A Novel Use for Real Time Locating Systems: Discrete Event Simulation Validation in Medical Systems

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ABSTRACT

In 2009, the St. Louis Veterans Affairs Medical Center (VAMC) installed a Real Time Locating system (RTLS) in their eye clinic. The system tracks staff and patient movement through a combination of radio-frequency identification and infra-red technology. This system, in addition to its primary purpose as a throughput monitoring system, was used to gather data for the validation of a Discrete Event Simulation (DES) of the eye clinic. Use of the RTLS gathered data greatly diminished the time required to validate the simulation, as well as the cost of labor needed to observe and record the data points necessary. RTLS systems may be employed by operations researchers and systems engineers to assist in patient flow analysis in capacities beyond the ‘Real Time’ aspects of the locating system.

Keywords: Discrete Event Simulation, Healthcare Delivery, Radio-Frequency Identification, Real Time Locating Systems, Technology Integration

INTRODUCTION

The Real Time Locating system (RTLS) installation used in St. Louis Veterans Administration Medical Center (VAMC) Eye Clinic consists of portable active radio frequency identification (RFID) and infra-red (IR) badges which are clipped to the lapel of staff and patients. Each badge broadcasts its unique identification number via IR flashes every three seconds. These flashes, which are invisible to the naked eye, are captured by IR sensors installed at specific critical locations. The sensors relay the identification number captured by the sensor to a server, which records the badge, time, and sensor information in a SQL database. Because each badge is associated with a unique individual, the vendor-installed software (Enterprise View, Versus Technology) is able to display a blueprint of the Eye Clinic on a computer screen, and locate icons representing the associated individual on the blueprint according to the sensor which

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captured the badge’s latest flash. In this way, it is possible to display a live, interactive in silico version of the Eye Clinic. Most marketing for RTLS focuses on the value of this live system, and the various capabilities based on the live interaction of the computer, badges, sensors and individuals within the clinic. RTLS systems have been shown to improve efficiency in a supply chain and construction systems by allowing access to information in real time, and visual representation of bottlenecks (Kim et al., 2008; Song et al., 2006). The badges also incorporate a button, the actuation of which results in an RFID pulse which is used for event notification.

Discrete Event Simulation is a method for the examination of systems and processes which involves the computerized scheduling of simulated tasks according to a clock. DES, as a field of study, has been applied to the medical sciences for more than thirty-five years (Mihram, 1974), however it is only recently, with the advent of more sophisticated software and more powerful computers, that DES is becoming more widely employed as a method of clinical and epidemiological investigation (Smallman & Dexter, 2010; Jun et al., 1999; Brown et al., 1997; McKenzie et al., 1998; Chick et al., 2000). In the case of the St. Louis VAMC Eye Clinic, the DES consists of clinical operations and facilities decomposed into their component elements and assembled in a computerized model. The clinic operation is modeled as consisting of four basic elements: entities, resources, locations and paths. Clinical processes are defined as the manner in which entities (patients, paperwork, and computer records) move along paths (physical pathways) to consume or employ resources (physicians, nurses, technicians, equipment and supplies) at locations (offices, waiting rooms, procedure rooms). Lengths of time for various tasks, which generally are stochastic in nature, are based upon measured data taken from observation of the real world processes that are mimicked in the DES.

The Eye Clinic DES will be used to analyze clinical throughput and patient flow, as well as to test the consequences of intervention in a simulative environment prior to implementation in the real world clinic. Medical clinics are examples of human interactive hybrid dynamic systems (HDS) (Fishwick, 2007), which are characterized by large numbers of semi-independent subsystems, changes to any one of which will cause propagating effects to the entire system. Therefore, accurate, validated models of these systems are invaluable in predicting those consequences, and ameliorating any negative unintended effects resulting from desired changes and improvements to the system (Gunal & Pidd, 2005). As such, DES can be a formidable tool in translational research, by testing and forecasting the effects of implementation of policy changes and systems redesign (Hoot & Aronsky, 2008; Barret et al., 2007; Daun & Clermont, 2007; Hung et al., 2007). The ECS specifically is geared toward determining the value of staffing and process changes and their effects on patient time in the clinic. However, in an environment where revenue or resource utilization was paramount, such metrics may be readily adopted.

RFID IN HEALTHCARE

Radio frequency identification devices have been employed in healthcare since roughly the turn of the millennium, with the first peer reviewed article known to the authors concerning their use with human subjects - an exhortation to caution regarding potential interference between RFID devices and cardiac implanted pacemakers (Harthorne, 2001) - appeared in Cardiology in Review. The positive potential of these technologies begins to flourish in the literature in 2004, regarding identification errors (Valenstein & Sirola, 2004), prevention of drug counterfeiting (Rudolph and Bernstein 2004), and unit efficiency in endoscopy (Kowalski et al., 2004). The identification of the potential for this technology to enhance safety was recognized early on (Perrin & Simpson, 2004). A PubMed search of the keyword “Radio Frequency Identification” yields 9 articles from 2000 until 2004, inclusive. The same search

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