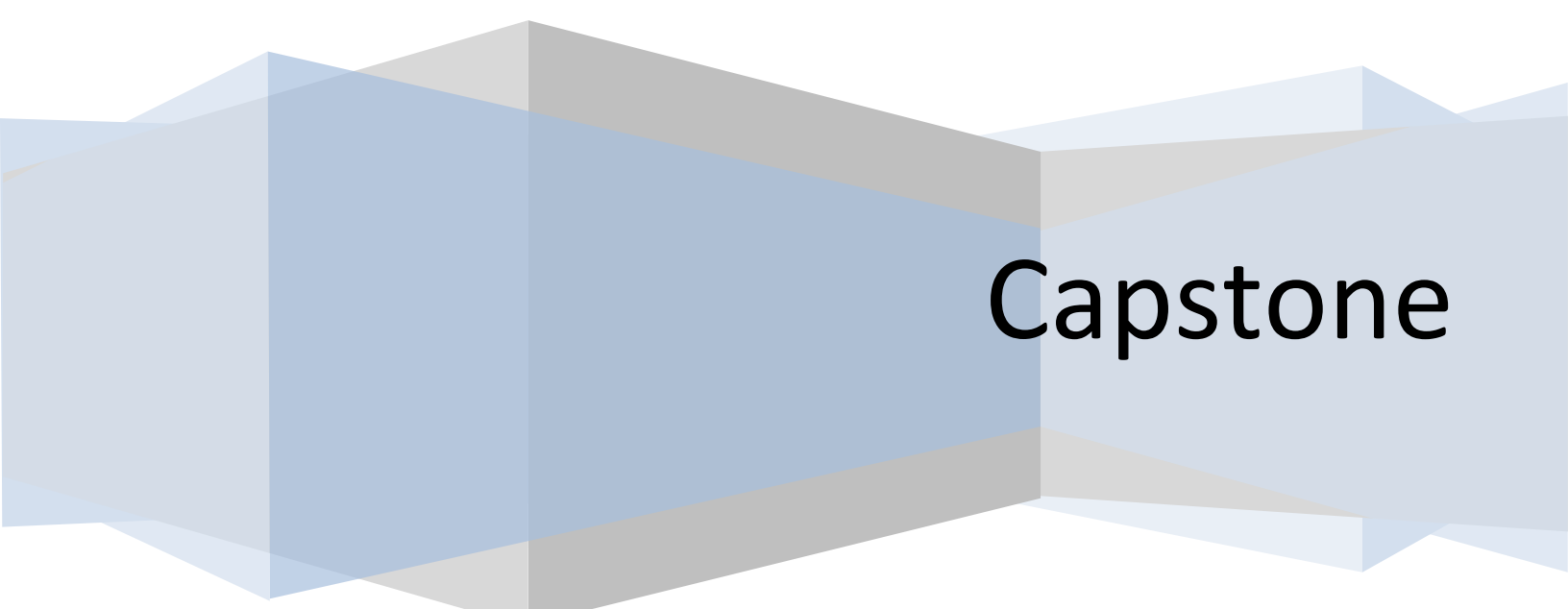


Bellevue College
Medical Informatics Program

Business Intelligence Use in Healthcare



Capstone

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1 Introduction

Scenario: A Medical Center is considering investing in a Real Time Location System (RTLS) for their medical equipment. Our team has been asked to predict the possible ROI on the equipment and target the equipment that would maximize it.

Real Time Location Systems (RTLS), also referred to as Radio Frequency ID (RFID), can be utilized in the healthcare environment to track medical equipment that is mobile and has a significant cost associated to it for the hospital. In this document we refer to RTLS and a smarter, next generation, active RFID system.

1.1 Purpose

The goal for using RTLS would be to improve patient care and patient encounters by reducing time lost from locating equipment, loss prevention (theft), and tracking and integration for patient encounters within the hospitals' EMR system for a variety of decision making departments.

1.2 Scope

A data warehouse used with analytic modeling and algorithms can provide a medical center with information to identify best practices in support of practicing evidence based medicine. Using best practice information provides valuable input to process improvement using principles such as Six Sigma¹. Information gathered from systems such as EMR and RFID systems statistically show which practices, treatments, and equipment provide the best ROI. We will use the RTLS project as an example of how implementation of analytics with an RFID system can take a good system known to improve patient safety, and use the information with analysis over time to improve operational efficiencies within the patient care process.

1.3 Technology

The technology used in this project is identified throughout. Complete descriptions of the sample operational database, SQL Server 2008, and SQL Server Business Intelligence Studio can be found in the appendix.

¹ (Kumar, 2010)

2. Executive Summary

We used the example of an RFID system to demonstrate the use of Business Intelligence in supporting business decisions supporting the strategic goals of a medical center. Our study shows the considerations for choosing an RFID vendor for the medical center and how return on investment can be predicted using business intelligence analysis.

For the product acquisition process, the choices made are specific to our sample medical center, without discussing the process other medical centers might use to choose a vendor. This allows us to discuss the implementation steps in the data warehouse and analysis. Once a medical center invests in the technology to build and maintain a data warehouse, and implement analytics, using historical and predictive data will be routine in healthcare, without the need to implement analytics for each new project or acquisition.

Finally, we discuss many extensions to this specific RFID project and other areas where business intelligence can be useful in healthcare.

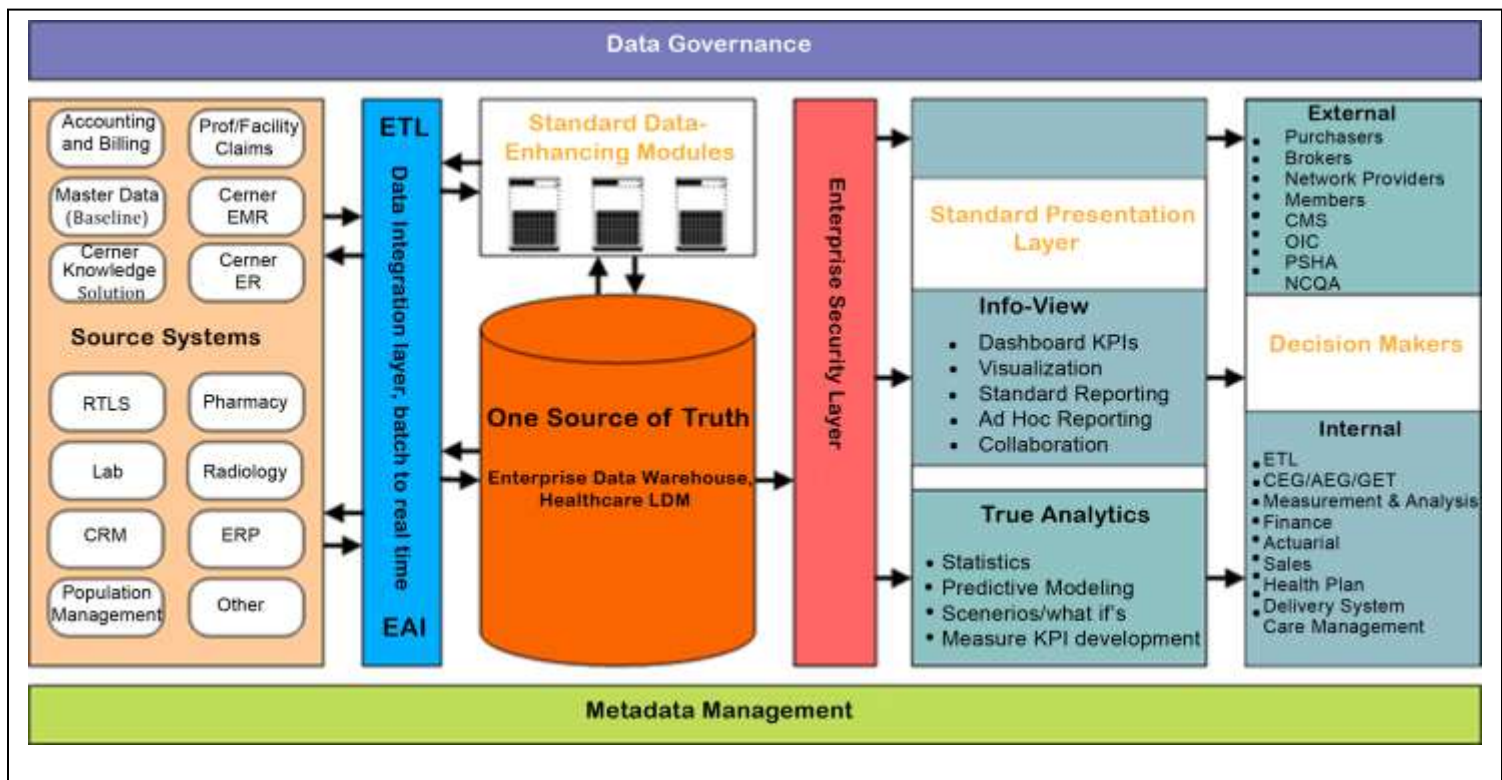


Figure 1 Overview of Medical Center Information System including RTLS and Business intelligence

2.1 Use of Analytic Tools to Improve Healthcare at Lower Costs

It is well known that in the United States, healthcare costs are rising. National healthcare expenditures grew 4.0% to \$2.5 trillion in 2009, or \$8,086 per person, and accounted for 17.6% of Gross Domestic Product (GDP). In 2010, total federal, state and local government spending amounted to 36 percent of GDP². In the projected period of 2009-2019, average annual health spending growth (6.1 percent) is anticipated to outpace average annual growth in the overall economy (4.4 percent). By 2019, healthcare expenditures are expected to grow to 19.3%, with the public share of total health care spending expected to exceed 50 percent by 2012, and then reach nearly 52 percent by 2019³.

Historically, healthcare reform happens slowly and incrementally. Healthcare has lagged behind due to many factors, such as how disperse and fragmented the providers and payers are, the culture of patients “allowing the doctor to make all the decisions”, and concerns about information security. George W. Bush supported insurance reform, malpractice payout caps, and required HMOs to give patients complete doctor choice. President Obama and Congress passed the Affordable Care Act not just to control health care costs, but also to improve quality of care. Incentives encourage EMR adoption which provides data for improving health care. Computer systems in manufacturing have allowed companies to work smarter by improving process and reducing waste for decades. In 1989 Expeditors International had 27 locations. The same year they implemented a computerized air export program. In 1999, their 20th year, they grew to 163 locations, with a wide variety of shipping options.⁴

New government incentives are aimed at bringing health care into the digital age, by not just collecting information, but sharing and using it for decision support. One of the terms used to describe this is evidence based medicine. By analyzing what past data is available, and providing point of service information about drug interactions and allergies, clinicians are supported by statistically sound “best practices” that should preclude the current vast practice variation that currently exists. It is important to note that while this information is supportive of physicians; individualized care should still be practiced.

Clinical data analysis is only possible with structured data input, such as using an electronic medical record which provides forms for clinicians to enter patient information that is encoded by the EMR for

² (Bartlett, 2011)

³ (Services, 2009)

⁴ (Expeditors International, 2011)

billing and future data analysis. Actual use of collected clinical data for decision support will be sometime in the future, but the time to change the healthcare culture is now.

Standards development is another big piece of the healthcare puzzle. Before information can be analyzed, standards must ensure that like data is collected. Structured data input, direct data collection from medical equipment and common data sharing protocols all make this possible.

2.2 Strength of a Business Decision Supported with Analytics

Healthcare best practices, supported with data collected from standard diagnostic groups can show what treatment plans have the best results, least readmissions, and least complications. This information serves as a guide to healthcare providers and a reminder of things likely to be missed.

Based on best practice information, staff can work to improve process and workflow, increasing efficiency and reducing waste. Tracking equipment and related utilization to improved patient care is beneficial to the bottom line. In a 2006 survey Health Purchasing News, more than 300 healthcare respondents, 70% cited patient safety as a top benefit to RFID, with improved patient flow and general productivity ranking second⁵.

The current generation of RFID, called RTLS, has improved the system to be active and smarter offering more benefits and opportunities for tracking.

3 RTLS Acquisition Process

3.1 Steering Committee and Champion

Our Medical Center has established a steering committee of major stakeholders with a strong project manager.

Senior Level: Chief Financial Officer Project Champion

Project Manager: Medical Center Project Manager

Committee Members: CISO, Chief Information Security Officer, Department Nurse Manager, IT Network Specialist, Clinical Engineer, Chief Financial Officer.

⁵ (Revere, 2010)

Implementation group: Facilities/Engineering, Clinical Engineering, IT (network, security, application/programming)

Project lead or Manager needs to be able to communicate at a senior level with authority to make decisions and solicit resources from a variety of departments as needed

Project manager communicates at a senior level with decision making authority (Committee containing Medical Center Board Members and Senior Level Finances).

3.2 Objectives

The medical center is seeking to solve the following issues:

1. Equipment Loss
 - a. Medical Center is currently replacing 8 wheel chairs per month. Medical centers are required by law to supply wheelchairs. Patients are waiting until one can be located.
2. Staff time loss in equipment location attempts.
 - a. Maintenance personnel searching for equipment to service, and removing nonfunctioning equipment from regular use.
 - b. Nursing staff locating equipment for use is not spent on direct patient care.
3. Patient Safety
 - a. Lost equipment not properly maintained may resurface and be used in patient care.
 - b. If equipment cannot be located, there is a delay in patient care.

Issues	Wheelchairs	Alaris Infusion Pumps	Patient or Transport Beds
# Owned	400	500	600
# Lost or Stolen	100	75	200
# Replaced Yearly	96	Not Replaced Individually – purchased in quantity with warrantee	
Average Cost	\$650.00	Brain \$2,200 Modules \$1,000 Syringe Module \$1,800 Average \$1666.67	Lease \$250-\$350/day
Price Range	\$300 - \$1,000.00		
Service	Required	Quarterly	
Search Time per Shift			up to 8 hours
Maintenance Issues	Routine, scheduled PM's are required by Join Commission however unable to comply and therefore use asset inventory database to meet requirement	500 pumps (Brain) include 1200 modules	Rental beds are leased @ \$250/day Rental Air Mattresses are leased @ \$100/day
Staff Issues		Staff searching for equipment are not caring for patients	
Liability Issue	Law requires hospital to have wheelchair available if needed by patient.	Un-serviced equipment used in patient Care	Un-serviced Equipment used in patient Care

Figure 2 Equipment Chosen for RTLS tagging

3.3 Vendor Review and selection

The committee reviewed information from GAR RFID, Key Scan, Inc, RF Technologies, Inc, Reva Systems Corporations, Awarepoint, Inc, and CenTrak.

Following this review, the following variations were noted.

1. RFID Technology is powered two ways; active (battery assisted) and passive technologies (each have pluses and minuses to both)
 - a. Most vendors use one or the other technology. Awarepoint was the only vendor that uses both technologies.
 - b. Some try to use the existing WiFi infrastructure of the hospital
 - c. Some specialize in only one certain kind of RFID (e.g. patient wristbands, hardware non-sterilized)

- d. Some companies include proprietary application software to collect and send information to other applications; others just supply data mapping information or a database for the RTLS system management
- e. Some companies provide only RFID tags; allowing home grown Database and infrastructure to manage; these companies provide limited number of metrics form their devices.
- f. Biometric and asset inventory systems companies offer RFID systems, but as a sideline, not their primary business.

We chose Awarepoint to investigate further because:

- They take advantage of both battery-assisted and passive technologies in their products
- They are focused on only RTLS implementations and offer a wide range of asset tag devices, including ones that can be autoclaved without removing
- Awarepoint has already partnered with Cerner and Four Rivers Software, two companies whose products are already implemented in the hospital. This allows Clinical Engineering's asset tracking and inventory system to integrate with Awarepoint as well as the EMR applications. Additional departments such as finance and billing can take advantage of the information available as both are connected to the existing application software.
- Awarepoint has an open API allowing application programs to be written.

3.4 System Goals

Minimize losses in time and equipment

Improve patient safety

Contribute information toward evaluating the complete patient experience

3.5 System Requirements

Any new equipment acquired must minimally, be compatible with, and strive to support and improve security and compatibility of existing medical center systems.

The medical center currently uses Microsoft platform, using SQL Server for Database management, perimeter firewalls. The network is supported by Cisco and Nokia routers acting as gateways, and HP Pro-curve switches in the datacom closets. The Awarepoint RTLS system will be routed through the Pro-curve switches into the hospital information systems.

The asset tracking and inventory management program, Four Rivers Software, runs on SQL Server platform and is used by Clinical Engineering and Facilities Management to track all materials and equipment. Finance has access to inventory system for billing, contract negotiations and depreciation scheduling.

The Cerner EMR application runs on a Citrix platform, backed by a SQL Server Database.

Wireless networking technology was a specific importance regarding patient safety and security. In a recent article in the Wall Street Journal⁶ FDA scientists are bombarding pacemakers and hearing aids with electromagnetic waves to see how they interact with the growing volume of waves people encounter in daily life. These scientists have found that some RFID transmitters can shut down some pacemakers. Pacemakers function by sending a small electronic pulse to the heart when it fails to beat on its own. The RFID pulse can be mistaken as the heart beat by some pacemakers. The 802.15.4 network standard is the committee's choice for RTLS wireless communications.

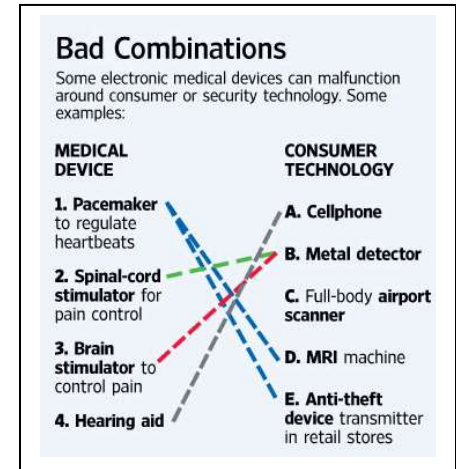


Figure 2 Medical Devices and Electromagnetic Waves

3.6 ZigBee Standard 802.15.4

RFID-RTLS can play an important role in automation of common tasks – improving operational efficiency, increasing patient flow and enhancing patient safety. Knowing the location, status and movement of equipment and people can provide a rich warehouse of information that can be mined and used to improve hospital business processes and asset utilization, reduce capital expense and rental costs, and improve staff productivity

RTLS must be able to co-exist with other hospital infrastructure technologies, such as LAN's, WLAN's (Wi-Fi), and the growing variety of network-enabled and wireless medical equipment

⁶ (Wang, 2011)

Often times existing Wi-Fi infrastructure is considered a possible solution to RTLS implementation. But, the requirements of sensor data collection conflict with the original design goals of Wi-Fi. These conflicts can render Wi-Fi based RTLS impractical and expensive, and can adversely affect mission-critical applications running on the hospital's Wi-Fi infrastructure.

ZigBee is the only standards-based technology that addresses the unique needs of remote monitoring, control, and sensor network applications. ZigBee sensor networks require far less throughput but offer even greater flexibility than either of the other network types. Thus, these networks are well suited to applications requiring low data rate transmissions. For example, in RFID-RTLS implementations, asset tags need only send brief transmissions of approximately 100 bytes. Lower throughput results in lower complexity, longer battery life, and lower cost. Additionally, with ZigBee sensor networks, RF frequencies are allocated which maintain separation from Wi-Fi and other traffic, preventing the battle for bandwidth that may affect mission-critical applications when converging RFID-RTLS with Wi-Fi.

With the use of clear channel assessment practices, wireless communication protocols such as 802.11 or 802.15.4 (upon which ZigBee is based) include collision avoidance techniques to prevent interference.

In a typical Wi-Fi deployment, channels 1, 6, and 11, the three non-overlapping channels in North America, are typically used. To avoid interference, ZigBee allocates traffic on channel 26, which is to the far right, well out of the range of Wi-Fi networks. In addition, ZigBee 802.15.4 networks communicate at 1mW of radiated RF power, compared to 100 mW for nodes within Wi-Fi networks, and 1 watt for mobile phones.

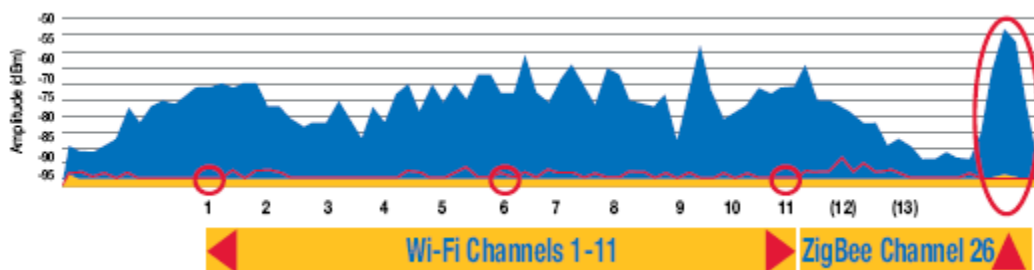


Figure 3 Radio Frequency Channel use⁷

⁷ (Hegli, 2008)

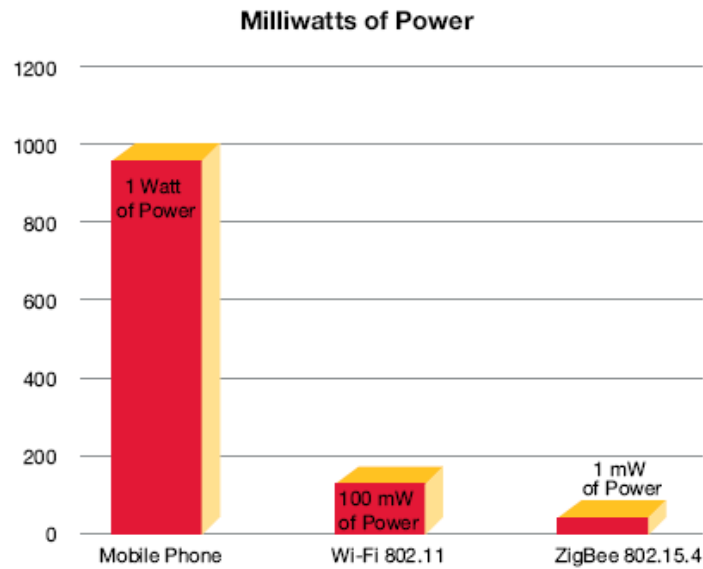


Figure 4 Device Power Use⁸

These networks can be designed to communicate small amounts of data very infrequently, with most asset data residing on the server, indexed by unique ID's associated with the tagged asset. The low transmission power of 802.15.4 ZigBee networks results in both overall lower power consumption and longer battery life.

ZigBee devices have the ability to form an RF mesh network between nodes. Each node is self-routing and able to connect to other nodes as needed. ZigBee sensor networks leverage this mesh network to route data among the sensors themselves to collection points or to bridges onto the LAN. The network of sensors communicates wirelessly with each other along with wireless communication from the battery-powered tags to the sensors.

⁸ (Hegli, 2008)

3.7 Proposal.

IT Services Project Intake Form

SECTION I – Basic Information: <i>(To be completed by the project requester)</i>					
Name/Title of Request <i>(Provide a name that characterizes the work)</i>		RTLS – BI Proposal		Urgency (H/M/L)	Low
Requesting Department		Finance – Asset Management		Request Date	6/16/2011
Requester	Finance	Phone #		E-mail	
Department Manager	Finance Mgr	Phone #		E-mail	
Director/Executive	Hospital Administrator	Phone #		E-mail	
1. Business Need/Requirement Description <i>(Describe the issues this project request is intended to address.)</i>					
1) Implementation of a Real-Time-Locating-System (RTLS) for inventory and asset tracking of medical devices throughout the hospital 2) Creation of a Business Intelligence integration database to improve asset management and increase productivity and return on investment					
2. Proposed Solution and Alternatives					
No present alternative exists. Proposal is to investigate through site survey and further analysis with the intention to purchase and implement an RFID system					
3. Expected Benefits					
- Reduction in inventory loss - Time and workflow improvements - Improved asset management of medical devices - BI Implementation for data mining					
4. Potential Risk/Impact					
No perceived risk or impact to project implementation. Objective is to improve workflow and inventory management loss through theft and misplacement, as well as provide for a data warehouse and analytics as a means to decrease expenses, improve workflow and the overall patient experience.					
5. Primary Sponsor and Stakeholders					
Senior Level: Chief Financial Officer Project Champion Project Manager: Medical Center Project Manager Committee Members: CISO, Chief Information Security Officer, Department Nurse Manager, IT Network Specialist, Clinical Engineer, Chief Financial Officer. Implementation group: Facilities/Engineering, Clinical Engineering, IT (network, security, application/programming)					
6. Approving Entities					

Figure 5 Project Intake Form - Page 1

IT Services Project Intake Form

7. Scope of IT Work
Install additional server to house RTLS system and data warehouse. Implement Data warehouse, SSIS, SSAS, SSRS, and Alerts
8. Ongoing Production Support
Maintain existing Asset Management system with addition of an RTLS device on each asset. Daily reposting and equipment reconciliation
9. Target Completion Date, Major Milestones, Driving Factors and Constraints
Up and running six months from starting date, with daily census report produced. Major milestones: (1) Vendor contract negotiations, (2) current equipment reconciliation of affected equipment (3) identifying and tagging equipment (4) Zigbee Network implementation, (5) sending alerts (6) verifying SSIS (7) Report production Driving Factors: Continual equipment loss / replacement, staff time looking for equipment. Constraints: Equipment availability during system implementation. However, no significant equipment downtime required.
10. Funding and Budget Number
Startup costs: \$88,500, recoverable in 4-5 months following implementation

Figure 6 Project Intake Form - Page 2

3.8 Cost Benefit Analysis

Hardware:		
HP Proliant DL380 G6 Server		\$1,800
Software:		
	MS Windows Server 2008	\$200.00
	MS SQL with 5 CALs	\$200.00
	AwarePoint Proprietary Application	\$0.00
RFID/RTLS:		
	Price per unit: \$15 x 1,500 units	\$22,500.00
AwarePoint:		
	Site Survey, Network Mesh Design, Scanning of CAD (Computer Aided Design) drawings, and training	\$30,000.00
Hospital Labor:		
RTLS units must be entered into and associated with the existing asset tag for equipment in the inventory management system used by the Clinical Engineering Department staff	Estimate is 25 assets/hour for one person. This equals 60 hours total labor or 15 hours for four people	
Network Cabling: none required		
		\$0
Power: Use existing power outlets		\$0
Business Intelligence Software		
	Microsoft BI stack, SSIS, SQL, SSRS, Microsoft Visual Studio 2008 with Business Intelligence Tools	\$300
1 FT employee, database developer/BI Analyst	6 month contract	\$35,000
Potentially implemented by grad student would significantly decrease this cost.		
Total Startup Cost		\$88,200

Cumulative cost Savings over 4 month period			4
Wheelchairs:	32 chairs replaced @ average cost of \$650.00		\$20,800
Pumps:	28 Pumps missing and/or replaced @average cost of \$1,666.67		\$46,667
Beds:	Average patient stay: 2.3 days 19 Beds missing 19 beds x 2.3 days = 43.7 days x \$250/day		\$10,925
Total Un-captured Savings			\$78,392
Break Even Month			4.50

Based on total startup costs and expected savings, costs should be recovered in a 4.5 month period. We consider this a conservative estimate as we did not factor staff time searching for equipment.

Unlike passive bar coding, RTLS technology can cause alarms to sound or doors to lock. RTLS is not a replacement for bar coding, but will coexist with users applying the correct data collection technology for the correct situations. While bar coding is useful for highly structured and engineering processes, RTLS is for mobile assets in largely chaotic, unstructured business processes such as hospitals.⁹

4 Implementation of Supportive Business Intelligence

4.1 Data Warehouse Schema

Our design for the data warehouse is a basic star schema centered on the FactTransactionLog recorded by the RTLS system. Staff dimension table would be populated from the enterprise employee database

⁹ (Kumar, 2010)

maintained by Human Resources. The location dimension would come from the Facilities operational database joined with the RTLS mesh mapping. Change is possible in the Staff, Location and RTLS Dimensions, so a changing dimension strategy should be defined.

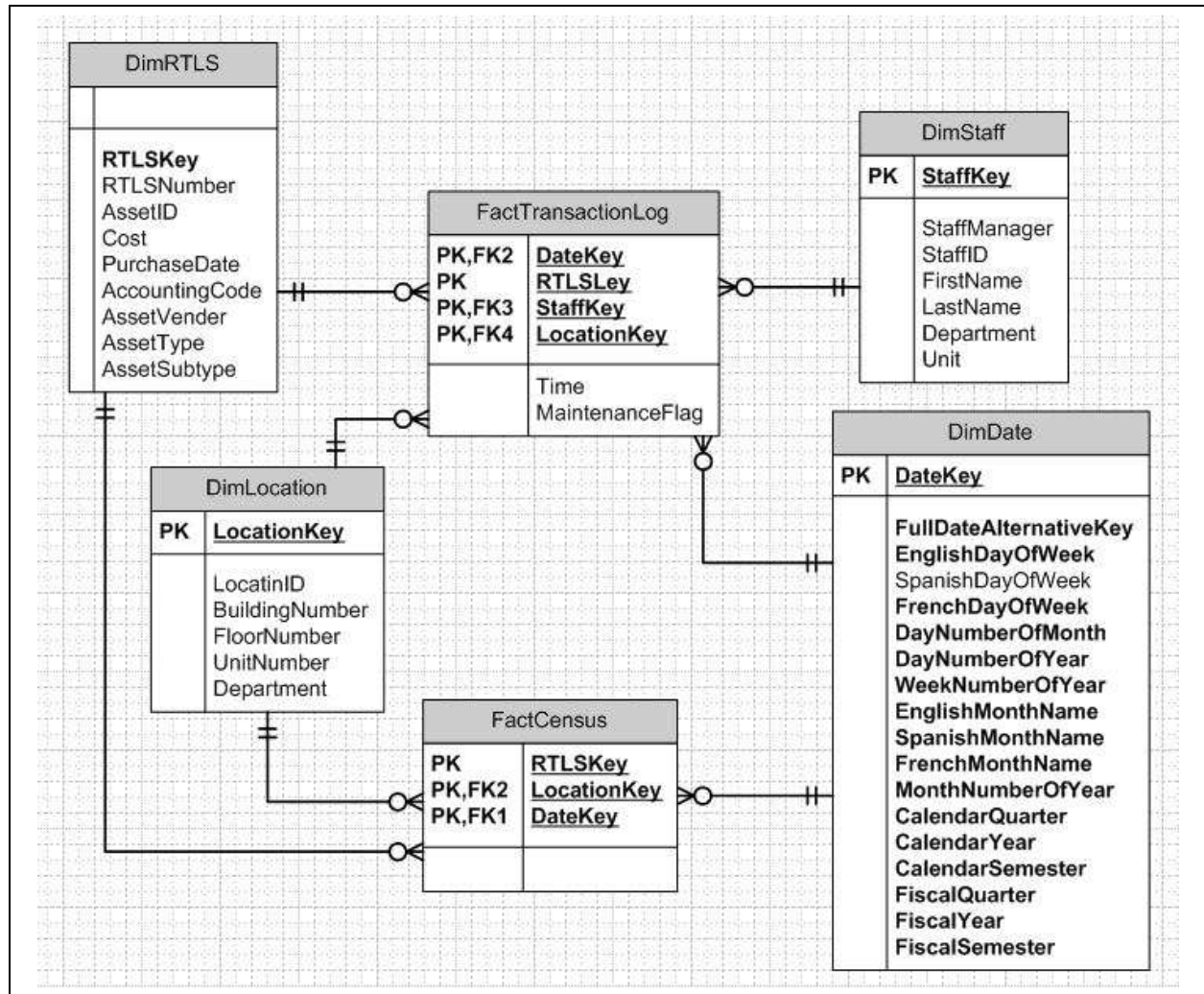


Figure 8 Data Warehouse Schema

4.2 Fact Tables

Transaction Log

The Transaction Log will provide the measures for the warehouse. Data will be collected from the RTLS (Asset Location data) and Asset definition data (Primary location, Contact person) into the data warehouse source at times defined by the system.

The Transaction Log would be recorded only when RTLS ID leaves a particular geographical zone. For example, an asset leaves one hospital room, the transaction will be recorded. An asset enters one hospital room, the transaction will be recorded.

FACTTRANLOG				
	Column Name	Condensed Type	Length	Nullable
	DATEKEY	int	4	No
	RTLSKEY	int	4	No
	LOCATIONKEY	int	4	Yes
	STAFFKEY	int	4	Yes
	TIME	varchar(10)	10	Yes
	PMAINT_FLAG	char(1)	1	Yes

Census Log

A daily census log will also be recorded. Once daily, all assets will be recorded so that we can account for Material (Assets) in transition mode (e.g. Material still in hospital lobby).

Reports will be generated summarizing this information.

FACTCENSUS			
	Column Name	Condensed Type	Nullable
	RTLSKEY	int	No
	LOCATIONKEY	int	No
	DATEKEY	int	No

4.3 Dimension Tables

DimRTLS

This table describes the information coming from the RTLS System and the Asset information from the operational asset database.

DIMRTL				
Column Name	Condensed Type	Length	Nullable	
RTLSKEY	int	4	No	
RTLSNUMBER	varchar(20)	20	Yes	
ASSETID	int	4	Yes	
COST	money	8	Yes	
PURCHASEDATEKEY	varchar(10)	10	Yes	
ACCOUNTNUMBER	varchar(20)	20	Yes	
ASSET_VENDOR	varchar(10)	10	Yes	
ASSET_TYPE	varchar(10)	10	Yes	
ASSET_SUBTYPE	varchar(10)	10	Yes	

DimLocation

This dimension table holds a unique location key for every area of the medical center. Information is taken from the current facilities operational database and the mesh network created by the RTLS system.

DIMLOCATION			
Column Name	Condensed Type	Nullable	
LOCATIONKEY	int	No	
LOCATIONID	varchar(10)	Yes	
BUILDINGNUMBER	varchar(10)	Yes	
FLOORNUMBER	varchar(10)	Yes	
UNITNUMBER	varchar(10)	Yes	
DEPARTMENT	varchar(10)	Yes	

DimStaff

The staff dimension holds information about staff roles in alerts and access to location data. It is populated from the medical center human resources operational staff database.

DIMSTAFF				
	Column Name	Condensed Type	Length	Nullable
	STAFFKEY	int	4	Yes
	STAFFMGRKEY	int	4	Yes
	STAFFID	varchar(20)	20	Yes
	FIRSTNAME	varchar(20)	20	Yes
	LASTNAME	varchar(20)	20	Yes
	DEPARTMENT	varchar(20)	20	Yes
	UNITNUMBER	varchar(20)	20	Yes

DimDate

This is the standard date dimension holding information granular to the day.

DimDate			
	Column Name	Condensed Type	Nullable
	DateKey	int	No
	FullDateAlternateKey	date	No
	DayNumberOfWeek	tinyint	No
	EnglishDayNameOfWeek	nvarchar(10)	No
	SpanishDayNameOfWeek	nvarchar(10)	No
	FrenchDayNameOfWeek	nvarchar(10)	No
	DayNumberOfMonth	tinyint	No
	DayNumberOfYear	smallint	No
	WeekNumberOfYear	tinyint	No
	EnglishMonthName	nvarchar(10)	No
	SpanishMonthName	nvarchar(10)	No
	FrenchMonthName	nvarchar(10)	No
	MonthNumberOfYear	tinyint	No
	CalendarQuarter	tinyint	No
	CalendarYear	smallint	No
	CalendarSemester	tinyint	No
	FiscalQuarter	tinyint	No
	FiscalYear	smallint	No
	FiscalSemester	tinyint	No

4.4 ETL Process

The dimension tables will be loaded in a onetime ETL package from the RDIF system, the existing asset tracking database, staff and facility databases.

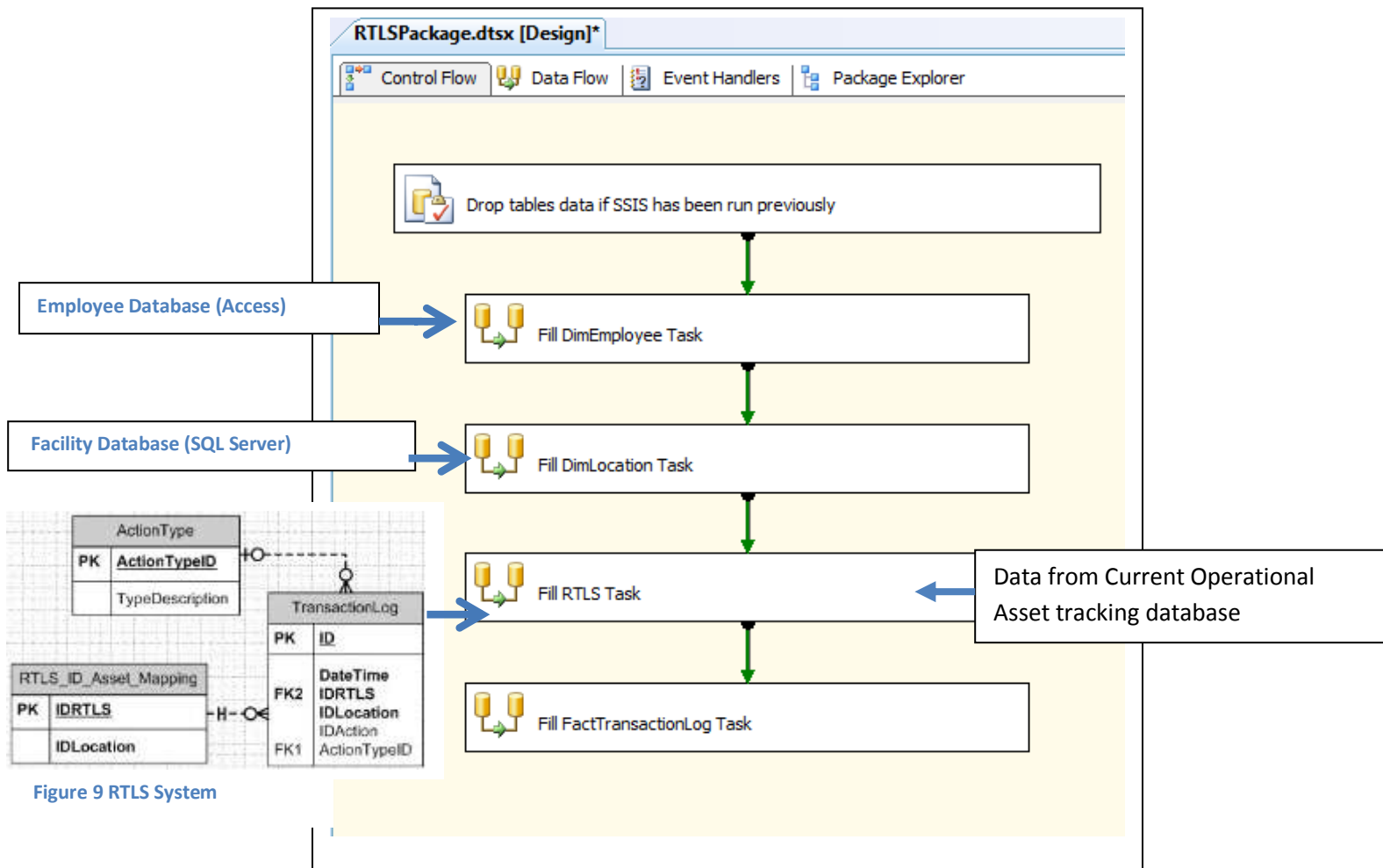


Figure 10 ETL package diagram for FactTrasactionLog

The transaction records will be generated as information comes from the RFID system in a separate package that provides dimension Table keys.

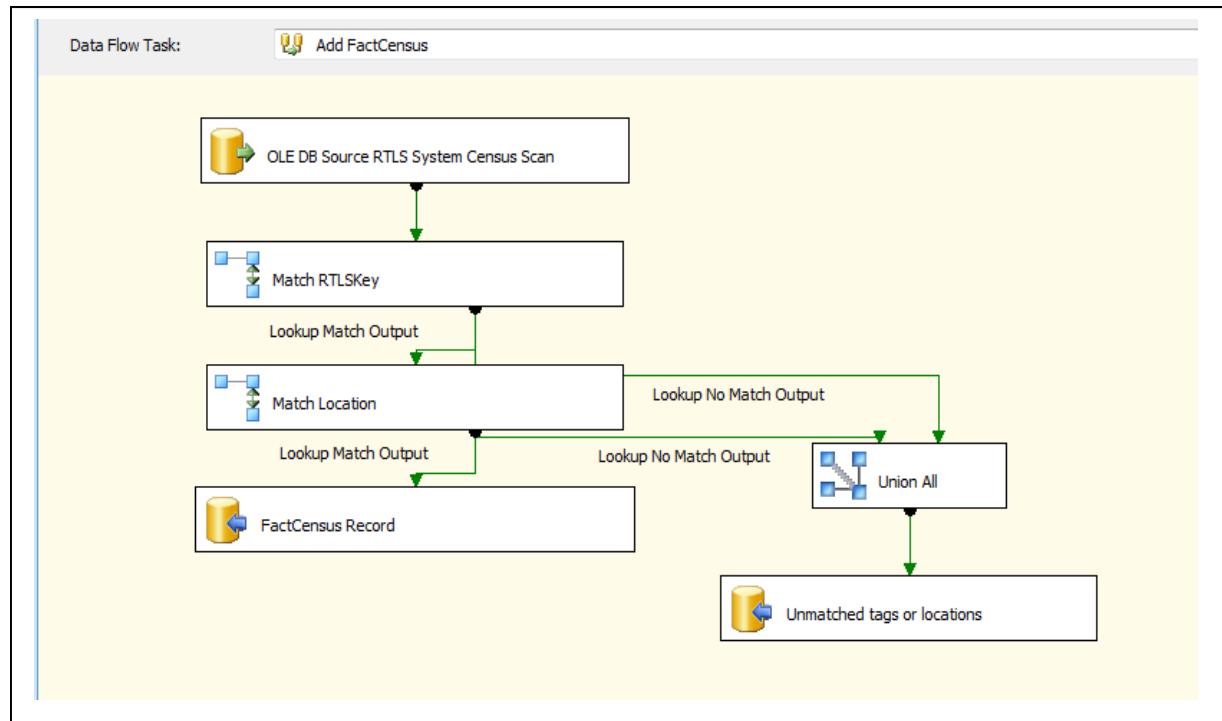


Figure 11 ETL Package for FactCensus

4.5 Analysis

The data warehouse architecture will provide the following analysis

- Trend analysis of equipment used within the organization
- Equipment available when needed
- Equipment loss will be minimized
- The manual time consuming asset search will be replaced with more efficient asset tracking system.

Reports generated

Type of Report	Report Name	Description
Inventory	Specific Assets By Area	Shows the current location of each asset, grouped by type.
	Assets near Maintenance Date	Shows the current location of each asset which will exceed its maintenance date soon.
Utilization	Missing Assets	Shows the last known location of all missing assets.
Alert History	Alert Summary by Alert	Shows how often each alert has occurred over a selected period of time.
	Unresolved Alerts	Shows the list of all alerts which have not been resolved over a selected time period.

Figure 12 Analytic Reports

For samples of these reports, please see appendix.

The data warehouse will provide a lot of improvements in the following areas:¹⁰

- Asset Management
- Patient Flow
- Patient & Staff Safety
- Equipment Maintenance

5 Conclusion

5.1 Summary Report RTLS

This report strongly supports the acquisition of RFID technology, specifically Awarepoint's RTLS system using Zigbee network technology. The initial project startup costs will be recovered in 4.5 months, and the base system can support many more tags, as the devices become less expensive.

The benefit to patient safety, decreased waiting and searching time is more difficult to quantify. There will be improvements in patient satisfaction encouraging them to choose the facility for all their medical needs.

Combining this system with a data warehouse and applying analytics will over time provide a tremendous amount of data that can be analyzed and mined for further information to improve efficiency, workflow, and patient safety, all while reducing losses and spending.

¹⁰ (Jackson, 2011)

5.2 RFID – BI Project Extensions

The main extension to the RTLS system would be integration with the EMR system. This would allow more complete data capture of the patient experience. If the BI system data is integrated with the EMR module we will be able to analyze why certain departments are doing better job of keeping assets.

Equipment tracking can be linked to patient use. This is valuable information in assessing, tracking, and billing for the patients' entire hospitalization. This information can be analyzed an information used to further improve processes.

Bracelets are available for health care personnel and patient tracking. Many hospitals have used these for tracking newborn infants. This subject brings up ethical issues of privacy with which hospital administrators will wrestle.

In the data warehouse, increasing the granularity of the date dimension to hourly, would allow more than one census scan daily, to predict the best times for maintenance.

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Appendix

A1 Technology

Sample Operational Database

Operational SQL server asset tracking database includes equipment cost, purchase date, maintenance schedules and history of equipment maintenance, updates, and system retirement. We designed our data warehouse simulating data that would have come from an EMR system or any other data source for the Medical Center that contained data for staff. Location data was extracted from the asset operational database. But may have come from whatever source the medical center uses to define location.

SQL Server 2008

Microsoft SQL Server is a relational database management system (RDBMS) produced by Microsoft. Its primary query language is Transact-SQL, an implementation of the ANSI/ISO standard Structured Query Language (SQL) used by both Microsoft and Sybase. SQL Server has been historically used by businesses for small- to medium-sized databases, but the past five years have seen greater adoption of the product for larger enterprise databases.

SQL Server Business Intelligence Studio

Business Intelligence Development Studio is Microsoft Visual Studio 2008 with additional project types that are specific to SQL Server business intelligence. Business Intelligence Development Studio is the primary environment that developers use to architect business solutions that include Analysis Services, Integration Services, and Reporting Services projects. Each project type supplies templates for creating the objects required for business intelligence solutions, and provides a variety of designers, tools, and wizards to work with the objects.

A2 Sample Reports from the RTLS Business intelligence Solution

Assets Alert Summary

Assets Alert Summary

RTLSNUMBER	Movement Date
WHEELCHAIR000001	06/01/11
WHEELCHAIR000001	06/02/11
WHEELCHAIR000002	06/02/11

Asset Locations

ASSETS LOCATIONS

ASSET	Date	LOCATION	BUILDING	FLOOR	UNIT	DEPARTMENT
WHEELCHAIR000002	06/02/11	401	1	4	1	RAD
WHEELCHAIR000002	06/05/11	402	1	4	2	RAD

Specific Assets by Area

ASSETS LOCATIONS

ASSET	Date	LOCATION	BUILDING	FLOOR	UNIT	DEPARTMENT
WHEELCHAIR000002	06/02/11	401	1	4	1	RAD
WHEELCHAIR000002	06/05/11	402	1	4	2	RAD