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Emergency Department Real Time Location System Patient and Equipment Tracking

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14. ABSTRACT

The Valley Hospital proposes to continue and expand their current work to implement an Emergency Department (ED) Patient and Mobile Equipment Tracking pilot project in an effort to identify key opportunities to drive operational efficiency, improve patient satisfaction, and increase asset utilization. The project will also focus on researching opportunities to leverage the technology in a military setting in collaboration with the Telemedicine and Advanced Technology Research Center (TATRC). The proposed research project intends to demonstrate the effectiveness of using middleware to homogenize data produced by varied real time location system (RTLS) platforms for consumption by a common user interface and application. The project is intended to lead the way to further study of the application throughout the hospital in the inpatient and peri-operative setting.

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Introduction

The Valley Hospital continues to expand their work on medical error reduction by implementing a Mobile Equipment Tracking system utilizing a real time location system along with radiofrequency tagging. The initial phase of the project built a hospital-wide infrastructure of RTLS hardware and defined the desired zone-based configuration needed for adequate tracking. AgileTrac software was then installed to pass the milestone marks to disparate systems for the purpose of location, preventative maintenance or repair of tagged equipment. The proposed research project intends to demonstrate the effectiveness of using middleware to homogenize data produced by varied real time location system (RTLS) platforms for consumption by a common user interface and application. The project is intended to lead the way to further study of the application throughout the hospital in the inpatient and peri-operative setting tagging other assets as well as patients and caregivers.

Body

Background: The Valley Hospital proposes to implement a real time location system (RTLS) to locate asset management and patient flow in a healthcare setting. This system will be implemented in a phased approach to accommodate the absorption of the technology and integration with existing workflow processes and computerized information systems. This proposal will detail the Hospital's intent to implement a pilot project in the Emergency Departroent (ED) Patient flow and include Mobile Equipment Tracking in that area to identify key opportunities to drive operational efficiency, improve patient satisfaction, and increase asset utilization. The pilot project will also focus on researching opportunities to leverage the technology in a military setting in collaboration with the Telemedicine and Advanced Technology Research Center (TATRC).

The RTLS industry contains many proprietary, vendor-specific hardware and software platforms which are designed to 1: promote a particular technological development agenda, or 2: overcome a perceived or actual enviromnental characteristic. This proposed project is not intended or designed to promote or advocate for one technology over another, but to promote a framework where multiple, disparate RTLS technologies can coexist in the same ecology and allow their disparate outputs to be merged into a cohesive, organized flow of information. This research project proposal intends to demonstrate the effectiveness of using middleware to homogenize data produced by varied real time location system (RTLS) platforms for consumption by a common user interface and application.

Subsequent phases of the project will include Patient flow, clinical process management and Mobile Equipment Tracking in the Perioperative Suite, expansion of Mobile Equipment Tracking to include beds, intravenous infusion pumps and other movable assets of critical clinical nature for the entire campus, additional phases will include patient flow and clinical process management to improve critical or time-sensitive events.

Hypothesis: We believe that diverse, disparate, wireless real-time location tracking teclmologies can co-exist in a single environment and that the positional information they provide can be merged into a single set of data outputs that can provide a single pane-of-glass view of the real-time location of materiel assets, clinical process management and patient flow that these data outputs can also be sent to ancillary asset and workflow systems based on their parochial interests. We further believe that, by enabling this homogenization of information supplied by the most appropriate RTLS systems that are installed, we can improve operational efficiency, improve patient satisfaction, increase asset utilization and positively impact patient safety

Technical Objectives:

- Select and implement a Real-Time Location System (RTLS) in The Valley Hospital Emergency Department. This implementation will provide relevant (room-level or bay-level) positional information for tagged movable assets and during a future phase, patients admitted to the Emergency Department. The system will provide zonal positional information for all other areas of the Hospital Emergency Department.

- Ensure the solution complies with all RF transmission guidelines to avoid interference with Hospital's wireless communication systems and clinical modalities.

- Select and implement an RTLS Server ("middleware") application. The purpose of the RTLS Server will be to homogenize the output from the RTLS System for consumption by heterogeneous computerized information systems. The middleware application must be scalable to allow for inputs from multiple, disparate, RTLS systems as well as multiple, diverse, parochial information systems. The middleware application must be compatible with multiple interface specifications for the heterogeneous computerized information systems. The middleware application must contain user-configurable, rules-based workflow and notification components to guide information delivery and notification processes for key events.

- Interface the RTLS Server to the Hospital's Emergency Department information system. This interface will provide real-time positional data which will be consumed and processed by the information system to display the current location for each admitted patient on the unit in a later phase.

- Interface the RTLS Server to the Hospital's bio-medical device asset management system. This interface will provide real-time positional data which will be consumed and processed by the asset management system to facilitate asset location for any device needing repair.

- Select and implement an RTLS in The Valley Hospital for positional reference of staff and patients throughout the campus. The system will provide zone-based coverage for patient care units and designated areas. The system will provide threshold or other relevant positional information to the RTLS Server for analysis of event-driven triggers in a later phase of the project.

- Select and implement an RTLS in The Valley Hospital for positional reference of materiel assets throughout the campus. The system will provide zone-based coverage for patient care units and designated areas. The system will provide relevant positional information for key areas within the patient care units and other designated areas in a later phase of the project.

- Identify opportunities to leverage the use of the RTLS Server rules to enhance patient throughput initiatives and other operational efficiencies through the improved utilization of materiel assets, coordinated event alerting based on key relevant positional triggers to improve workflow processes in a later phase of the project.

Military Significance: Creating a method for homogenizing location data from disparate RTLS systems that will allow multi-vendor sourcing of hardware and accelerate the adoption of multi-site implementations. Current manual asset management processes often cause insufficient availability of assets, labor-intensive physical inventories, shrinkage and inadequate asset maintenance as well as uncertainties in readiness status, which can impact the critical patient care issues. Real-time asset management systems based on RTLS technology can reduce inventory requirements, ensure adequate inventory to meet operational demands, minimize shrinkage of assets, and improve productivity and accountability. The technology platform being introduced will enable these benefits and provide an open framework on which vendors can create solutions.

The military already has disparate RTLS systems actively deployed. This project would allow for the continued selection and implementation of diverse RTLS technologies that are designed to meet the environmental and process requirements while enabling cross-departmental information sharing and more effective asset mapping for logisticians.

Public Purpose: This project would provide a framework for product evaluation and selection by organizations wishing to invest in RTLS technology but confused by the diverse solutions and lack of standardization. Our project will afford organizations the opportunity to select the most appropriate RTLS technology solution(s) for their enviromnent while allowing for information-sharing requirements to parochial, legacy information systems. Wifi-based RTLS systems could coexist in the same organizational ecology as RF/IR systems based on the department or unit's needs. The positional information available from each RTLS would be processed by the centralized RTLS Server and integrated through its rules engine to spawn correlated event notification to interested parties and present a holistic view of managed assets.

In addition to the technical application advancement, the ability of the system to generate milestone marks as well as location of patients and assets will be a tremendous assist to gaining healthcare efficiency, increased patient satisfaction and enhanced patient safety.

Healthcare organizations struggle with the ability to track their assets for example, I.V. infusion pumps. The ability to readily locate pumps at the moment they are needed will ensure the patient is receiving their medication therapy in a timely manner, which is an important patient safety issue. The fact that the employee didn't have to spend an excess amount of time to locate the pump is an employee satisfier. The system's ability to track assets will help organizations to purchase the right amount of pumps and create cost savmgs.

The ability to track patients through their steps in the care process using a real time location system will help healthcare organizations learn what processes can be improved upon to increase efficiency and provide timely, safer care for patients. The milestone marks generated by the RTLS will be far more objective allowing benchmarks to be established so healthcare organizations can use them in their process improvement activities. In so doing, care will be delivered to patients in a way that will minimize risk, minimize bottle-necks in the system and hasten diagnosis and start of treatment to the patient. In addition, creating capacity for staff to spend more time at the patient's bedside.

Collectively, these enhancements will create safe, patient-centered, effective, efficient and timely care. These elements reflect the vision of health care for the American public written in the Institute of Medicine's report, "Crossing the Quality Chasm."

Methods: The testing methodologies to be used will confirm the accuracy of the solution, displaying the asset on an electronic map that consistently corresponds to a real-life physical location. The process for vetting the solution will require repeatable results establishing positive identification that an identified asset's RTLS Server location matches it's real-life, physical location whether it be zone-based or room-based level of granularity. We will perform this testing using a tagged asset. Using the positional reference software map contained in the RTLS Server, observe and compare that that to the physical "real life" location. The testing method will be deemed successful when we can confirm a statistically significant number of occurrences that the tagged asset is displayed within 3 feet of its "real life" location. In zone-based coverage areas, confirm that a statistically significant number of positive occurrences exist to locate the asset in the software match the "real life" location. Further testing will include confirmation that interfaced heterogeneous information systems include the appropriate location values as are observed within the RTLS Server. This location information must be consistent and updated in the heterogeneous information system within 300 milliseconds of a location-change event generated from the RTLS.

Key Research accomplishments

RTLSPatient Tagging

September 2013- Interface-Meditech Patient RTLS Location Functionality

AgileTrac will refresh periodically when new location information is sent which will allow Valley to see patient location information real time. The technology path that the messages will follow is, AgileTrac ESB services will capture real time updates of patient locations and push that information via Coverleaf web service to Valley. This functionality only addresses the method of data exchange that will push a patient's current location to Valley and Meditech for processing and display within the modified Meditech UI. Meditech edit to the RFID # field to the correct format is completed as well as the outbound interface from Meditech to GE ADT. The final testing revealed a failure in the Meditech outbound interface to disassociate the RFID tag from the discharged patient. This has been corrected by connecting all the depart patient status options to the tag disassociation.
October 2013-The testing procedure for the real time location of the patient onto the ED tracker board was completed successfully. The test included the following processes;

Action	Expected Response
Patient arrives in the ED and is tagged (scanned into MT)	MT display on location tracker (Emergency)
Patient is in the ED waiting room	MT display on location tracker (ED waiting)
Patient is taken to Triage	MT display on location tracker (Triage)
Patient is placed in Exam Room 22	MT display on location tracker (ED 22)
Physician signed up	MT tracker Status Event= PHY
Patient is fully registered	MT tracker Reg Status= REG ER
Patient transfer to DI waiting for Bergen elevator	MT display on location tracker (ED 1ST FLO)
Patient on 2nd floor elevator area	MT display on location tracker (2ND FLOOR)
Patient in DI Holding area	MT display on location tracker (RADIOLOGY)

Patient transfer back to ED outside Bergen elevator	MT display on location tracker (ED 1ST FLO)
Patient to be admitted	MT tracker StatusADM; Reg Status ADM IN
PT bed requested	MT tracker StatusBED; Reg Status ADM IN
PT transferred to floor	MT display on location tracker (ED22); Status2FLR
PT arrives in room P4336	MT display on location tracker (P4336)

June 2013- I-Dashboard and ODS Database

The ED dashboards have been designed to provide movement to movement specific data to enable drill-down level review. The level of detail is sufficient to provide Valley with the ability to run ad hoc reports from a reporting copy.
System Validation included "use cases" to demonstrate each reporting aspect of the system.
The ED Patient Tracking Dashboards have been completed along with the QMS and data integrity audit. The ability to deploy the ADT interface timestamps is predicated on the Meditech updates.

The I-dashboard was installed and the research team is ready to work with the reports that are generated from the application. This application will allow for the researcher to compare the manually collected timestamps to the RTLS timestamps and make an assessment of variance between the two data sources.

Time Stamps to be collected have been tested to location:
a. "Arrival": Patient Status "ED Arrival" minimum entry time
b. "Enter Triage": Patient Tag locates to a "Triage" Location minimum entry time
c. "Exit Triage": Patient Tag exits a "Triage" Location minimum exit time
d. "Enter ED Exam Room": Patient Tag locates to an "ED Exam Room" Location minimum entry time
e. "ED Departure": Patient Tag enters a "ED Drop Box Location" minimum entry time for Out Patients (Treat and Release) or Patient Tag enters an "In Patient Depart Location" such as the "ED Elevator Lobby" maximum entry time
f. "Discharge": Patient Status "Discharged" minimum entry time for Out Patients (Treat and Release)
g. "Enter IP Room": Patient Tag enters an "In Patient Room" Location minimum entry time
h. "Admit": Patient Status "Admitted" maximum entry time
i. "Admit Order": Date and time an Order to Admit an ED Patient is issued

j. "Enter Radiology From ED Exam": Patient Tag enters a "Radiology" Location minimum entry time
k. "Exit Radiology to ED Exam": Patient Tag exits a "Radiology" Location minimum exit time
l. "Exit ED Exam to Radiology": Patient Tag exits an "ED Exam Room" Location minimum exit time and directly precedes the timestamp "Enter Radiology from ED **Exam"**
m. "Enter ED Exam From Radiology": Patient Tag enters an "ED Exam Room" Location minimum entry time and directly follows the timestamp "Exit Radiology to ED **Exatn"**
n. "Exit ED Exam Room": Patient Tag exits an "ED Exam Room" Location minimum exit time
o. "Registered": Patient Status "Registered" maximum entry time for Out Patients (Treat and Release)
p. "ED Drop Box Departure": Patient Tag locates to an "ED Drop Box" Location minimum entry time
q. "ED Inpatient Departure": Patient Tag enters and "Inpatient Depart Location such as the "ED elevator" maximum entry time.
The Room/Unit configuration and the Asset Dashboards Module was moved to the live environment and the ADT interface is working.

July 2013- RTLS System Validation

Validation Task A. To determine the AgileTrac RTLS and ED Patient Tracking Dashboard accuracy and responsiveness data to that recorded from live patient movement within the prescribed patient paths of the ED Patient Treatment.

Validation Task B: Patient to Patient Tag Disassociation within AgileTrac to ascertain that a Patient Tag deposited into a Valley Drop Box does disassociate the Patient from the Patient Tag in AgileTrac.

Validation Task C: Patient to Patient Tag Disassociation within Meditech.
A patient discharged within Meditech did disassociate the patient from the patient tag in Meditech. In addition, that Meditech has sent the A03 Discharge HL7 message to AgileTrac.

Validation Task D: Patient Location Reporting
Once the tag is deposited into a Drop Box and disassociated from a patient, a patient's location record will no longer be updated with RTLS.

June 2013- Patient Tag Loss Mitigation

Since Patient tagging began in June 2013 the number of patients that left the hospital with the tag still on reached 500. The researcher has set up a process to notify the ED and the nursing unit the patient was discharged from to alert the caregiver of the failed process. Patient transport companies have been notified to be looking for patient tags so they can

be removed prior to departure. Nursing Homes have been notified of the patient tagging process so they can return the tag to the hospital. Signs have been posted at hospital exits reminding patients to be sure the tag has been removed. A process is being developed to notify the staff when they make discharge follow up phone calls that a patient was discharged with a tag. A return envelope will be sent to the patient so they can mail the tag back to the hospital.

Reportable Outcomes

The results of the validation testing showed a total of 53 patients were recorded during the 72 hour validation time frame. 100% of Patient Disassociated from the Patient Tag upon Tag deposit into a Drop Box, or the receipt of the Valley ADT A03 discharge message, whichever was the first to took place. 40 of 53 (75.5%), patients successfully disassociated from Patient Tag with Drop Box deposit. 13 of 53 (24.5%) patients successfully disassociated from Patient Tag with Valley ADT A03. AgileTrac did not receive the Meditech ADT A03 for 5 Tags (9.43%) at the time of data collection.

Valley data indicated that tags were seen in Valley Hospital locations after patients departed, as a result of no patient-to-tag disassociation in Meditech. This occurrence is noticed in the Valley Operation when assigning a tag to a new arriving patient. The Meditech System returns a status that the tag is already assigned. The Valley Team acknowledges that when a patient departs prior to discharge, it is necessary for the tag to be manually disassociated from the patient in Meditech. Valley is to develop and deploy an internal process change to handle these cases. Valley will establish a process for departing patients registered in the Meditech when they arrive in the Emergency Department but leave before being seen. Meditech does not consistently send AgileTrac the HL7 message of A03 indicating a discharge.
All patient-to-tag assignments (53 of 53 cases tested) were successfully disassociated.

The !-dashboards are live and recording results of patient tagging on a daily basis. The essence of the research question posed in this project was to capture defined key movements of the patient through their Emergency department encounter and compare them to the same key movements tlmt are manually captured. The research premise is that RTLS times captured are equal to or shorter than those manually recorded. To date, the results show that average overall arrival to departure of the ED patient to an inpatient unit is 258 minutes which matches to the minute with the manually data capture of 258 minutes.
The average overall time that a treat and release patient spends in the ED through the ASPIRE data collection process is, 164 minutes versus 181 minutes captured via RTLS.
The explanation for the difference between the two times is the pediatric patients presented in the ED do not receive an RFID tag. This population of patients has the shortest length of stay in the ED as treat and release patients thus bringing down the overall average.
The addition of 2 minutes recorded for Arrival-Enter Triage is accounted in the ASPIRE data collection process as registration time. The RFID tag is placed on the patient at the end of the registration process. Hence the 4 minutes represents the same measurement.

The metric, Admit to ED IP departure is measured with different timestamps in ASPIRE versus RTLS however the intent is to capture the same segment of movement. In the ASPIRE timestamp the measure begins at registration and ends when the patient status is changed to inpatient in the HIS system. In the RTLS system the capture begins on registration and ends when the patient physically departs the ED by passing the signpost at the department exit.

Comparison of other metrics is showing RTLS times to be shorter than manually entered times for the following timestamps.

Metric	Duration (Min) ASPIRE	Duration (Min) AgileTrac
Arrival - ED Departure	190	181
Arrival - ED Departure Out Patients	164*	181
Arrival - ED Departure In Patients	258	258
Arrival- Enter Triage	6*	4
Enter Triage - Exit Triage	9	9
Arrival-Enter ED Exam Room	20	18
Enter ED Exam Room - ED Departure	190	186
ED Drop Box Departure - Discharge	N/A	15
Arrival - Discharge	196	200
Admit - ED IP Departure	59*	67
Admit - Enter IP Room	99	99
ED IP Departure - Enter IP Room	N/A	32

RTLS Asset Tagging

RFID tagging and RTLS has made the role of Materials Management Coordinator at The Valley Hospital much more efficient and has allowed the Coordinator to expand his role and add value to the organization. Before equipment was RFID tagged, the Materials Management Coordinator would have to round on all of the in-patient units searching for important clinical equipment. This would take a full 8 hour shift to accomplish and take away from other duties.

The Materials Management Coordinator utilizes RTLS on a daily basis as an integral tool to accomplishing his job. With equipment RFID tagged, the Coordinator can ensure that important equipment can be found in seconds, equipment can be utilized instead of being static in unoccupied patient rooms or clean utility rooms, monitor if equipment was cleaned properly by environmental services and insure that yearly maintenance dates are met for all equipment. This takes about an hour to review instead of the eight hours it took searching for equipment before RFID tagging.

This tool will be used to improve other areas, Adult code carts will be tagged to help our central supply and distribution department eliminate supplies from reaching their expiration dates. This will reduce product waste and increase workflow by being able to approach time dependent work with predictability.

Rental equipment will be tagged to track location so it can be returned to the vendors on the date it stops being used. This will add workflow efficiency in tracking the rental equipment as well as cost savings from not having to pay on extra rental days while the equipment is being found.

In a recent mock Joint Commission survey, the finding that came out throughout the organization was clutter in hallways which block egress in case of emergency. Excess equipment increases hazard of trips and falls for patients, visitors and staff.
Lack of storage has been perpetuated over the years as space once designated for storage of equipment has been redesigned into clinical functioning space or office space. At the same time advances in technology have facilitated the purchase of even more equipment. With the tension mounting as a result of this multifactorial issue a solution is being sought.
The investigator believes that the RFID/RTLS technology can further assist in the successful management of equipment supply and storage logistics.
Before further development of this plan can talce place, a process needs to be developed to manage asset tag battery life. At the onset of the RTLS project the Centrax manufacturer projected the battery life of the tags to be 3 years. The investigator's experience is showing an actual life of 1.5 years. With frequent equipment movement as well as numerous access points, the battery is drained much more quickly.
A low battery equipment tag report has been developed and generates a list of tags that fall below a threshold of signals which indicate the battery has limited life. The information is then parsed to either the Biomedical engineers to be address during clinical equipment preventative maintenance process or the Engineering department managing larger transport equipment, beds, stretchers, wheelchairs, etc.
The current phase of the process is locating the equipment that may have a dead tag and get them retagged. Once this is complete, the inventory will all be accounted for. The RTLS reports that show equipment movement history will be used to identify opportunities to reduce the quantity of inventory of particular pieces of equipment. One of the main goals is to determine the right amount of equipment needed in the organization. Once this is established a process to transport and offload a percentage of the equipment from the hospital campus to a local storage facility will reduce the clutter. The next step will be to use the RTLS reports to capture the amount of movement and use

of each piece of equipment then based on these findings, build a "just in time" delivery scheduling process to support the equipment needs at the hospital and timely removal of equipment not needed on site.
The RTLS vendor has advised that a sign post can be installed at the warehouse location to assist in managing and accounting for each piece of equipment as well as managing low battery.
The current process for cleaning the equipment is taking place on the patient care units. A number of variations in this process were identified during analysis. Not all equipment could be distinguished as having been cleaned, clean and soiled equipment were interspersed in clean and soiled utility spaces, in hallways as well as, patient rooms.
The original design of the RTLS process established a workflow which could track the movement of equipment through the clean to soiled to clean states. Analysis of the RTLS tracking reports showed an overall compliance rate between 30-50% of equipment traveled through the process as designed. Through observation, the fmdings validated the reports however, the process as designed didn't meet the staff workflow. The contributing factors to the hindered success are: the limited space in the soiled utility rooms does not make it conducive for the Service Associate (SA) to clean the equipment there. The nurse needs a piece of equipment quickly and asks an SA to clean it and bring it directly to the patient's room. Soiled equipment in a patient's room that is undergoing a terminal clean may have the equipment cleaned in the patient's room as well. This usually occurs if the nurse tells the SA that a patient is waiting to be admitted into that room.

The investigator offers a hybrid solution to the cleaning and storage of equipment.
The material management process using RTLS established equipment par levels for each unit. As stated earlier, this segment of the project has worked very well. It has proven to be an efficient, effective way to manage the location and movement of equipment to where it needs to be.

Conclusion

This research has demonstrated the ability to capture timestamps of a patient's movement through an Emergency Room visit using RFID and RTLS. This success is attributed to the ability to accurately recreate the key performance indicators (KPis) as defined in the ASPIRE workflow into timestamps using RTLS. The output of this design allows for an accurate comparison of the data between the two systems.
The hypothesis that RTLS can provide times equal to, or possibly shorter, than the manual data entry process was proven to be a true statement.

Experience with RFID and RTLS in managing assets has proven to be an effective, efficient and job satisfYing technologic advancement. As described earlier in this report, the continued development of its application in order to optimize the number of pieces of equipment to have, the process for cleaning, repair and preventative maintenance and all the logistics of equipment movement will be mapped in the next phase of this project.