess the impacts of RFID on health care systems is scarce.

This is a step towards filling this gap by studying cases and deriving results from our findings. Yin (1994) pointed that a case study is an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially where the boundaries between the phenomenon and context are not clearly evidenced". Case studies are a valuable tool for examining a contemporary phenomenon, especially one that is not clearly understood, asking how and why questions, and capturing the context (Tzeng, et al., 2007). With this note in mind, this author considers using the case studies as an appropriate tool for the analysis of the situation.

The study process in this article is comprised of six steps. First, related cases from the literature are viewed; second, a table discussing the results of cases is provided for better understanding of the situation; third, a synthesis of cases is provided; fourth, an integrative framework of RFID and healthcare management value is given; and fifth, research propositions are presented. Sixth, the research propositions are evaluated using system thinking approach.

5. RFID-enabled Healthcare Systems

This section is devoted to the review of RFID-based healthcare management systems that can be used in the development of a series of new propositions. However, these propositions are in need of verification using true data from real life cases. The cases to be used as our source of information are:

1. The healthcare supply chain (Kumar et al., 2008)
2. Emergency room management (Chen et al., 2008)
3. El Camino Hospital in Mountain View (Crayton, 2004)
4. Public views of mobile medical devices and services (Katz and Rice, 2008)
5. Children hospital (Crayton, 2004)
6. The social and organizational factors (Fisher, and Monahan, 2008)
7. Service application of RFID (Ngai et al., 2007)
8. Monitoring Alzheimer patients (Corchado et al., 2007)
9. Psychiatric Patient Localization (Huang, C-L, et al., 2008)

6. Discussion of findings

In studies conducted by Zare Mehrjerdi (2012a, 2012b, 2013), the lists of the names of cases used along with extra information helping to understand each case study individually and hence all together can be obtained. Through analysis of above case studies we can obtain the following common points:

1. The adoption of RFID, as it was the case in Sushi restaurant, results in a

2. The RFID assessment is possible from the operational viewpoints for the cases provided in this study. Looking at the problem from the strategic side, another viewpoint of the RFID situation would be obtained.

3. The implementation of RFID-based systems should take into consideration the needs of patients, caregivers, and the hospital management system as far as the work quality and productivity, and profitability of the system are concerned.

big change in the business and in the work habits of that organization's personnel.

The integration of RFID technology and healthcare systems helps enterprises to develop business models that serve their needs best. This will result into an effective and efficient management system that can coordinate upstream as well as downstream of the system. By concentrating on the productivity enhancement as a result of integrating RFID technology into healthcare management system, the following table proposes the productivity enhancement values along with the sources of productivity creations by this technology implementation. Table 1 describes productivity enhancement and the sources of its creations detailing on the refining and extending situations.

Table 1. Productivity enhancement and sources of its creation

Value Created	Sources of creations
Refine	Responsiveness: better responsiveness means better management which ties to customer satisfaction and therefore higher level of productivity
	Asset utilization: through better utilization of the company's asset higher level of productivity would be achieved
	Better management of process is directly related to the higher utilization of resources and hence a higher level of productivity
	Higher level of control (i.e., control of stolen goods, inventory control, and etc.) brings greater degree of efficiency and hence productivity enhancement
	Competitive advantage relates to better utilization of resources and investments and hence the productivity enhancement for the company
Extend	Service management
	Virtual integration of healthcare management system
	A new productivity level to be achieved
	New business opportunities for the organization

Using the cases named in section 5 above an discussed by (Zare Mehrjerdi, 2009, 2013) we would come to this conclusion that the research propositions can be stated as are identified below. The proposition of high value to this study as far as the coupling of RFID and healthcare management regarding productivity enhancement is concerned are all of those listed under the cases of 1, 2, 3, 5, 6, 8, and 9. With regard to the cases reviewed before and our backgrounds on the SCM and RFID, the propositions for this research can be stated as below:

Proposition 1: In the integrated RFID healthcare management system, the firm efficiency as well as its competitive advantages will be improved**.**

Proposition 2: In the integrated RFID healthcare management system, RFID plays a good role in the value generation for the entire system. This could happen through better communication, active management of patients and staffs, right and on-time decision making, enhanced asset utilization, improved service providing, and more.

Proposition 3: In the integrated RFID healthcare management system, RFID technology can generate higher productivity level for the entire system, nurses, physicians,

staffs, caregivers, patients, and insurance companies to mention a few.
Proposition 4: In the integrated RFID healthcare management system, RFID technology can enhance system-client profitability as a result of patient-care process optimization.

7.Propositions evaluation using systems thinking

The evaluation of propositions using systems thinking approach is possible when all variables of highly concerned are identified one by one using multiple cases studied. The variables of the highly concerned in this study are: RFID technology, quality, efficiency, productivity, responsiveness, better management, on time decision making, on time data collection, inventory control, security level, error reduction, organizational challenge, asset management, patient monitoring, and accuracy in decision making. Table 2 lists key variables with their descriptions from the reviewed cases.

Table 2. List of variables with their description from cases reviewed

Row #	Variables	Emphasis on
1	Quality	Sushi, short-shelf-life (Karkkainen (2003)
2	Efficiency	Wal-Mart, Sushi, healthcare, Short shelf-life (Karkkainen (2003)
3	Effectiveness	Healthcare
4	Productivity	Wal-Mart, healthcare
5	Responsiveness	Sushi
6	Better management	Sushi
7	On-time decision making	Sushi
8	On-time data collection/data accuracy	Sushi, Li and Visich (2006)
9	Inventory control/costs	Wal-Mart, Sushi
10	Security level	Sushi
11	Accuracy in decision making	Sushi
12	Labor costs reduction	Short-shelf-life (Karkkainen (2003)
13	Human errors	Wal-Mart
14	Revenue	Wal-Mart
15	Out-of-stocks	Wal-Mart, Sushi
16	Better Service	Wal-Mart, City library, Sushi
17	Tracking/Products/Production	Sushi, short-shelf-life (Karkkainen (2003), Li and Visich (2006)
18	Product safety	Sushi,
19	Spoilage reduction	Short-shelf-life (Karkkainen (2003)
20	Lead time	Intel
21	Delivery time	Intel
22	Asset management	Li and Visich (2006)
23	Reduced shrinkage	Li and Visich (2006)
24	Space utilization	Li and Visich (2006)
25	Material handling	Li and Visich (2006)
26	Error reduction	El Camino Hospital in Mountain View (Crayton, 2004)
27	Organizational challenge	Hospital and Social Dimensions (Fisher, and Monahan, 2008)
28	Asset management	Sushi
29	Patient monitoring	Alzheimer patients (Corchado, et al., 2007)
30	Information sharing	Li and Visich (2006)

8. Systems Thinking

System thinking is a conceptual framework for problem-solving that considers problems in their entirety. Problem-solving in this way involves pattern finding to enhance understanding of, and responsiveness to, the problem. Outcomes from systems thinking depend heavily on how a system is defined because systems thinking examine relationships between the various parts of the system. Boundaries must be set to distinguish what parts of the world are contained inside the system and what parts are considered the environment of the system. The environment of the system will influence problem-solving because it influences the system, but it is not part of the system.

A number of theoretical frameworks for problem-solving that adopt systems thinking have been presented in literature. Some examples include Soft Systems Methodology, Spiral Dynamics, Systems Intervention Methodology, and Value Systems Theory. Life cycle assessment is a particular tool for systems thinking problem-solving that has been prominent in the literature.

Such assessments look at entire cycles that exist in systems. The concept of purposeful systems is applicable to all of the systems frameworks where there is some goal and the system is bounded and created to achieve that goal or goals, and hence the purpose of the system (Sushil, 1992). Furthermore, Holland (1999) introduced the concepts of adaptive and responsive systems, respectively, which are important and relevant for general systems thinking and, as will become apparent elsewhere in this paper, for a knowledge management framework.

Adaptive systems change in response to changes in the system to better achieve the goal or purpose of the system Holland (1999). Responsive systems learn from the system past performance to improve functioning and efficiency.

"A system is an entity that exists and functions as whole through the interaction of its parts whilst exhibiting an emergent behavior that is unique to its internal structure and degree of complexity." Systems have then emergent properties that are not found in its parts considered in isolation.

These properties of a system cannot be predicted or understood by merely analyzing its parts. Even though a given system behavior is a response to the environment in which it is embedded, it is completely influenced and determined on how its constituent parts are interconnected to each other, i.e. system design. System thinking studies the whole as a result of the connections between its parts. System thinking is thus the opposite of reductionism, the idea that something is simply the sum of its parts (O'Connor and McDermott, 1997).

Systems archetype is composed of many circulations formed as a result of all kinds of problems that affect one another in society. Senge and Lannon (1990) classified these circulations into nine major systems archetypes: (1) Delayed balancing process; (2) Limitation to goals; (3) Shifting the burden; (4) Temporary solution; (5) Escalation; (6) Success; (7) Common tragedy; (8) Failure; and (9) Growth and underachievement.

Due tot the fact that reinforcing and balancing loops build the foundation for other loops, in the sections that followed first the reinforcing loop and then balancing loop are discussed briefly.

The concept of system thinking is derived from a computer simulation model, created in 1956 by Professor Jay W. Forrester of MIT to deal with management problems in enterprises. Then, Senge and Lannon (1990) applied this concept to organization research, and advocated that for effective application of system thinking, researchers have to pay attention to the four tiers/levels in the system: event, behavior pattern, structure and mental pattern. System thinking is important because the society is full of dynamic complexity.

The term dynamic complexity was coined in 1990 by Senge and Lannon to indicate that the real world we live-in, is actually composed of numerous causes and effects. People often concentrate on individual events

and forget to consider the entire environment, and thus confine themselves to thinking in parts rather than wholly.

Therefore, to solve dynamic complexity, we need the assistance of system thinking to clearly see the relation between all problems and prevent the phenomenon that a change in one part affects the whole. Senge and Lannon (1990) mentioned that most problems in our society are full of dynamic complexity. The operation of an enterprise is just like a small society. We start system thinking by realizing a simple concept, 'feedback', which explains how actions intensify or offset each other, and whose ultimate aim is to clearly see the simple structure behind the complicated events so as to simplify social problems.

Systems archetype is composed of many circulations formed as a result of all kinds of problems that affect one another in society. Senge and Lannon (1990) classified these circulations into nine major systems archetypes and named them: (1) Delayed balancing process; (2) Limitation to goals; (3) Shifting the burden; (4) Temporary solution; (5) Escalation; (6) Success; (7) Common tragedy; (8) Failure; and (9) Growth and underinvestment.

The concept of system thinking is derived from a computer simulation model developed by Jay W. Forrester to deal with management problems (1956). Senge and Lannon (1990) indicated that most problems in our society are full of dynamic complexity. Causal loop diagram is used to represent the conceptual feedback structure of systems (Sterman, 2000). Systems archetype is composed of nine major systems as was originally classified by Senge and Lannon (1990). The causal loop diagrams can be interpreted as follow:

1. In each causal link, the variable at the tail of the arrow is called as the independent variable and the variable at the head of the arrow is called as the dependent variable.
2. A positive sign (+) causal link means that when the independent variable increases (decreases), the dependent variable increase above (decreases below) what would have been if the independent variable did not change.
3. A negative sign (-) causal link means that when the independent variable increases (decreases), the dependent variable decreases below (increases above) what would have been if the independent variable did not change.

There is a body of knowledge in the field of simulation that can be drawn upon in order to develop a powerful model which can be used to explore the impact of changes to individual factors and to link the factors directly to project outcomes.

8.1 Reinforcing feedbacks

are the engines of growth. Whenever we are in a situation where things are growing, we can be sure that reinforcing feedback is at work. Reinforcing feedback can also generate accelerating decline – a pattern of decline where small drops amplify themselves into larger and larger drops, such as the decline in bank assets when there is a financial panic. In a reinforcing process, a small change builds on itself. Whatever movement occurs is amplified, producing more movement in the same direction. Figure 1 depicts a typical reinforcing feedback or loop where the increase in technology investment brings higher productivity and as a result competitive advantages and then higher profit would results. This sort of feedbacks can be seen in many functions of organization where management needs to get hands on that in their business modelling and decision makings.
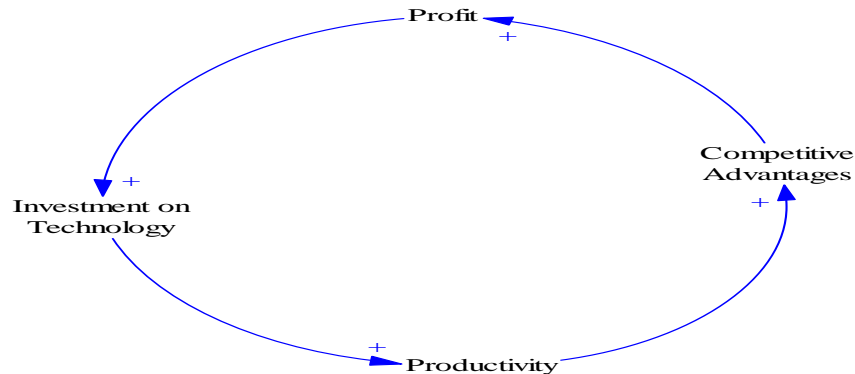
Figure 1: A reinforcing feedback

8.2 Balancing feedback

operates whenever there is a goal-oriented behaviour. If the goal is stay at the same position that we are then the balancing feedback acts just like a car breaks and do not let things happen. Such situation can be seen when the goal-level is set to zero. If the goal is set to move a higher ground then the balancing loop acts just like an accelerator and give your engine the power to go faster to reach the goal set by the decision makers. This situation occurs when a goal level higher than the current level of the system is identified as the system goal. Hiring new employees is a balancing process with the goal of having a target workforce size or rate of growth. Balancing feedback processes underlie all goal-oriented behaviour (see figure 2). What makes balancing processes so difficult in management is that the goals are often implicit, and no one recognizes that the balancing process exists at all. And often this has something to do with corporate culture. But identifying these balancing processes is crucial for system dynamics modelling.
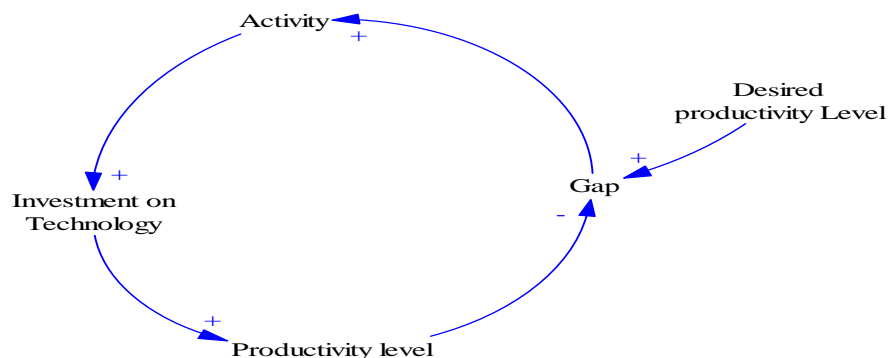

Figure 2: A balancing feedback

Many feedback processes contain "delays", interruptions in the flow of influence which make the consequences of actions occur gradually. Delays are interruptions between actions and their consequences. Delays can make you badly overshoot your mark, or they can have a positive effect if you recognize them and work with them. Delays exist everywhere in business systems. We invest now, to reap a benefit in the distant future; we hire a person today but it may be months before he or she is fully productive. But delays are often unappreciated and can lead to instability or even breakdown, especially when they are long. Adjusting the shower temperature, for instance, is far more difficult

when there is a ten-second delay before the water temperature adjusts, then when the delay takes only a second or two. During the ten seconds after you turn up the heat, the water remains cold. You receive no response to your action; so you perceive that your act has had no effect. You respond by continuing to turn up the heat. When the hot water finally arrives, it is too hot and you turn back; and after another delay, it's frigid again.

According to system dynamics knowledge one can model a complete dynamic system by combining these different elements, like reinforcing feedbacks, balancing feedbacks, and delays. For example, a model could be built, to analyze a business system with limits

to growth. For this purpose a reinforcing process is set in motion to produce a desired result. Hence, it creates a spiral of success, and meantime it generates unintended secondary effects that only noticeable in the balancing process. This is the loop eventually help to slow down the success of the process.

Proposition 1: In the integrated RFID healthcare management system, the firm efficiency as well as its competitive advantages will be improved. The following reinforcing loop (Figure 3) indicates this fact that management is a force behind the efficiency and productivity improvement and hence the competitive advantage of the organization would improve, in general.
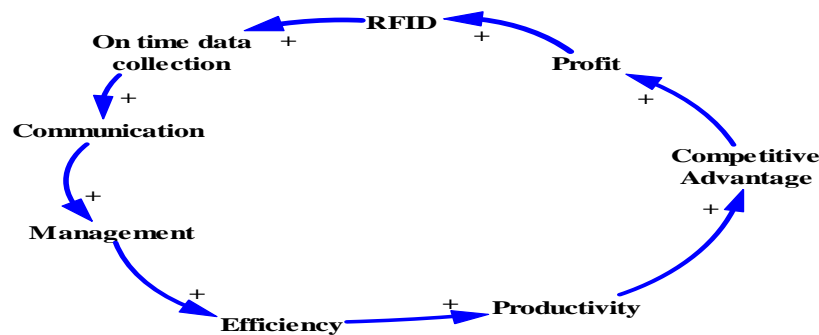

Figure 3: a Causal loop diagram for proposition 1

Proposition 2: In the integrated RFID healthcare management system, RFID plays a good role in the value generation for the entire system. This could happen through better communication, active management of patients and staffs, right and on-time decision

making, enhanced asset utilization, improved service providing, and more. Figure 4 shows a causal diagram with four reinforcing loops relating key internal variables of the system with RFID technology impacting on data collection and decision making.
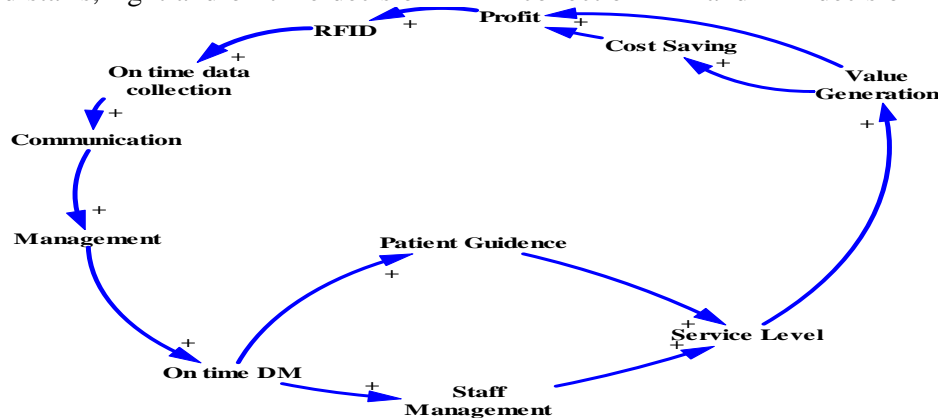

Figure 4: a Causal loop diagram for proposition 2

Proposition 3: In the integrated RFID healthcare management system (Figure 5) RFID technology can generate higher productivity level for the entire system, nurses, physicians, staffs, caregivers, patients, and insurance companies to mention a few.
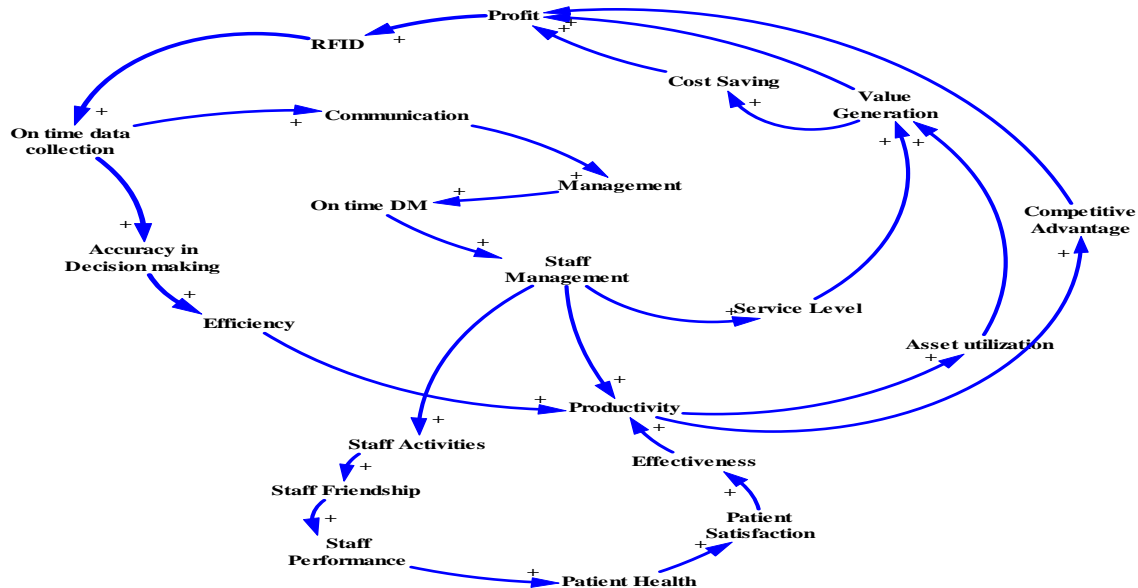

Figure 5: a Causal loop diagram for proposition 3

Proposition 4: In the integrated RFID healthcare management system, RFID technology can enhance system-client profitability as a result of patient-care process optimization.
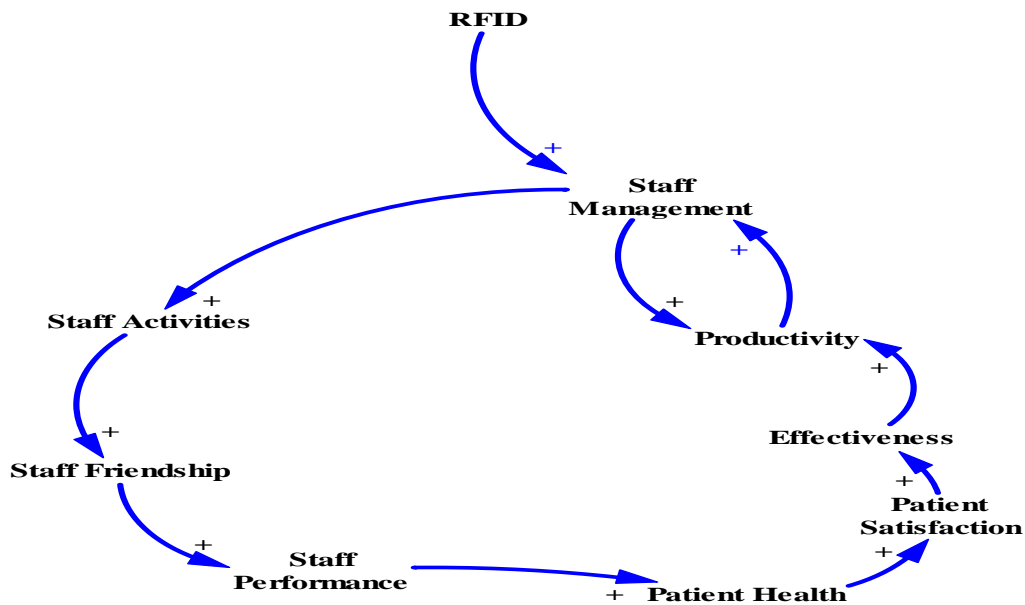

Figure 6: a Causal loop diagram for proposition 4

9. A Systems Perspective

The major limitation of this research is a lack of empirical support for the four proposed propositions. As RFID gets more popular and organizational and financial data associated with that get available then the test of propositions get easier. There are some possibilities that the refinement of some of the propositions may also become necessary in the future too.

In this section, the dynamics of a RFID-based supply chain system considering productivity as a variable rate of the system have been analyzed using the concept of system thinking. On the basis of the observations made in this study key factors are identified and then an appropriate model is developed. The proposed model merges operations management, process improvements, and decision making concepts with theories of behavior into a whole.

Using the results of cases studied and our data summary from table 2 the following diagram showing the relationships between the RFID, productivity, quality, and profitability can be proposed. All loops are of reinforcing type where each causes some sort of growth in the system. A loop associated with the RFID and its impact on the quality and then the profitability is shown in Figure 7. This loop relates RFID technology with on time data collection, on time decision making, patient guidance/responsiveness, service level, and then relates the productivity and profitability variables with the RFID
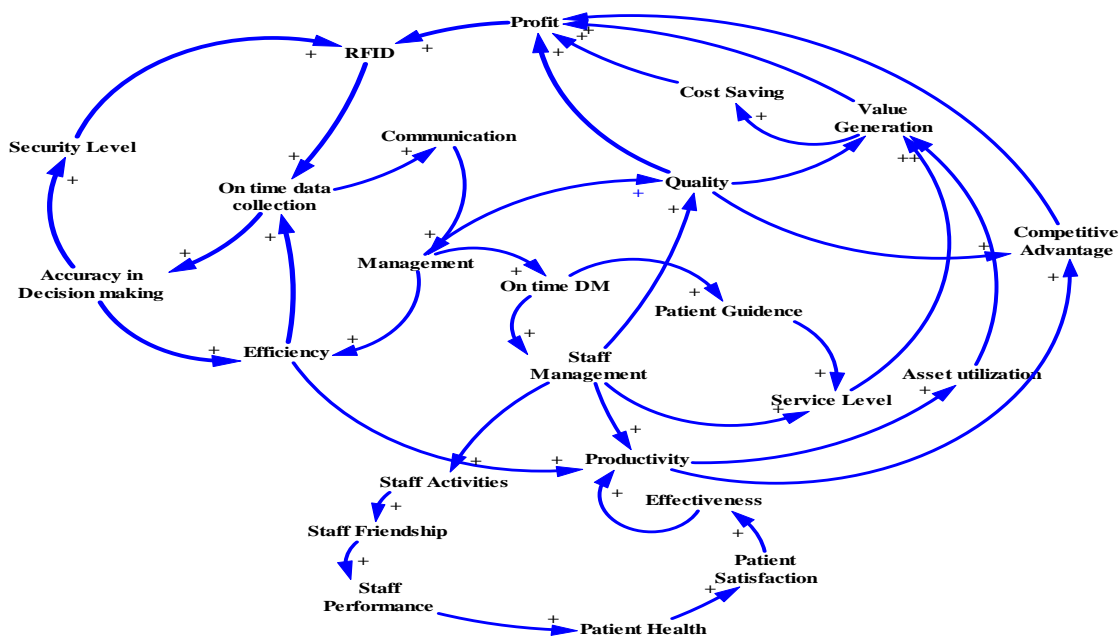

Figure 7: A causal loop for demonstrating the impacts of RFID on productivity, quality, and profitability in supply chain

10. Management Implementation

RFID is a flexible technology and has many attractive attributes that can be integrated into different systems. It can uniquely identify any object on which a tag is attached. The tag can be read in any orientation. RFID-based systems can be integrated into existing healthcare systems to improve the efficiency of the main processes carried out in any hospital/emergency room and increase the quality of services to be provided. The ability of RFID to uniquely identify every item is very suitable for hospitals/emergency rooms. An RFID-based healthcare system

would bring with itself many properties as are listed below:

1. Speed up the finding of equipment such as patient wheelchairs
2. Improve the stock control of the medications and surgical needs
3. Ability to track down misplaced surgical items and hospital materials
4. Increase the security at sensitive entrances
5. Bring convenience to hospital system
6. Improves hospital work flow
7. Increase staff productivity
8. Enhance patient service

Highlighting the financial savings from RFID technology into equipment tracking in healthcare industry:

1- Not being able to locate the equipment, hospitals buy extra or replacement devices for availability, which causes high annual spending and many devices are left unutilized or under utilized. Using RFID to manage these devices increases the utilization rate, cuts annual spending, allows divestment of under-utilized assets, and improves confidence that equipment is always be available when needed.

2- With RFID equipment tracking in place, expensive medical devices can be quickly brought into control by alerts based on location and notification when a device leaves a predefined area.

3- Equipment management with RFID can eliminate inefficient, long manual searches for assets that need maintenance or need to be returned to central processing units, and can maintain up-to date equipment status.

4- With a decrease in patient wait time, there is improved patient care, more employee satisfaction for nurses, technicians, doctors, etc., lower per-patient cost of service delivery, effective work flow, and operational efficiency with support staff always at hand.

RFID is a solution that enables a nurse, a technician, or an authorized employee to easily determine the location of equipment, run queries or reports to provide inventory information, parametric searches, graphical representation to identify the location of the equipment or the asset, and also manage the service and maintenance of the equipment using any computer tied into the network. The results of these applications are beginning to provide proof that using RFID technology in the healthcare industry provides significant labor savings, improved efficiency, and a good return on investment.

The global challenges that RFID is facing with are human expert challenges, privacy issues, technology challenges, standard challenges, pattern challenges, cost challenges, infrastructure challenges, ROI challenges, barcode to RFID migration challenges, management commitment challenges, and technical support challenges. There are not many skilled RFID professionals that can help to set up appropriate systems to construct suitable applications.

Main obstacles of RFID can be classified as: (1) Standardization for RFID is not yet completed; (2) Early adopters of RFID are still managing consciously; (3) Many potential adopters are waiting on the sidelines for proofs of successful and safe adoptions; (4) Compatibility with legacy systems is not addressed seriously; (5) Security issues need to be resolved; (6) Complexity and high cost for coverage in large plants prevent fast adoption; (7) Power supply is always a great concern for wireless systems; (8).

The reliability of wireless system remains unproven and it is considered too risky for process control; (9) Lack of experienced staff for troubleshooting; and (10) Future trends of the technology.

11. Conclusion

RFID technology can provide a variety of benefits for healthcare system and its management. There are a number of ongoing trials and studies at hospitals and

healthcare centers around the world utilizing and integrating RFID into their hospital information systems. Because of RFID studies and trials, it has been found that RFID elicits improvements in inventory management, patient safety, and security. Some hospitals have found that through RFID systems, medical errors have been reduced, which results in a reduction in costs to run medical programs. Positive Patient Identification can be achieved through the use of an RFID system. This is an essential policy for a hospital since the leading cause of death due to medical errors is caused by patient misidentification, and specimen or medication misidentification. These errors result in billions of dollars in national costs per year. Reducing medical errors not only increases patient safety, but also provides a huge benefit to a hospital. Each type of RFID system can be tailored to fit the needs of all healthcare programs. Every hospital is encouraged to integrate their existing system with RFID in order to reap the benefits of the evolution of healthcare technology's marvel, RFID.

RFID is an emerging technology with full benefits to be emerged in several years to all industries worldwide. It will bring a good opportunity for improving healthcare supply chain efficiency and hence the safety of the public in return. Large US companies and many large worldwide companies will be the big beneficiaries of such technologies soon. This means that many companies will take the advantage of this technology to increase their profitability and enhance productivity. This is an indication that larger companies will get larger and richer companies will get richer. If RFID is to achieve the level of adoption that has been forecasted, it is important to understand the capabilities and limitations of the technology as it evolves, the different types of applications where it can be used, and how business value is realized resulting in impact to the organization and the value chain.

In this article, author has discussed about the RFID active and passive tags, the costs of tags, its producers, and frequencies. Active RFID tagging has evolved to be a necessary technology for business productivity improvement efforts and security in the enterprise. Active RFID will complement and complete the capabilities of passive tags. In security, active tags can provide automation for immediate visibility into the activities in and around an enterprise. The homeland defense applications are expected to continue to grow as anti-terrorism funding trickles down. The growth in the use of sensors will be a continued driving force behind the implementation of active RFID solutions. In spite of the advantages of the RFID technology, there exist some technical and managerial problems for RFID applications including the reliability, identification range, implementation cost and EPC standards. As for the health care supply chain applications, the RFID tagging mechanisms can be classified into item tagging, case tagging and pallet tagging where the RFID tags are attached onto items, cases and pallets, respectively. Since the unit price of an RFID tag is still too high for organizations to afford the item tagging mechanism. For this reason, at the current status, the RFID tags are mainly applied to reusable pallets, cartons or cases and the identity of each item on the pallet (or case) cannot be accurately revealed.

This research was conducted on the healthcare topics using nine reported cases from the industry. There are many other cases reported that can be looked into by readers. Four proposals are offered in this article that can be studied further using data from real situations. This author has tried to demonstrate the truthfulness of these proposals using causal loops and the system thinking concept.

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