Real-Time, Location-Based Patient-Device Association Management: Design and Proof of Concept

Raoufeh Rezaee, University of Ottawa, Ontario, Canada
Malak Baslyman, University of Ottawa, Ontario, Canada
Daniel Amyot, University of Ottawa, Ontario, Canada
Alain Moutham, Montfort Hospital, Ontario, Canada
Rana Chreyh, Canadian Blood Services, Ontario, Canada
Glen Geiger, The Ottawa Hospital, Ontario, Canada

ABSTRACT

Background: Hospitals need to accurately manage mobile devices (e.g., intravenous pumps) associated to their patients and health providers to ensure patient safety. Some hospitals have already invested substantially in real-time location system (RTLS) technology, a specific type of Internet of Things (IoT) application for indoor positioning, to manage mobile clinical devices. Objective: This paper investigates the reuse of RTLS systems to monitor patients and their assigned devices and to manage their connectivity automatically, in real time. Method: A system called Real-time Patient-Device Association and Disassociation (RPDAD) is designed, implemented, and tested in a hospital room and in a university laboratory. Results: RPDAD helps manage patient-device associations through a tablet application, with accurate suggestions for closest devices and automated detection of unexpected disassociations, resulting in real-time alerts. Conclusion: RPDAD offers a usable means of managing associations that does not depend on bar-coding technologies. It also helps amortize investments in RTLS.

KEYWORDS

Internet of Things, Mobile Asset Management, Patient Monitoring, Patient-Device Associations, Patient Safety, Radio-Frequency Identification, Real-Time Location Systems

INTRODUCTION

A real-time location system (RTLS) can wirelessly identify and track the location of people or assets. An RTLS is a well-known type of Internet of Things (IoT) application, where the position of connected, smart devices inside a building is monitored on a continuous basis. This monitoring often involves radio-frequency identification (RFID) technologies (Bolic et al., 2010; Sundaresan et al., 2015). Hospitals have started using RTLS technology for tracking smart and expensive medical devices such as mobile intravenous pumps and cardiac monitors. A recent market study (MarketsAndMarkets.com, 2016) reports that the RTLS market for healthcare will grow from half a billion USD in 2015...
to an estimated 3.1 billion USD by 2022. RTLS technology enables hospitals to be “smarter”, but this often comes at a high cost. Hospitals are hence looking for supplemental RTLS applications, beyond asset tracking, in order to justify and amortize their investment.

This paper explores the feasibility of reusing RTLS technology for tracking patients and their assigned medical devices and healthcare providers in real time, and of detecting when they are connecting or disconnecting. We use the terms association and disassociation to explain the transitions between the existence and the non-existence of connectivity between a patient, a device, and the healthcare provider legally and clinically responsible for the patient connected to that device. Specifically, by receiving the identification of a patient and a device, and by linking them, a patient-device (also called patient-to-device – P2D) association happens (He et al., 2011). Such process is triggered by a healthcare provider (typically a nurse) next to the patient. Similarly, a P2D disassociation represents the termination of an association between a patient, a device, and possibly the healthcare provider responsible for the association. A disassociation may be caused by a variety of reasons such as being explicitly requested by a healthcare provider or by having a patient moving away (by mistake or on purpose) too far from the associated device (Herbst et al., 2010). To distinguish these two cases, the terms manual disassociation and automatic disassociation are respectively used thereon.

With emerging, IoT-enabled mobile equipment that communicates patient status information to hospital information systems, correct patient-device associations are becoming essential to ensure that the right medication is provided to the right patient, that information about the right patient is transmitted to electronic health records, and that the right healthcare provider is alerted when a device is unexpectedly disconnected. Currently, there are some issues regarding device-patient associations in hospitals. As patient safety is a primary objective for healthcare providers, considering the accuracy of patient identification is essential, especially during the device association process. Manual association by healthcare providers is one of the current methods for assigning the patient to the device according to their identifier (ID), but it is time consuming and may lead to errors (Byungil & Howon, 2007).

Another motivation for our work is rooted in a common method for managing associations between patients and devices: the use of barcoding systems. Such approach is also time consuming and not always practical, despite relatively low percentages of errors reported by health providers. Bar codes can also be damaged or switched, they have low storage capacity, and they require a line of sight by the nurse to be used (ECRI Institute, 2008). The third motivation is the location of required mobile devices (intravenous pumps, cardiac monitors, etc.), often unknown to care providers. Tracking equipment is crucial in asset management, especially in a centralized distribution model (Shirehjini, 2012). Yet, a recent study by Horblyuk et al. (2012) illustrates that next to 60% of mobile devices remain idle at any given time while nurses spend over 20 minutes per shift looking for mobile equipment. With better real-time tracking, hospitals can often reduce the amount of equipment inventory, which consequently reduces maintenance, replacement, and service costs.

The availability of new and relevant technology provides interesting avenues for solutions. For the past few years, real-time location systems have been introduced in the healthcare sector to tackle some issues such as tracking patients, staff, devices and other resources. For example, The Ottawa Hospital (TOH), a major research and teaching hospital in Ontario, Canada, recently acquired a commercial RTLS for managing mobile assets such as mobile cardiac monitors and intravenous pumps. As such infrastructure is expensive, hospitals desire to see such investment amortized over many types of services beyond asset tracking, such as care flow management (Bougueng Tcheneube et al., 2013), RTLS-based hand hygiene management (Baslyman et al., 2014; Baslyman et al., 2015), and many others (Bendavid 2013; Fisher and Monahan 2012; Sundaresan et al., 2015).

In this context, the research hypothesis explored in this paper is: The design of an RTLS-based software system that monitors and tracks patients and their assigned devices and manages their connectivity in real time is feasible in a way that provides accurate location in order to support patient safety. This hypothesis focuses on the possibility of having an automated RTLS-based patient-device association and disassociation system that is reliable in terms of performance, accurate in terms of
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