

RTLS in Hospitals: Technologies and Applications

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1. INTRODUCTION

The healthcare sector around the globe faces an increased demand to cut down costs, streamline operational efficiencies and comply with government regulations while improving the quality of care services. The combined effect of scarce and limited competent resources, inefficient systems and an aging population result in a significantly increased demand for healthcare services. For instance, in Québec, Canada, the healthcare system's expenses have increased from 31% of total program expenses in 1980 to 45% in 2010 and 49% in 2015 (Conseil du trésor, 2015), forcing an important reorganization of the health and social services network. Although these numbers are taken from a local Canadian context, they represent a global trend for healthcare services where the health system's share of program expenses is constantly rising. For instance, in the US, according to the Centers for Medicare & Medicaid Services (CMMS), national health expenditures projections were expected to grow at an average rate of 5.7 percent for 2013-2023. By 2023, health expenditures (financed by federal, state, and local governments) are projected to account for 48% of national health spending and to reach a total of \$2.5 trillion. In 2012, such expenditures constituted \$1.2 trillion or 44% of national health spending (CMMS, 2013). In this context, it is interesting to note that the total hospital spending is reaching \$918.8 billion, with major spending on physician and clinical services. This situation is worsened by an increasing shortage of doctors, nurses and skilled ancillary personnel, undue work pressures, ineffective communication mechanisms and already existing but unreadily available clinical information (Agarwal *et al.*, 2008).

Indeed, in order to address these challenges, hospitals around the globe are increasing their adoption of

1. Hospital information systems such as vertical Enterprise Resource Planning (ERP) solutions
2. Advanced mobile technologies such as portable computers, tablets and smart-phones
3. Wireless data networks such as Wi-Fi networks and
4. Automation technologies such as barcodes, and more recently Radio Frequency Identification (RFID) technologies which use radio waves to automatically identify and track any (mobile) object in real time, without human intervention.

This paper discusses the adoption of RFID technologies enabling innovative mobile service applications in hospitals, by examining how the technology can be used to increase the performance of operations management while enhancing patient care processes. In particular, the paper will look at RFID technologies enabling Real Time Location Systems (RTLS) adopted by a growing number of hospitals for asset tracking, patient workflow management and other applications where knowledge of the real-time location and status of mobile objects (e.g., products, people and assets) are important.

In the academic and professional literature, it is interesting to note an increasing interest of this specific topic from different perspectives such as using the technology for time-use measurement among bedside

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nursing staff (Jones and Schlegel, 2014), for understanding and modelling service delivery variations (e.g., due to unavailability of resources) occurring in a hospital department (Shukla *et al.*, 2014), assessing the impacts on process performance (Stübig *et al.*, 2014; Laskowski-Jones, 2012), looking at the adoption of the technology (Yazici, 2014; Cao *et al.*, 2014), studying implementations issues and project challenges (Fisher and Monahan, 2012), as well as looking at different RTLS options (Bendavid, 2013a; Zahid *et al.*, 2013) and architecture/network infrastructure models (Jeong *et al.*, 2014). Accordingly, since different RTLS technological options (hardware infrastructure and middleware platforms) are available on the market, hospital managers need to have a clear understanding of these options in order to determine wisely which one is best suited for their needs. The objectives of the paper are therefore to (a) clarify the link between RFID and RTLS (b) present an actualized portrait of RTLS technologies and vendors and (c) discuss some key applications enabled by RTLS.

The paper is organized as follows. The next section (2) presents an RFID system's technological layers and how RTLS are integrated with hospitals' backend systems to support efficient processes. In section 3, the RTLS market is presented. RFID applications in hospitals are discussed in section 4, with an emphasis on RTLS solutions enabling innovative applications designed to enhance patient care processes while improving the efficiency of operations. Finally, in sections 5 and 6 a discussion is proposed and future research directions are presented.

2. RFID SYSTEMS IN HOSPITALS

The practice and delivery of healthcare is fundamentally and critically dependent on effective and efficient communication. The practice and delivery of healthcare is fundamentally and critically dependent on effective and efficient communication. (Agarwal et al., 2008, p.2)

RFID Technological Layers: From Data Capture to Backend HIS Integration

Basically, RFID technology is a wireless Automatic Identification and Data Capture (AIDC) technology (AIDC) used to track and manage products, people and mobile assets in real time with minimal human intervention. Figure 1 presents an RFID system which can be represented as a four-layer system composed of (i) tags containing encoded data used to identify any object, (ii) readers and antennas used to automatically communicate with the tags and transmit the data (iii) through a communication network to a (iv) data management layer composed of a middleware system that manages the data and routes the relevant information to a specific Hospital Information Systems (HIS) where transactions are performed.

Object Identification: RFID Tagged Objects (Layer 1)

Layer 1 consists of RFID tags programmed to transmit signals at regular intervals or upon request, when interrogated by a reader. Simply stated, RFID tags are primarily categorized by their power source (active vs. passive) and frequency of operation (Low Frequency-LF, High Frequency-HF, Ultra-High Frequency –UHF or Microwave). The most “popular” RFID applications in hospitals involve active tags which are used for RTLS applications to track critical mobile assets (e.g. infusion pumps) or medical staff and patients.

Some active-solution providers such as *Ekahau*, *Stanley Aeroscout*, *emanate wireless* or *Zebra Enterprise Solutions* have developed tags that can leverage on a hospital's existing Wireless Local Area Network

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