Leveraging complex event processing for smart hospitals using RFID

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\textbf{Abstract}

RFID technology has been examined in healthcare to support a variety of applications such as patient identification and monitoring, asset tracking, and patient–drug compliance. However, managing the large volume of RFID data and understanding them in the medical context present new challenges. One effective solution for dealing with these challenges is complex event processing (CEP), which can extract meaningful events for context-aware applications. In this paper, we propose a CEP framework to model surgical events and critical situations in an RFID-enabled hospital. We have implemented a prototype system with the proposed approach for surgical management and conducted performance evaluations to test its scalability and capability. Our study provides a feasible solution to improve patient safety and operational efficiency for an RFID-enabled hospital, by providing sense and response capability to detect medically significant events.

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\textbf{1. Introduction}

The pressures of improving patient safety while reducing operational costs for healthcare are forcing hospitals to adopt new information technologies so as to reduce medical errors and respond quickly to critical situations. Radio frequency identification (RFID) is a rapidly developing technology and it is believed to be the next generation innovation for automatic data collection, object identification, and asset tracking. Although RFID is still in its infancy in healthcare applications, it has gained much attention during recent years from both service providers and technology vendors. Some pioneering hospitals have implemented this technology to identify and monitor patients, track assets and medical supplies, and check patient–drug compliance. A survey conducted by \textit{BearingPoint (2007)} and the National Alliance for Health Information Technology on participants of more than 300 government and healthcare executives, indicates that RFID is “poised for growth in healthcare”.

With the capability to capture the identity and location of any tagged object automatically and periodically, RFID data in hospitals can be in huge amount. Besides, an increasing number of embedded devices in hospitals, such as physiological sensors and environmental sensors, emit data in real time. Consequently, a hospital needs to handle a large amount of data from a variety of sources and detect medically significant events timely by correlating RFID and non-RFID data. However, RFID raw data only provides low-level information such as Electronic Product Codes (EPC) of the tagged objects, location and timestamp, which are not directly related to business processes. Physiological events such as patient body temperature and blood pressure are also in low level. Other data such as patient medical record needs to be correlated to signify actionable information for decision making. Therefore, the ability to transform raw data in health care practices into useful knowledge in order to realize the maximum value from RFID technology becomes a critical issue.

Complex event processing (CEP) (\textit{Luckham, 2002}) provides an effective solution to process event streams in real time for today’s dynamic business environment. Compared to the delayed-analysis methods used traditionally in relational databases, CEP involves continuous processing and analysis of high-volume and high-speed data streams such as RFID data. It also correlates distributed data to detect and respond to business-critical situations in real time. Thus, CEP helps to deal with a variety of data streams to deliver actionable information. For example, in the case of patient identification in a surgery, if a wrong patient is taken to the surgery room mounted with an RFID reader, an alert will be triggered and sent to the care provider immediately. Therefore, leveraging CEP to manage hospital events that are captured by RFID systems and embedded devices for situation detection can be helpful to solve the challenges faced by healthcare.

In this paper, we propose an RFID-enabled CEP framework for managing hospital data from a variety of sources, specifically for surgical procedures. We apply the logic of CEP to model basic events and event patterns in hospitals to detect medically