2010

Radio frequency identification: a case for health care

Sylvain Bureau
ESCP Europe Paris

Markus Bick
ESCP Europe Berlin

Selwyn Piramuthu
University of Florida

Yannick Meiller
ESCP Europe Paris

Wei Zhou
ESCP Europe Paris

See next page for additional authors

Radio frequency identification: a case for health care

Abstract

The use of RFID tags in healthcare applications has been gaining momentum over the past decade. This is partly due to recent advances in information technology and the need to reduce errors while simultaneously improving the efficiency of the system. We, at the RFID European Lab, have been studying various aspects of RFID implementations in healthcare environment over the past several years. The potential for RFID implementations in healthcare environment is enormous. We consider several such opportunities and identify possible extensions.

Publication Details

Bureau, S., Bick, M., Piramuthu, S., Meiller, Y., Zhou, W. & Fosso Wamba, S. (2010). Radio frequency identification: a case for health care. iiWAS'10 12 Internatonal Conference on Information Integration and Web-based Applications & Services (pp. 875-878). New York: ACM.

Authors

Sylvain Bureau, Markus Bick, Selwyn Piramuthu, Yannick Meiller, Wei Zhou, and Samuel Fosso Wamba

RADIO FREQUENCY IDENTIFICATION: A CASE FOR HEALTH CARE

Sylvain Bureau
ESCP Europe Paris
Information Systems and Technologies
79, ave. de la République, 75543 Paris
++33149235815
sbureau@escpeurope.eu

Markus Bick
ESCP Europe Berlin
Business Information Systems
Heubnerweg 6, 14059 Berlin
++493032007182
markus.bick@escpeurope.de

Selwyn Piramuthu
University of Florida
Information Systems and Operations Management
Gainesville, Florida
++1352392.8882
selwyn @ ufl.edu

Yannick Meiller
ESCP Europe Paris
Information Systems and Technologies
79, ave. de la République, 75543 Paris
++33149235882
ymeiller@espeurope.eu

Wei Zhou
ESCP Europe Paris
Information Systems and Technologies
79, ave. de la République, 75543 Paris
+33149232044
wzhou@escppeurope.eu

Samuel Fosso Wamba
University of Wollongong
School of Information Systems & Technology (SISAT)
University of Wollongong
Northfields Ave
NSW, 2522, Australia
+61242213136
samuel@uow.edu.au

ABSTRACT

The use of RFID tags in healthcare applications has been gaining momentum over the past decade. This is partly due to recent advances in information technology and the need to reduce errors while simultaneously improving the efficiency of the system. We, at the RFID European Lab, have been studying various aspects of RFID implementations in healthcare environment over the past several years. The potential for RFID implementations in healthcare environment is enormous. We consider several such opportunities and identify possible extensions.

Categories and Subject Descriptors

C.2.1 [Sensor networks], H.4.0 [Information Systems Applications – General]

General Terms

Management, Performance, Design, Economics, Human Factors.

Keywords

Radio Frequency Identification – RFID, healthcare, process optimization, risk management, performance assessment

1. INTRODUCTION

Literature about Radio Frequency identification (RFID) is abundant when dealing with technical, privacy and security, or ethical issues but few papers address managerial issues. This situation is quite awkward compared to the large audience that RFID has in the business media. For the last 10 years, RFID has simultaneously been fashionable and trendy while also being rejected and run down in the press. This technology, like many others, has its pros and cons. However, beyond these debates, mainly orchestrated by technology providers and major RFID users, some recurrent topics can be identified in the literature. The primary one among these is related to the impact of RFID solutions on system performance. Businesses are interested in knowing if they should adopt RFID applications to increase their competitive advantage. To increase performance with RFID, various solutions and applications have been proposed. Among them, we identified two major topics: the first one is related to process optimization and the second one deals with risk management: Firstly, RFID applications are designed to optimize processes by improving data capacity and operational efficiency; they also provide solutions for real-time information access and exchange, or better internal and external coordination. Secondly, RFID solutions are very often associated with risk management as this technology helps improve overall data accuracy and information visibility.

In our research, we plan to focus on these two major applications – process optimization and risk management – and we consider the general questions related to performance assessment of RFID solutions in particular. To do so, we (eight professors from various academic disciplines and countries) decided to build up collaboration and partnerships with public institutions, governments, industries, and universities through research, executive education programs, and surveys. Our main objective is to address managerial and business issues related to RFID solutions and to analyze major trends such as the Internet

of Things and ambient technologies. We will therefore address several types of questions through different academic angles. Specifically, we intend to focus our research around the two structuring and recurrent issues to determine the relevance of RFID applications mentioned above. In order to do so, we intend to carry out multiple empirical studies, applying various methodologies with primary focus on the field of healthcare.

In the remainder of this paper we first explain why this field is extremely relevant to be studied when it comes to RFID. Second, we describe the three research areas and related related research questions in more detail. Next, we provide a brief introduction to the planned studies/designs and their corresponding methodologies. The paper ends with some concluding remarks and some opportunities for next steps.

2. HEALTHCARE

RFID is one of the most promising information system technologies in the healthcare industry today and in the immediate foreseeable future [1]. Many RFID specialists claim that this technology can enable healthcare to overcome existing technological and workflow limitations. This technology should help improve tracking of patients, medical personnel, drugs, and equipment, decrease medical errors, provide positive identification of patients and medications, secure access to sensitive areas in hospitals, provide safer medications to patients and, last but not least, it can facilitate better information management. RFID would also drastically reduce or entirely eliminate the time the nurses spend on non-patient care, to ensure correct materials are ordered by the procurement department, and to reduce storage, transport, and support costs. RFID not only has applications within hospitals but in the entire healthcare sector. According to the United States' Food and Drug Administration (FDA), the potential benefits of RFID to hospitals and healthcare facilities are numerous. These include patient safety by ensuring that patients receive the correct medications and medical devices; preventing the distribution of counterfeit drugs and medical devices; facilitating device recalls; managing assets such as hospital equipment; tracking patients; providing data for electronic medical records systems.

Finally, there are three main reasons why it is important to know more about RFID and study its impact in the healthcare sector: First, the number of chips sold is increasing: hospitals are currently one of the largest buyers of RFID technology [2]; [3]; [4]. Second, there are a wide variety of RFID applications in healthcare with solutions enabling dispensation, security, geolocalization and inventory monitoring. The tags can be attached to objects (e.g., surgical instrument, drug), assets (e.g., medical gas bottle, wheelchair) and also people (e.g., nurse, patient). Third, healthcare concentrates most of the challenges related to RFID. Technical, standardization, ethical and managerial issues are very sensitive in this industry. With regards to technical issues, hospital environments are often "hostile" for RFID solutions: metal, heat, cold, liquid, RF interference, and complex information systems for instance make them more difficult to implement [5]. Moreover, healthcare is extremely regulated and even if the FDA tends to encourage the adoption of RFID, many rules constrain the implementation of such solutions [6]; [7]. While ethical and privacy issues are often raised with RFID, these concerns become obviously crucial in the healthcare industry [8]; [9]. Management is also a highly sensitive issue as mistakes can have a serious impact on patient safety: medical errors are very expensive financially and in terms of human health.

3. APPLICATIONS IN HEALTHCARE

3.1 RFID and Process Optimization

The health care environment is characterized by processes that can be broken down into component tasks. For example, a patient waiting to see a physician first signs in at the reception, waits for the physician, etc. [10]; [11]. When an item (e.g., bottle of medical gas) is needed for an operation, its need is first recognized followed by a request for this item, etc. [12]. Each of these tasks can further be recursively divided into sub-tasks until only the lowest-level tasks remain. These tasks (or sub-tasks) generally follow a sequence in their respective health care application scenarios. In the health care environment, some of these tasks (or sub-tasks) have temporal constraints that dictate the subsequent task be performed immediately with minimal time delays (e.g., anesthetization immediately preceding operation). For smooth operation of these processes, all the (physical and otherwise) constraints need to be satisfied with minimal deviations given pre-specified performance criteria. These constraints have related implications such as optimal allocation of talent from a human resource management perspective (e.g., doctors, nurses) as well as physical resource (e.g., equipment) allocation to achieve improvement in productivity (e.g., inventory reduction) and overall health care delivery performance (e.g., patient outcome).

In this stream of research, we are interested in the use of RFID-generated item-level information to (1) identify tasks as well as sub-tasks to develop schedules that facilitate effective performance, (2) use process mining for extracting usable patterns associated with successful processes, (3) develop knowledge-based systems for decision support, and (4) avoid mismatch through appropriate (RFID) tagging of items to ensure items that are required to be simultaneously present at any location are indeed present and vice versa. We have begun work on all of these streams, and preliminary results have already been either published or submitted for publication. We are in the process of advancing our earlier work in these areas. More precisely, we will address the following specific research questions related to this area:

- How can RFID tags be used for effective intra- and inter-hospital inventory management?
- How can we improve the individual (and aggregate) processes in a healthcare organization through process mining of RFID-generated information?
- What are the drivers and challenges of RFID-enabled healthcare transformation?
- What are the top-ranked drivers and challenges of RFID-enabled healthcare transformation?

3.2. RFID and Risk Management

Hospital risk management mostly deals with the methods and standards to reduce uncertainty in a complicated medical care environment and thus the risks of possible medical accidents. Risk management could be considered from either an individual patient's perspective or the entire set of patients. When considered from a single patient's perspective, risk management involves allocating all possible resources to this patient to achieve the best possible outcome. Although most healthcare

organizations aim to operationalize this for every patient, it is rendered impractical by the sheer number of patients and the constraints associated with available resources that include medical equipment and personnel. These dynamics are different in a public vs. private or specialized healthcare organization. However, the underlying goal in all of them is to deliver the best possible healthcare while still operating under their resource constraint set. This necessitates appropriate management of resources and risks to prevent compromising on the healthcare delivery process. The healthcare environment is highly dynamic and is rife with uncertainties both in terms of demand (e.g., patients, medical personnel, medical equipment) and outcome. Although not all components of risk management can be addressed through instance-level tracking and tracing, RFID tags enable identification of relevant entities and their related processes across time to generate effective risk management strategies.

In our research, we will investigate innovative methods to manage uncertainty and risks in healthcare practices from IT management, process mining and logistics management perspectives. We are specifically interested in studying the practice of RFID in healthcare risk management. There are several reasons. First of all, despite their popularity in healthcare industry and the uniqueness of their applications RFID tag applications have not been extensively studied in this area. Their benefits including both tangible and intangible pay-offs and possible application mechanisms are generally not completely known in many business sectors, including healthcare. Secondly, while existing research addresses some of the issues discussed above, there is a paucity of published research on improving process mining in healthcare environments using information generated through RFID tags. As a result, we believe that our research has excellent potential to help the healthcare practitioners not only to better understand the problem of uncertainty and risk management but to explore creative solutions. More precisely, we address the following specific research questions:

- What is the effect of item-level RFID tags on reducing risks in healthcare environments (e.g., cross-contamination as in Creutzfeldt-Jakob disease, matching patients and pharmaceutical items)?
- How can RFID tags be used to authenticate and ensure the simultaneous presence of tagged-objects (e.g., necessary surgical instruments for an operation, simultaneous presence of essential personnel)?

3.3. RFID and Performance Assessment

Many RFID specialists claim that RFID can enable healthcare to overcome existing technological and workflow limitations [1]. Among other advantages, RFID should "reduce drastically or entirely eliminate the time the nurses spend on non-patient care, to ensure correct materials are ordered by the procurement department, and to reduce storage, transport, and support costs" [13]. But these results could vary on the field depending on several contingencies (e.g., size of the hospital, age of the information systems, type of applications). Moreover, benefits might not be the same for different stakeholders (e.g., patients, medical professionals, IT companies, pharmaceutical industry, etc.) involved. As for any project involving RFID, assessment is critical. If RFID solutions could enable better information visibility to improve supply chain management [10], information needs also to be gathered to evaluate the potential benefits of an RFID project. The problem is that many analyses are focused on only one single dimension of the issue: technical, managerial, economical, or legal. Moreover, the evaluation tools used do not always take into account the specificities of the situation on the field. Eventually, assessments made on the field do not always consider the various stakeholders involved in the project and do not consider sharing the value created.

We consider that healthcare is a very fruitful field of study for performance assessment related to the use of RFID for several main reasons: (1) hospitals' performance is a major challenge from a resource constraints perspective, (2) a very large variety of RFID applications is used in hospitals and many other solutions are designed to be used within healthcare, (3) hospitals have sociological and organizational specificities which lead to very complex issues that are highly critical when it comes to RFID (e.g., the case of ethics can be a good illustration of such an issue), (4) related to the third, healthcare performance cannot be assessed only through quantitative dimensions, (5) the last element which makes it really interesting to focus on RFID applications within hospitals is that processes in these organizations are highly collaborative and call for fine-grained modeling of performance assessment.

4. METHODOLOGY

We intend to address the various aforementioned questions through complementary methodologies: qualitative, quantitative, analytical and simulation modeling. Each of these methodologies has its specific strengths, and validating results from these approaches would corroborate our overall findings and recommendations.

Qualitative: We plan to develop various case studies through multiple sources of evidence, including interviews, on-site observations and focus groups, which will allow us to increase our construct validity [14]. We will develop several case studies related to RFID applications in the healthcare sector.

Quantitative: We already diffused a Delphi study [15] and we also plan to diffuse a questionnaire to better understand the situation beyond our specific empirical fields. We have already sent a large survey and a Delphi survey related to healthcare in France, Germany, Canada, the USA and Australia. We plan to complete these surveys and expand it to Italy.

Modeling and Other Tools: We intend to use appropriate modeling methodologies to complement the methods mentioned above. Specifically, we propose to use simulation analyses, analytical modeling, data mining, knowledge-based systems, and cryptography as necessary [16]; [17].

5. CONCLUSION AND NEXT STEPS

The academic literature on RFID is extensive in the field of engineering, but rather limited on issues pertaining to management. We will therefore address several types of questions through different academic angles, and via diverse empirical fields. Specifically, we intend to focus our research around two structuring and recurrent issues to determine the relevance of RFID applications, the impact of such applications on the optimization of processes, and their role in risk management. We will also consider the issue of performance evaluation, as it is a critical factor for the diffusion of RFID solutions. In order to do so, we will carry out multiple empirical

studies, applying various methodologies. We will examine the healthcare sector that is lead by users of RFID solutions. Within this sector, we intend to observe several organizations and types of applications using very diverse methodologies (qualitative and quantitative approaches, modeling and simulation tools).

We have begun work on all of the three streams, and preliminary results have already been either published or submitted for publication. Specifically, we have already developed adaptive knowledge-based systems with learning capability for managing physical resources such as bottled gas, surgical equipment, and prosthetic ancillaries in health care environments. Preliminary results from these systems show performance improvements that are scalable and promising for large-scale implementations. We have developed cryptographic protocols that ensure simultaneous presence of appropriate items, and are fine-tuning these protocols to eliminate vulnerabilities or at the least alleviate deleterious effects resulting from unavoidable vulnerabilities. Process mining using RFID-generated item-level information has not received much attention in the health care domain although there are several potential applications in this domain that are begging to be considered. Our earlier work considered mining workflow information as well as generating scheduled from a human resource management perspective.

Nonetheless, one of the main issues that arises when assessing RFID impacts is that it requires a cross disciplinary approach as this project is related to as many fields as innovation, information systems, logistics, inter-organizational systems, and so on. Another issue is that many evaluation methodologies adopt a single actor perspective which cannot be relevant in the case of a majority of RFID projects within healthcare. Eventually, the evaluation criteria suggested in the literature are very often imposed. There is no proposition of a sort of a *maieutics* process which could help practitioners to find relevant questions that they should ask before choosing and applying a standardized evaluation tool. However, we think as a multi-disciplinary and multi-national research lab we have the skill-sets required to provide the respective results related to the research questions mentioned above.

6. ACKNOWLEDGMENTS

REFERENCES

[1] Correa, F. A., Gil, M. J., and Redin, L. B. 2007. RFID and Health Management: Is it a Good Tool against System Inefficiencies? *International Journal of Health care Technology and Management*, 8 (3-4), 268-297.

[2] OECD. 2007. *Working Party on the Information Economy*. RFID Implementation in Germany: Challenges and Benefits: 71.

[3] Page, L. 2007. Hospitals tune in to RFID. *Materials Management in Health Care*, 16 (5), 18.

[4] Sokol, B. H. 2006. *RFID & Emerging Technologies Guide to Health care*. Fast Track Technologies, Ltd. (FTT).

[5] Van der Togt, R., Jan van Lieshout, E., Hensbroek, R., Beinat, E., Binnekade, J. M., and Bakker, P. J. M. 2008. Electromagnetic Interference From Radio Frequency Identification Inducing Potentially Hazardous Incidents in Critical Care Medical Equipment. *JAMA*, 299 (24), 2884-2890.

[6] Atun, R. A., Gurol-Urganci, I., & Sheridan, D. 2007. Uptake and Diffusion of Pharmaceutical Innovations in Health Systems. *International Journal of Innovation Management*, 11 (2), 299-321.

[7] Strickland, L. S. and Hunt, L. E. 2005. Technology, Security, and Individual Privacy: New Tools, New Threats, and New Public Perceptions. *Journal of the American Society for Information Science & Technology*, 56 (3), 221-234.

[8] Yang, X., Xuemin, S., Bo, S., and Lin, C. 2006. Security and Privacy in RFID and Applications in Telemedicine. *IEEE Communications Magazine*, 44 (4), 64-72.

[9] Ohkubo, M., Suzuki, K., and Kinoshita, S. 2005. RFID Privacy Issues and Technical Challenges. *Communications of the ACM*, 48 (9), 66-71.

[10] Zhou, W. and Piramuthu, S. 2009. Health Care Process Mining with RFID. In *Proceedings of the 2nd International Workshop on Event-Driven Business Process Management* (Ulm, Germany), LNBIP 43, 405-411, Springer.

[11] Piramuthu, S. (2001). Knowledge-based Approach to Validating Patient Work Flow Sequences in the Health care Industry. In *Proceedings of the EUNITE Workshop on Intelligent Systems in Patient Care* (Vienna, Austria), 43-48.

[12] Meiller, Y., Bureau, S., Zhou, W., Piramuthu S. 2010. Simulation of a Health Care Knowledge-based System with RFID-generated Information. In *Proceedings of the Asian Simulation Technology Conference* – ASTEC2010 (Shanghai, China, 2010)

[13] Myerson, J.M. 2007. *RFID in Supply Chain - A Guide to Selection and Implementation*. Taylor and Francis Publishers.

[14] Yin, R. K. 2009. *Case Study Research: Design and Methods*. Fourth Edition. SAGE Publications, CA.

[15] Fosso Wamba, S. & Ngai, E. W. T. 2011. Unveiling the Potential of RFID-enabled Intelligent Patient Management: Results of a Delphi Study. In *Proceedings of the 44th Hawaii International Conference on System Sciences* (HICSS-44), Kauai, IEEE Computer Society.

[16] Meiller, Y., S. Bureau, W. Zhou, and S. Piramuthu. 2010. "Decision Support with RFID for Health Care," In *Proceedings of the 2nd International Conference on Networks & Communications* (NeCoM-2010), Chennai, pp. 243-249, CCIS 90, Springer.

[17] Meiller, Y., S. Bureau, W. Zhou, and S. Piramuthu. 2011. "RFID-embedded Decision Support for Tracking Surgical Equipment," *Proceedings of the 44th Hawaii International Conference on System Sciences* (HICSS-44), Kauai, IEEE Computer Society.