Mountain View Systems LLC

Case Study:

RFID Medical Equipment Monitoring System,

Emory University Hospital and Piedmont Hospital, Atlanta

by
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BACKGROUND OF THE STUDY

In early 2004 the author's consulting team (the "Team") began a collaboration with Emory Hospital in a program called the Emory RFID IV Pump Management Pilot. The Emory RFID Pilot was initiated as a cooperative effort between Emory University, Goizueta Business School, the Hospital, and the Team with the approval of Jimmy Hatcher, CFO, Emory Hospital. At a meeting with Facility Administrator Lee Partridge, Hospital Administrator David Pugh, and Director of Anesthesia Arnold Barros we discussed the possibility of achieving dramatic cost savings at Emory by tracking IV Pumps with passive RFID tags. That meeting led to the decision to conduct a pilot in the hospital. The Team volunteered the resources needed to design, build, install, and test the limited pilot system. The pilot's goal was to develop an RFID hospital equipment-tracking system that could provide substantially improved visibility resulting in measurable short- and long-term cost savings.

Although our original concept was innovative, our first model had features that we found unacceptable. For example, we were not satisfied with the intrusiveness and high cost of installing fixed RFID antennas at key nodes in the hospital. That would have required pulling long lengths of expensive plenum-grade coaxial cable in the ceilings, and the long cable lengths attenuated the system's RF performance. To solve those problems we engineered a small self-contained RFID reader module that uses wireless technology to communicate with our equipment-tracking database. The reader modules are easily positioned or repositioned, allowing low installation costs and flexible visibility. Yet, although that was an improvement, we were still not satisfied with the relatively high initial cost per module and the limitations of nodal visibility. However, we were able to achieve a ten-fold reduction in the number of modules by placing them in the elevators rather than at the elevator landings.

By mid-2004 we expanded the scope of the Emory initiative to tracking IVPs at Piedmont Hospital in collaboration with Facility Administrator Jeff Allen and Equipment Distribution Director Lawrence Baskett. Piedmont's IVP management process differed somewhat from Emory's. The Team was challenged to create an RFID-enabled process that paralleled Piedmont's current process. To meet that challenge we applied a proprietary innovation (that had been developed for a document archive warehouse in 2002). The resulting RFID system has application as an IVP management solution in most hospitals. Indeed, Emory's Arnold Barros is now in favor of applying the Piedmont system to his hospital, rather than what was proposed as the Emory solution (as described in this case study).

In summary, this case study addresses 1) current process problems, 2) a description of RFID system architectures and how they can be applied, 3) a description of a fiscally self-sustaining, enterprise-wide expansion of the pilot at Emory, and 4) a description of the "smart cart" solution developed for Piedmont.

Organizations such as hospitals, manufacturing plants, and professional offices use portable objects such as medical equipment, tools, and physical documents that are distributed within the organization's operating environment such as a building, factory, or office complex (i.e., a structural space). Originating from a central distribution point, the portable object is delivered to a specified location in the structural space. However, as a function of its use, the portable object may travel to various different locations in the structural space, for example to a different wing of a hospital. Once the user has completed using the portable object, that object becomes available for use elsewhere within the organization's facility. However, the uncertainty of the portable object's last location makes it difficult to retrieve for redistribution. The result is a high cost of managing the organization's inventory of portable objects. For example, it is time-consuming, labor-intensive, and inefficient to locate portable equipment by manually searching large buildings and structural spaces. Also, in order to meet time-critical demand extra objects may need to be rented from outside suppliers, further increasing cost. Thus, a need exists for an effective system for tracking portable objects within a structural space at low cost.

Durable equipment in a hospital, IV equipment in particular, is notoriously difficult to manage. IV pumps (IVPs) move about through a milieu that constantly challenges efforts to predict their patterns of usage. IVPs are vital--patient requirements demand immediate availability. Therefore a retrieval system that delays delivery of an IVP when needed stresses the patient care environment. Current processes for the recovery and redistribution of IVP's have the following chronic limitations.

- IVP shortages occur.
- Rental IVPs to fill the gap are expensive. Hospitals we've talked to spend six figures in IVP rentals annually.
- It's typical for hospitals to hire full-time employees whose sole duty is to roam the facility looking for IVPs.
- National studies estimate that, on average, each staff Nurse spends more than an hour per day looking for equipment or waiting for equipment.
- JCAHO initiatives are difficult to comply with under the present system. Meeting National Patient Safety Goals regarding Periodic Maintenance (PM) of hospital equipment is particularly problematic.

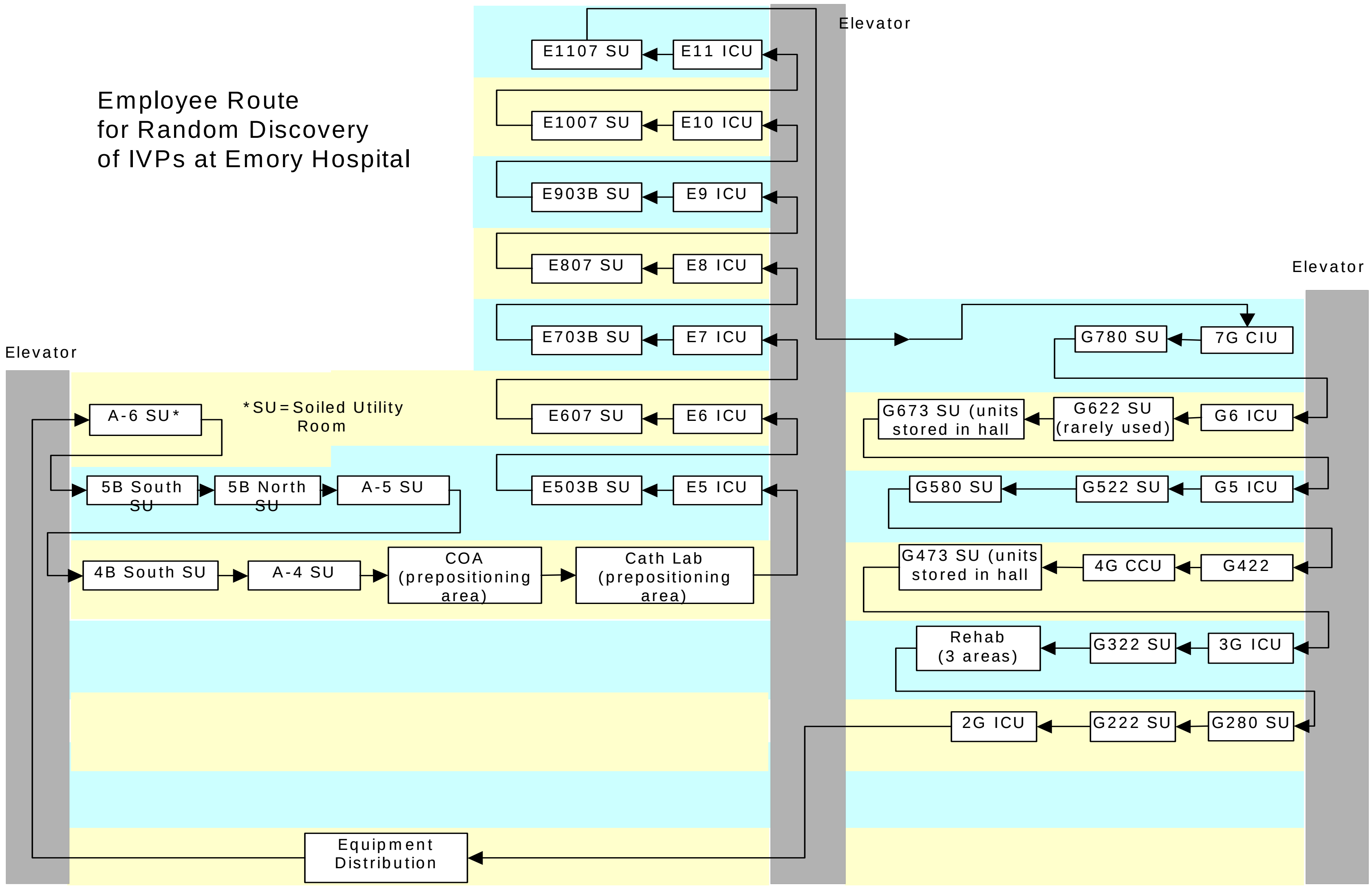
During 2004 and 2005 we researched in detail current methods of equipment management at Emory and Piedmont Hospitals. At Emory the retrieval and distribution process can be described as two basic scenarios.

1. Assuming that there are units charged and ready-to-go in the Equipment Distribution (ED) area, the employee consults the computer for [customer] requests, prints a barcode label for that request, and delivers the labeled pump directly to the customer.

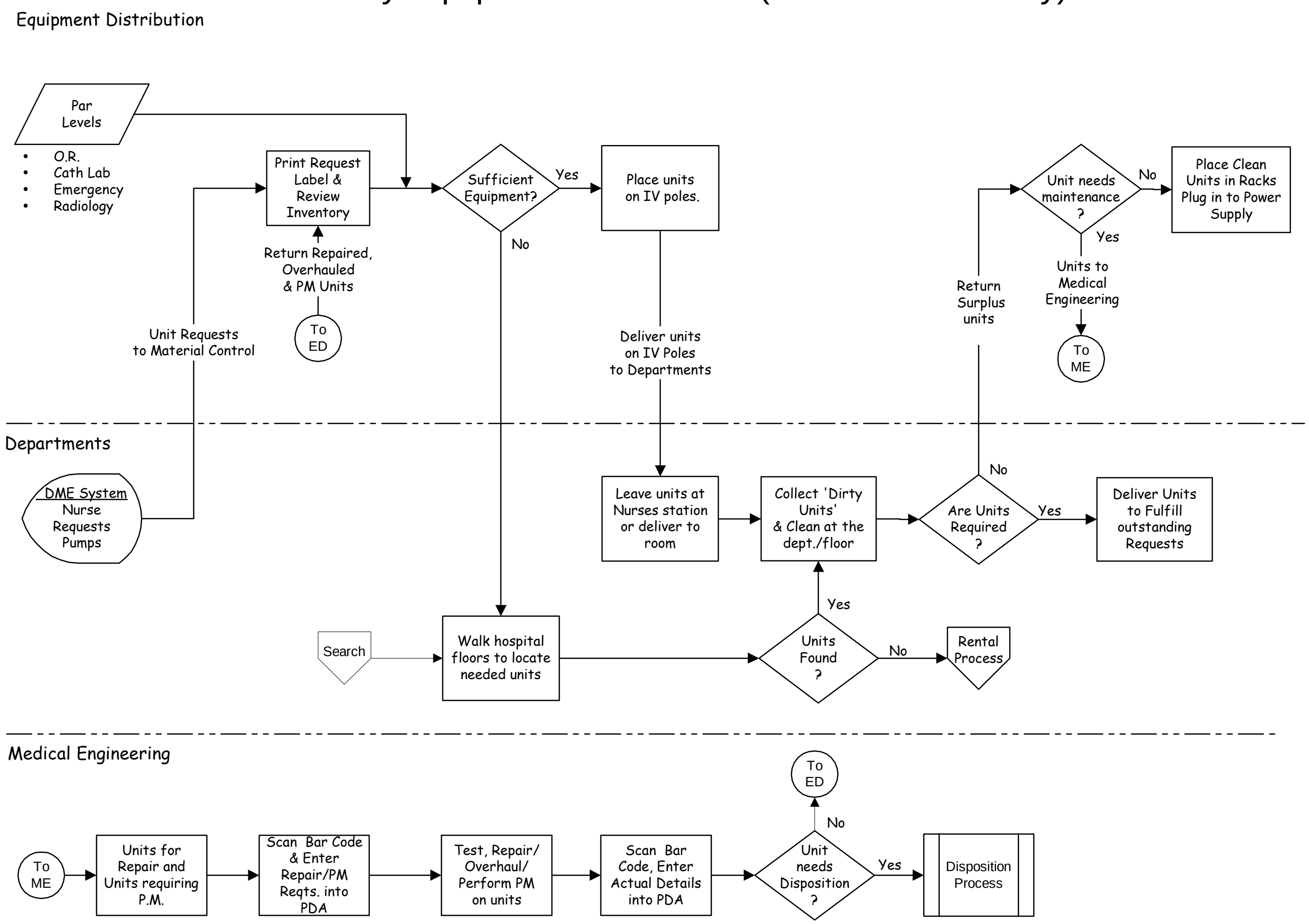
2. If there are no available units in ED, the employee responds to a request by printing out the request label and beginning a search of the hospital for a usable unit.

In either of the above cases, during the process of meeting customer demand for units, the employee collects units (i.e., "random discovery") that can either be cleaned and redistributed to customers, or returned to ED for recharging. The employee's route for collecting pumps is diagrammed on page 6, starting from ED. The process flow for the "random discovery" method of equipment management is shown on page 7. The goal is to transform that process from "random discovery" to "targeted visibility."

Employee Route for Random Discovery of IVPs at Emory Hospital



Emory Equipment Distribution (Random Discovery)



1) Transform the current "random discovery" of units into "targeted visibility" of units.

2) Immediate visibility of equipment usage patterns. Employees engaged in unit redistribution will know where usable units are located, reducing recovery time.

3) Identification of units that will require recharging. Units distributed from the ED recharge area will be automatically time-stamped. The time-stamp provides the ability to estimate when a unit will require recharging. The benefit is that employees will not waste time recovering spent units attempting to satisfy immediate demand requests.

4) Develop a historical database of unit activity that will provide the ability to further streamline process efficiency. Process visibility is the key to improving management of physical and human resources.

5) Reduction of the number of rental units required. A clearer picture of usage patterns will provide new opportunities for resource leveling. Surplus rental units can be recovered and returned quickly, reducing accumulating rental charges.

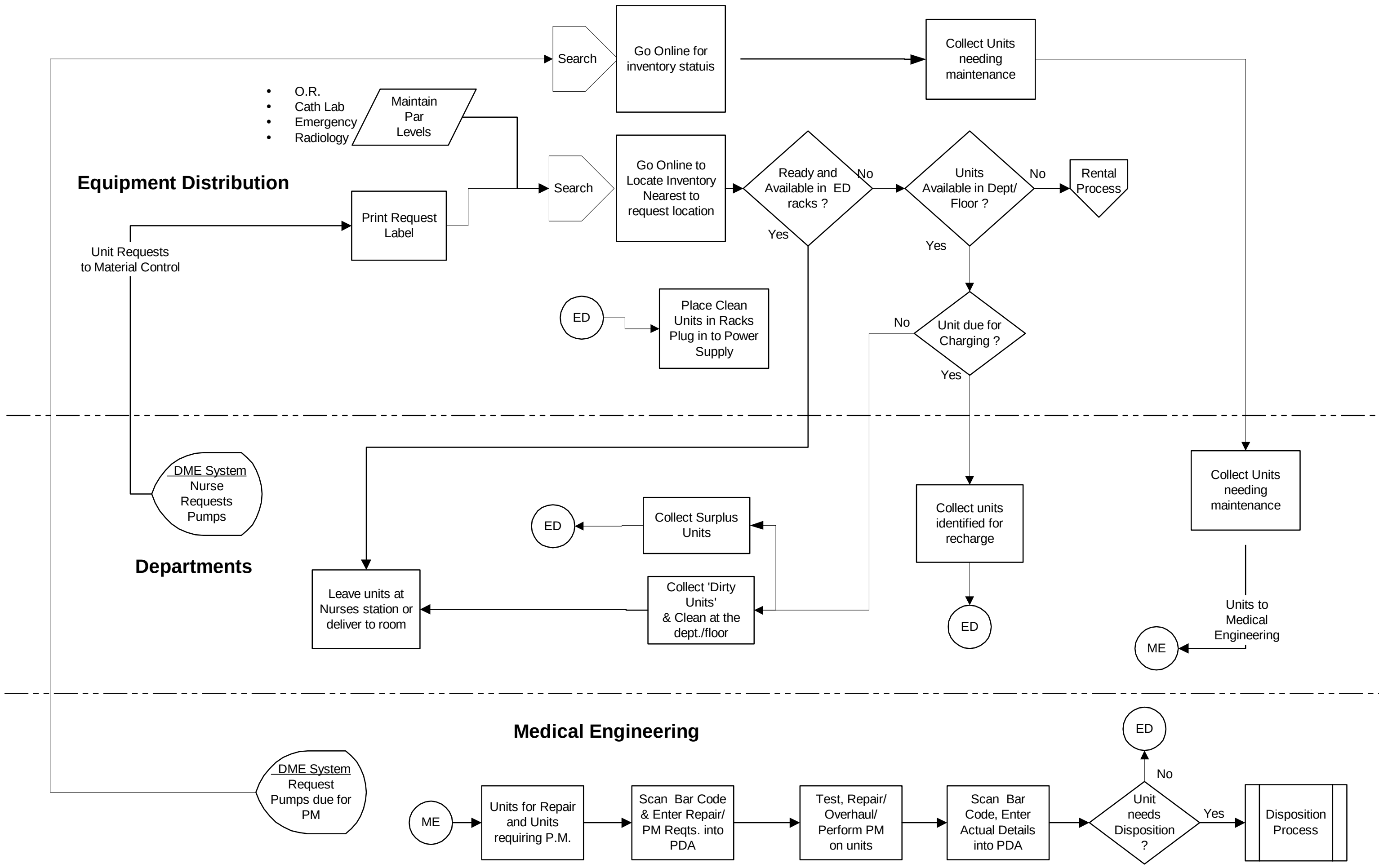
6) Location of units requiring periodic maintenance. The maintenance department is typically six months behind because of the inability to locate scheduled units. Improving the pass-through of that activity will result in fewer JACHO audit citations.

7) More productive use of employee time. Personnel engaged in unit management also serve as anesthesiologists and lab technicians. Streamlining the unit management task shifts human resources to billable patient care activities.

8) The system prepares Emory Hospital for the introduction of RFID-enabled products into the medical supply chain. The system operates in the UHF frequency band and uses the encoding structure adopted by the FDA in cooperation with the EPC and UCC standards boards. In addition to tracking medical equipment Emory will, by adopting those standards, have a virtually seamless transition to tracking medical supply distribution in the hospital.

The proposed system is capable of establishing the relative location of *any item* in the hospital that is tagged with a passive radio frequency tag. IVPs were chosen because they are the priority short-term need and because the cost savings relating to IVP management alone will pay for the cost of installing the proposed RFID management system.

Emory Equipment Distribution (Targeted Visibility)

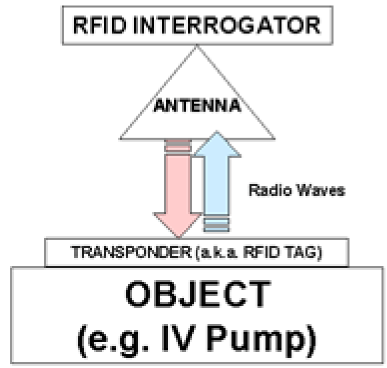


GENERAL SYSTEM CONCEPTS

The basic building block of an RFID data acquisition system consists of an RFID Interrogator (a.k.a. Reader) connected with coaxial cable to an antenna that communicates with passive (un-powered) transponders, a.k.a. RFID tags. The tags will be applied to selected IVPs.

The RFID Readers can be operated as either TCP/IP or RS-232 devices. At least initially, the Readers will be networked as RS-232 devices using hospital-approved RF data modems, but the Readers can be integrated into the hospital's 802.11g wireless network with little modification and at low cost.

As an IVP passes through the field of view of a local reader's RF interrogation signal source (the antenna), the tag responds with a unique digital code. Tag data acquired in this manner are saved, time-stamped, and transmitted to a secure central relational database where they are processed to determine the IVP's current location, history, and other characteristics.

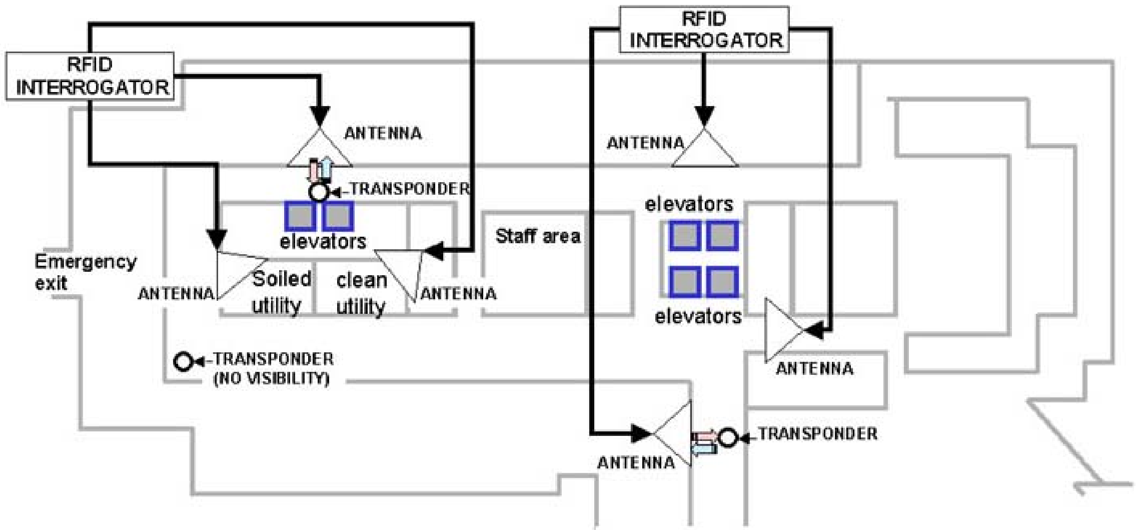


There are various methods for managing the location of portable objects within a structural space using RFID technology:

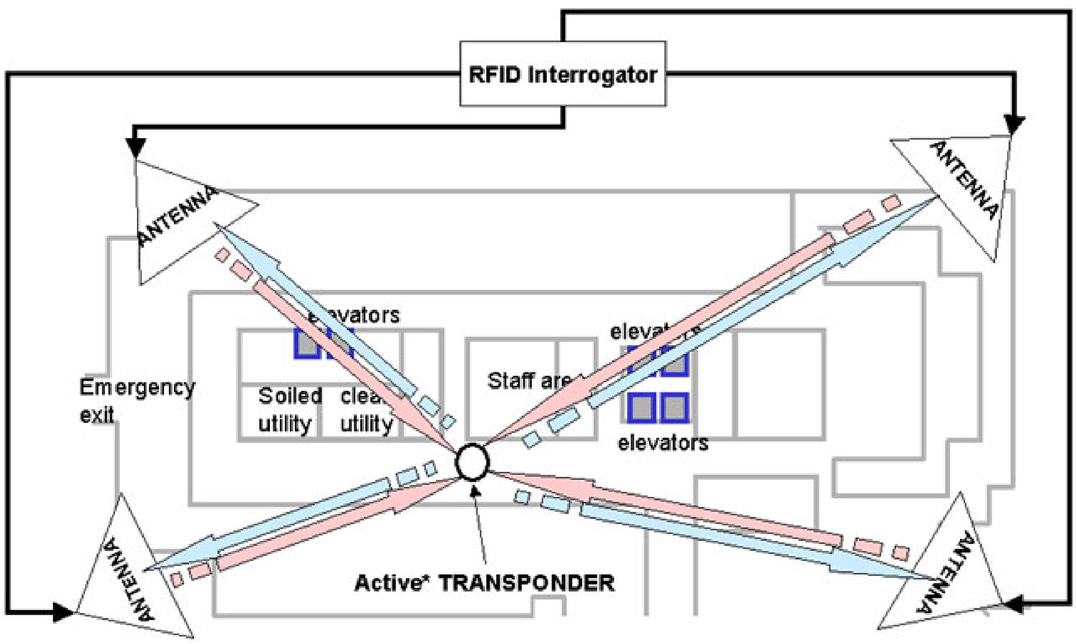
- Portal Method
- Triangulation Method
- Smart Space Method

The portal method creates a grid of many RFID Interrogators and antennae by positioning them in fixed locations within the structural space. Tagged objects that pass within the range of a fixed Interrogator are identified and time-stamped as having been seen at that location. This option is impractical because of the high cost of individual RFID interrogators and Antennae and the cost of installing coaxial cabling to the antennae in a large structural space. Furthermore, increasing positional accuracy requires the addition of more expensive RFID interrogators and cabling.

The Triangulation Method is to fit RFID Interrogators with at least two directional antennae that are positioned on the outer boundaries of the structural space. Portable objects fitted with Active (i.e., battery powered) RFID Transponders are then detected and located within the structural space using RF triangulation techniques. In order for the RF to penetrate obstructions such as walls and structural elements, the RF is preferably in the approximate range of 300MHz to 500MHz. However, current RFID industry standards in development for supply chain and asset management applications identify the 902MHz to 928MHz band as ideal. Although the Active Transponders have a longer RF detection range, they are not as small and inconspicuous as passive transponders, are more expensive, and require maintenance.



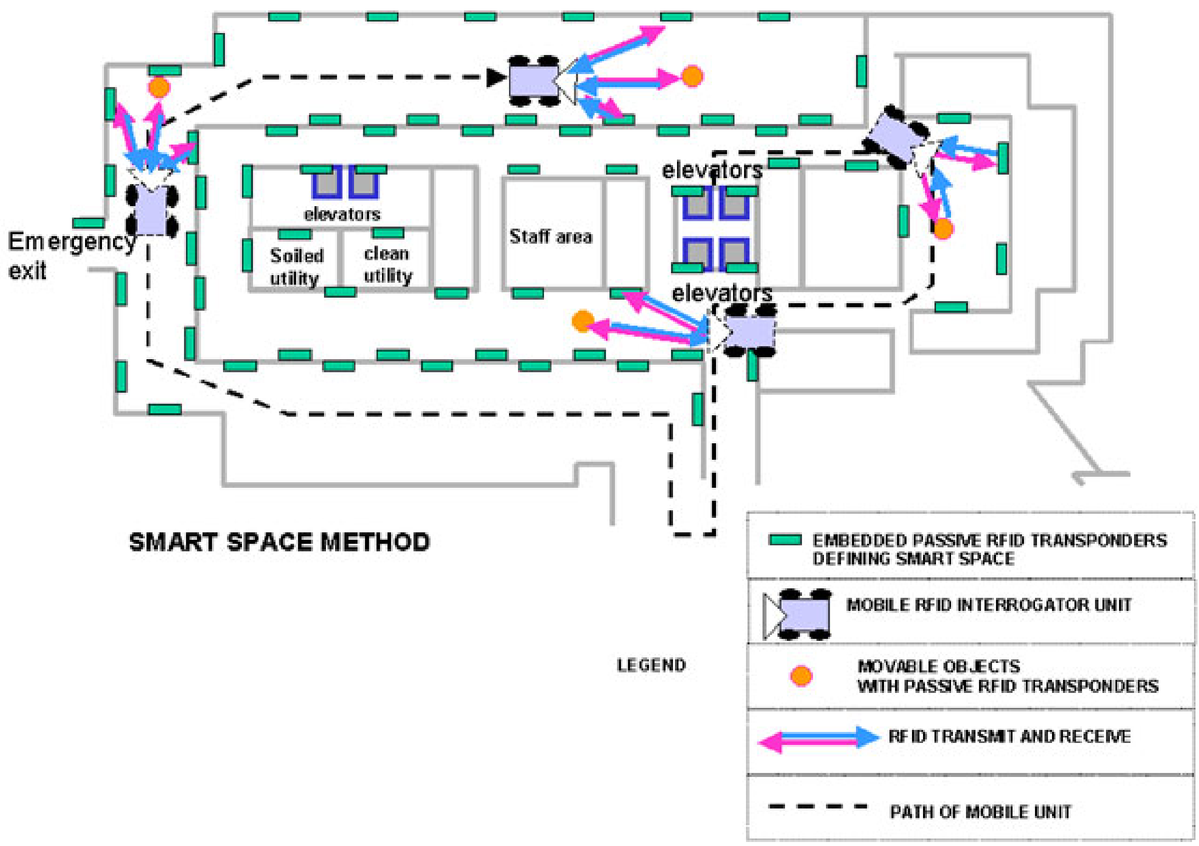
PORTAL METHOD



TRIANGULATION METHOD

*Active = Battery Powered

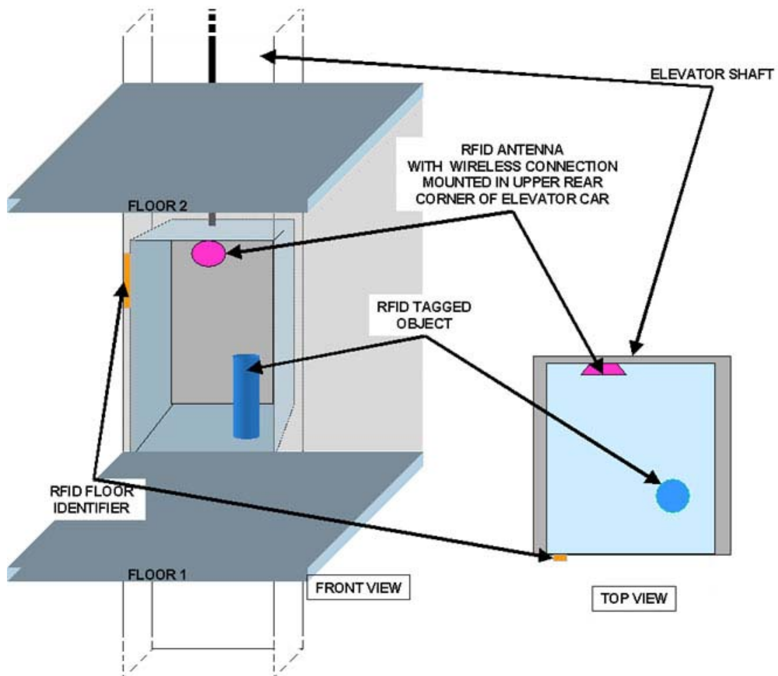
The so-called 'smart space' system architecture is an inversion of the Portal Method. Rather than populating the hospital with scores of [expensive] fixed RFID reader locations to detect IVPs, the smart space concept relies on a few mobile RFID Readers to detect locations marked with passive tags. While the RFID Interrogator-equipped cart is propelled within the structural environment, it uses passive transponder technology to detect the presence of tagged objects and tagged fixed locations, and makes a time-stamped correlation of objects with spatial locations. An integrated microprocessor performs the requisite algorithms needed to process the reply from one or more RFID tags, correlates the data and transmits the data, via a wireless RF modem mounted to the cart, to a central modem for storage and processing.



Rechargeable dry cell or gel batteries power the vehicle's electronics for up to 24 hours, and the vehicle is equipped with an onboard battery charger that can be plugged into a standard AC power socket. The electronics are mounted in the cart and are protected from environmental hazards such as pressure washing.

The mobile RFID Reader cart is a patent pending innovation created by Mountain View Systems that is part of the MVS Pinnacle system architecture (see Appendix B). Piedmont Hospital uses carts to deliver and recover IVPs, and Pinnacle was specifically developed for the IVP distribution process at Piedmont, where it was successfully tested. Since Emory Hospital does not use carts for distribution and pickup of IVPs, the Pinnacle system is not a good fit to the Emory IVP management process.

A variation on the mobile RFID Interrogator concept is to equip the hospital's elevator cars with RFID Readers. The Reader detects any IVPs in the elevator. When the elevator doors open, the Reader also detects a passive tag identifying the floor level. Logically, any IVPs no longer on the elevator when the doors close got off at the last floor level detected. The advantage of that method is that with only a few readers, IVPs can be tracked to the floor level and wing of the hospital.



MVS has successfully tested this concept in elevators. The elevator system hardware is virtually identical to our forklift-mounted system currently in operation at Atlanta Data Storage in Norcross, GA (Appendix C).

SPECIFIC SYSTEM PROPOSAL FOR EMORY

The selected hardware for the Emory system is based on a flexible system architecture that is congruent with Emory's IVP management process, and that is scalable to the larger goal of capturing supply chain management data in anticipation of emerging RFID controls in the pharmaceutical and medical supplies industries.

The overall structure is a system of distributed autonomous RFID interrogators readers linked to a central data collection point by wireless data modems.

The readers can operate as many as four nearby antennas.

The user interface is Internet-based, secured to e-commerce standards, and non-intrusive to hospital information systems. In the hospital, only AC power and a single channel of outgoing Internet connectivity will be required. The RFID system in the hospital will send data outbound only -- *there will be no incoming network access requests and thus few security issues.* No dedicated hospital computer equipment need be involved in the system other than web browsers used to access the Internet web interface.

To accomplish the objectives of streamlining the IVP management process, we determined that an elevator-mounted RFID system would be best suited to achieving Emory Hospital's IVP management objectives. We proposed to equip 15 elevators with RFID Interrogator modules, and 1 RFID Interrogator module to be positioned in the ground floor equipment distribution area. Each module consists of a NEMA4-rated equipment enclosure containing the following items:

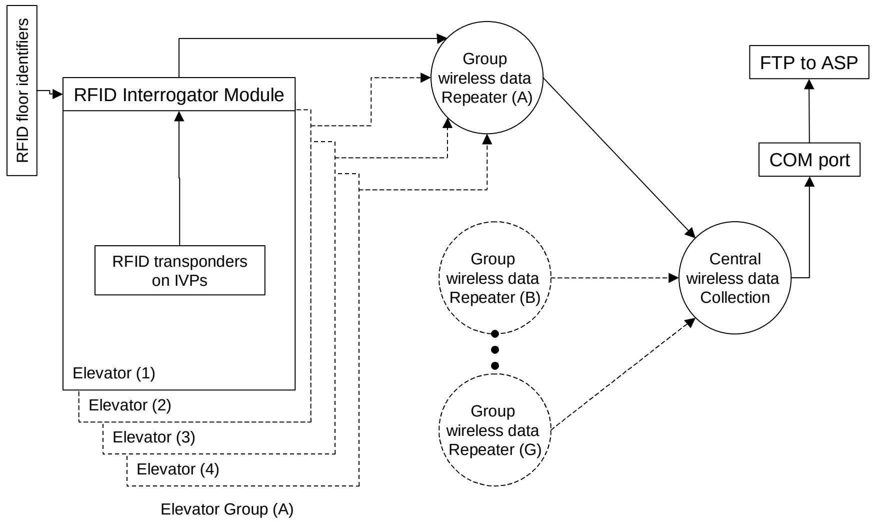
One 915MHz, 4-port RFID Reader unit

One 900MHz wireless data modem assembly

One AC to DC power converter

Each Interrogator Module installed in an elevator connects to 2 flat panel antennas mounted inside the elevator car to detect IVPs, and 1 smaller flat panel antenna positioned to read RFID transponders located to identify each floor location. Connections between the Interrogator Module and the antennas are made using FCC-approved RF connectors and hospital-approved plenum-grade coaxial cable.

A wireless data modem repeater module is installed near each group of elevators (A-G). Each wireless repeater routes data from its elevator group to the central wireless data modem. A total of six (6) wireless repeater modules accommodate the Emory system.



The Interrogator Module in the Equipment Distribution (ED) department connects to 4 flat panel antennas to monitor the IVP recharging area and the ED entry/exit portal. The ED Module is designated as the central data collection point for the 6 elevator group modems. The ED Module data modem receives data from the 6 elevator groups and uploads those data via an RS232 COM link on a dedicated embedded router (or on a standard PC). The router FTPs the data to a secure ASP server, where it is processed and displayed to authorized users.

STANDARDS BASED ARCHITECTURES

The described RFID system design is based entirely on open standards architecture (incorporating EPC Gen2) and is not dependent on a sole vendor for continued viability and expansion. The cost and complexity of expanding, supporting, and utilizing data from the system will therefore be competitive.

NETWORK COMPATIBILITY

Both the Piedmont and Emory RFID pilot systems consist of computer peripherals connected on a network that isolated from the hospitals' IT Departments. The system's sole IT requirement is a TCP/IP port to handle the outgoing data stream. Going forward, no significant bandwidth consumption is anticipated or necessary. Appendix A contains a network impact review for Emory Hospital's IT Department.

APPLICABLE SECURITY STANDARDS USED

Security standards include 128-bit encryption, PKI (Public Key Infrastructure) https, SSL (Secure Sockets Layer) Certificates from VeriSign (or equivalent certificate authority), and user level authentication that ensures a level of security appropriate for the most stringent requirements.

HIPAA COMPLIANCE

In the design of the pilot it was determined that the information collected by the RFID system and transferred to the ASP is by its nature not subject to HIPAA rule. No patient data are transferred. Nor is any of the data gathered meaningful to any third party. The data consist of randomly chosen serialized identifiers, time and date stamping, and random location identifiers, all sent to a completely secured server. The data mean nothing in and of themselves, but only relative to a secure back-end database that contains the actual information regarding the item to be identified, its location, and its history. Nonetheless, our requirement is to meet or exceed any applicable HIPAA standards.

RADIO FREQUENCY & SPECTRUM ANALYSIS

A radio frequency spectrum analysis of the pilot sites ensured that there was no interference with hospital systems. All RF emitters are compliant with FCC standards. The wireless data modems used are approved for hospital applications. RFID Tags on equipment are passive; that is, they are not independent sources of electromagnetic frequency emission. Instead, the tags reflect (backscatter) a secondary RF signal only when they are within range (less than 6 meters) from an active RFID interrogator signal. Interrogators and wireless modems are frequency hopping on a spread-spectrum and are limited to 1 watt of output power, conforming to FCC Title 45 Sections 15.245 and 15.247.

SYSTEM SCALABILITY

It is important to consider the future uses of any proposed RFID system. One of the big advantages of an RFID system that uses passive 915MHz transponders is that the FDA has mandated the use of 915MHz passive transponders to track pharmaceuticals and Gen2, 915MHz-band equipment is rapidly becoming the *de facto* RFID standard in all areas of supply chain management in the US. Installing an RFID system that uses active transponders in the 300-500MHz range to track IVPs will be useless in the emerging hospital product and asset management environment. We recommend that hospital administrators considering the adoption of RFID as a tracking system solution choose a vendor who will supply a 915MHz RFID system compatible with the FDA-mandated environment.

THE ELECTRONIC PRODUCT CODE (EPC) RFID TAG ENCODING STANDARD

Let's start with a basic understanding of tag encoding. Each passive tag is pre-encoded at manufacture with a unique 96- or 128-bit binary value. Using 128-bit encoding allows for a possible $3.4x10^{38}$ unique identifiers, which probably exceeds the number of objects in the world. If the pre-encoded tag has *read-only memory* it is classed as a Gen1 tag. A Gen1 tag serves as a unique "license plate" for an object that can be associated with a database of the object's characteristics located in a centralized database. This has the advantage of simply using the unique number that is pre-encoded into a Gen1 tag as it comes from the manufacturer; i.e., the tag itself needs no further processing. However, a significant barrier to adoption of RFID as a supply chain management tool has been the lack of a common interoperability protocol. In other words, the Gen1 tags from one RFID equipment supplier could not communicate with RFID equipment from a different supplier. Another limitation is that the data stored in a Gen1 tag cannot be changed.

The ability to program information about a product (e.g., the producer, the date of manufacture, the quality inspector's name, the serial number…) on the tag itself is a significant advantage. In order to do that the tags must have *read-write memory* capability. Those are the Gen1+[1] and Gen2 class of tags. That has the advantage of decentralizing the data, making it possible for distributed understanding of an object's characteristics. However, that structure has a drawback in that the tag's memory must be programmable by the user, which adds an extra step in the initialization process.

Gen2 tags have still further advantages. They communicate using a common protocol, so that Gen2 tags from different RFID equipment manufacturers can be read regardless of the brand of Gen2 RFID interrogator. Another advantage is their ability to be repeatedly reprogrammed. This allows the tag to be updated with new data (e.g., time-stamp, location, maintenance record) at multiple stages in the supply chain or asset management environment. Gen2 tags have better read ranges and are capable of higher data transfer speed.

RFID gurus Sarma, Brock, and Ashton of MIT's Auto-ID Project foresaw a world where "all physical objects…[would] act as nodes in a networked physical world." For Gen2 tags they proposed an open architecture system that would be independent of the specific tag technology affixed or built into the object being tracked. Their vision has emerged as the Electronic Product Code (EPC) standard. Generally speaking, the EPC structure for data stored in the RFID tag is as follows:

8 bit header	Manufacturer code	Product code	Serial Number

The 8-bit header serves as a way of identifying the format of the sequence of bits that will follow in the EPC standard, which allows for a multiplicity of formats, making system coding more flexible. That is a critical innovation because it allows for the use of various independent standards of identification to be understood by users of other formats. Sarma, et al suggest an Object Name

[1] Gen1+ tags have limited programming characteristics, and are designated as "*write once, read many*" tags.

Service (ONS) organization for registering and tracking product names, similar to the Domain Name Service (DNS) that registers web-site names.

In keeping with the general format of the EPC standard, the hospital system as designed to operate using the following coding formats.

PROPOSED OBJECT TAG FORMAT

8 BITS	16 BITS	16 BITS	24 BITS
BITS 0-7 (HEX) 80=OBJECT	BITS 8-23 Manufacturer code	BITS 24-39 Product code	BITS 40-63 Serial Number

PROPOSED LOCATION TAG FORMAT

8 BITS	16 BITS	4 BITS	16 BITS	12 BITS	4 BITS	4 BITS
BITS 0-7 (HEX) 00=LOCATION	BITS 8-23 (ASCII HEX) FACILITY	BITS 24-27 (BINARY) FLOOR NUMBER	BITS 28-43 (ASCII HEX) DEPARTMENT	BITS 44-55 (BINARY) ROOM NUMBER	BITS 56-59 TAG POSITION*	BITS 60-63 NOT USED

EXAMPLE (CONVERTED TO HEX) : 0050 4844 F522 7800

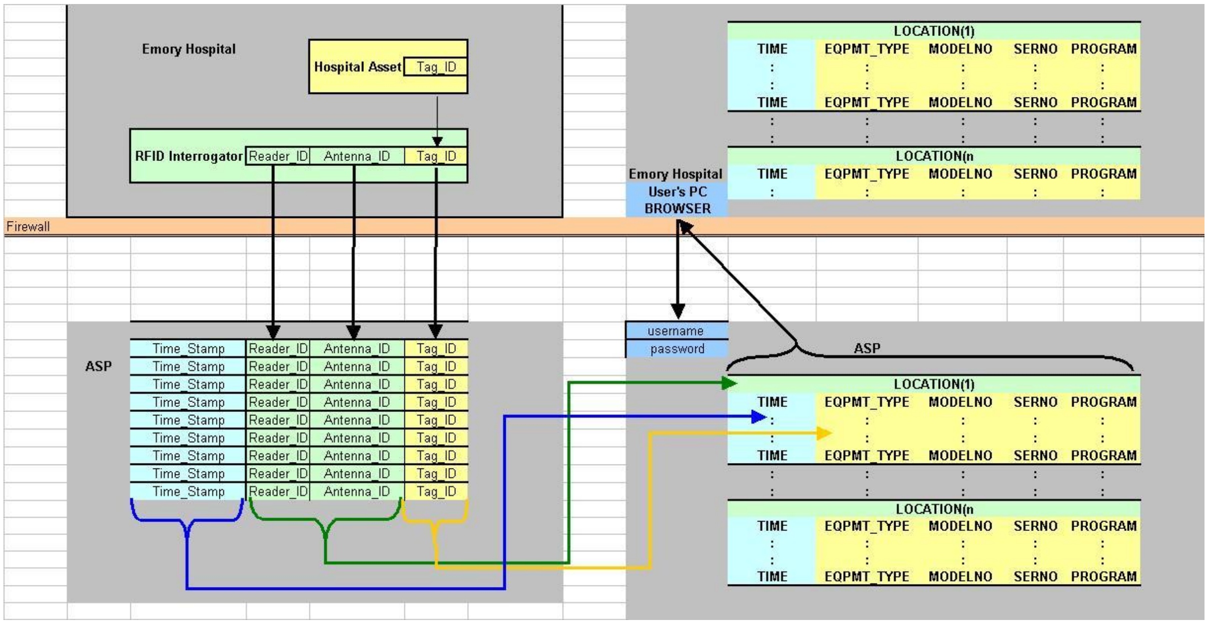
00 LOCATION	5048 PH (PIEDMONT HOSPITAL)	4 4th FLOOR	4F52 OR (OPERATING ROOM)	278 ROOM 632	0 (TAG ON CEILING)	0 N/A

*TAG POSITIONS:

- 0=CEILING
- 1=NORTH OR EAST WALL
- 2=SOUTH OR WEST WALL

APPLICATION SERVICE

Completing the IVP tracking system is proprietary ASP software that processes, updates, and displays the RFID equipment database. Because database is Internet-hosted on a secure server, authorized users can gain instantaneous access to the latest equipment status updates and statistics from any Internet browser. Value-added benchmarking across the customer's secure website, or across multiple customers' sites, offers powerful tools for process improvement and early warning of unplanned movement of assets. This unique system design enables broad system functionality from the outset with minimal capital investment, positioning the client for expansion and adoption of the system by the whole institution.


Emory Hospital
Hospital Asset
Tag_ID
RFID Interrogator
Reader_ID
Antenna_ID
Firewall
ASP
Time_Stamp
Emory Hospital
User's PC
BROWSER
username
password
LOCATION(1)
TIME
EQPMT_TYPE
MODELNO
SERNO
PROGRAM
LOCATION(n


Hospital Asset Tracking
File Edit View Go Bookmarks Tools Help
http://www.e-2-v.com
MOUNTAIN VIEW SYSTEMS
RFID TECH
Hospital Asset Tracking System
Main Menu
Home
Login
Username:
Password:
User Login
Lost Password?
WELCOME...
Welcome to Mountain View Systems' Hospital Asset Tracking System. With the help of RFID Technology we are able to track hospital assets throughout your environment. We offer a simple and secure interface via the web to monitor and update this information.
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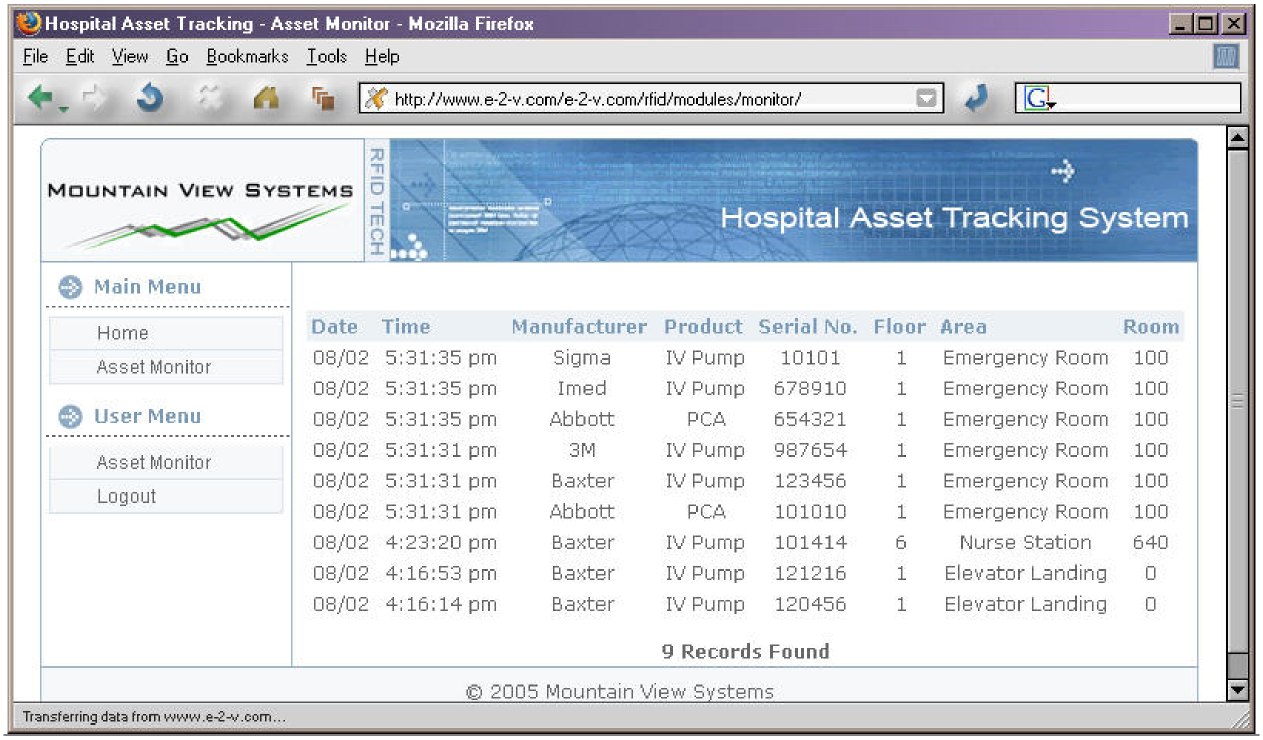
http://www.e-2-v.com/rfid/



COST PROJECTION FOR EMORY SYSTEM

System Level Pricing	Unit Price	Qty	Total
Central Interrogator Module	5,371.00	**1**	5,371.00
Elevator Interrogator Module	5,298.00	15	79,470.00
Wireless Data Repeater Units	948.00	6	5,688.00
Floor Level RF Identification Tags, pre-programmed	2.69	60	161.40
IVP RF Identification Tags, pre-programmed	1.15	500	575.00
Installation (160 hours)	115.00	160	18,400.00
Total Hardware cost			109,665.40
Unit Per month ASP Tracking (est. 600 units)	1.00	600	600.00

The proposed IVP tracking system will achieve the goals enumerated in the OBJECTIVES section of this proposal. By far the pivotal benefit will be the shift from "random discovery" of units into "targeted visibility" of units.

- The system is an inexpensive, practical system that can be deployed quickly, is easy to use, and is scalable to future needs.
- Emory staff in clinical, maintenance, medical engineering, and financial areas will benefit from instant position information, usage analysis, etc.
- Analysis tools from the project will ensure that expansions are directly related to specific needs and to definable financial savings or gains.

Data obtained from EUH in 2004 provides a baseline for estimating the value of the proposed RFID system. EUH owns about 600 IVPs for which MVS has a complete data set. Although there are more items in the mix of items to be tracked, focusing on these 600 IVPs will provide a conservative baseline for evaluating the financial impact of the tracking system.

Hospital DME List Anesthesia and Pumps	Units per yr.	Cost per unit	% Missing	Annual Unit Loss
(Per Arnold Barros)				
Single Channel Pumps	400	$ 4,000	15-20%	3-4/yr
Triple Channel Pumps	200	$ 6,500	15-20%	3-4/yr

The data also tell us that EUH rents 20-25 IVPs per year to cover for units missing (temporarily invisible) or lost (non-recoverable). IVP rental costs are given as $1000 per month. Keeping with a conservative interpretation of cost/benefit, assume 15% Missing and six IVPs unrecoverable per year. Assuming a 5-year straight-line depreciation of those assets, the 15% Missing represent a loss of use of those items of …

Single Channel Pumps: (400 x $4000 x .15) /5 = $48,000
Triple Channel Pumps: (200 x $6500 x .15) /5 = $39,000

Add the replacement cost of the 6 non-recoverable units…

Single Channel Pumps: (3 x $4000) = $12,000
Triple Channel Pumps: (3 x $6500) = $19,500

And…

IVP Rental costs: (12 months x $1000 = $12,000

Therefore the asset loss impact traceable to the current "random discovery" method of IVP management is about $130,500 annually.

Now consider the value of the MVS RFID system. Assume that the RFID "targeted visibility" method results in a modest 25% improvement in asset recovery and redistribution costs, an annual savings of $32,625. Applying the same 5-year depreciation to the RFID system cost of $109,665 returns an annual RFID cost of $21,933. Add the annual ASP subscription cost of ($600 x 12 months=) $7200 for a total of $29,133 per year, resulting in a net annual savings of $3492 *after the cost of the RFID system is deducted.* However, a 25% reduction in asset costs is a worst-case scenario. A 50% improvement is to be expected. To summarize…

Percentage of improvement	25%	50%	75%
Savings	$ 32,625	$ 65,250	$ 97,875
RFID system cost	$ (29,133)	$ (29,133)	$ (29,133)
Net annual savings	$ 3,492	$ 36,117	$ 68,742

After the RFID system is fully depreciated in 5 years, and assuming no growth in the number of items being tracked,[2] annual system cost drops to $7200.

Percentage of improvement	25%	50%	75%
Savings	$ 32,625	$ 65,250	$ 97,875
RFID system cost	$ (7,200)	$ (7,200)	$ (7,200)
Net annual savings	$ 25,425	$ 58,050	$ 90,675

The above cost analysis does not take into consideration several additional factors, difficult to quantify, that are nonetheless significant contributors to the bottom line. Among those factors are…

- Reducing the Float of High Value Equipment
- Minimizing Rentals
- Fewer Equipment Purchases
- Increasing Nursing Staff Patient Care Time, Productivity improvement of equipment distribution employees, Higher Retention of Staff (estimated savings of $300k/Annually)
- On-time scheduled maintenance and certification of medical equipment
- Lowering costs associated with JHACO audits

Furthermore, MVS predicts that new visibility of IVP usage patterns will result in identifying available process efficiencies that are currently hidden from view.

[2] Note that tracking more equipment units will reduce the per-unit system cost and increase potential asset savings. Calculating with an asset population of only 600 units minimizes the potential savings, resulting in a very modest projection.

GLOSSARY OF TERMS

Term	***Definition***
RF	Radio Frequency; a tuned, oscillating field of electromagnetic radiation generated for the purpose of communicating information.
RFID	Radio Frequency Identification; a method of acquiring data over a modulated electromagnetic field carrier wave, tuned to a specified band of frequencies, by imparting a reflection of the source field radiation back to the transmitter in sequences that are interpreted as information in the form of digital data.
Interrogator	An electronic instrument that generates modulated radio frequencies for transmitting and receiving RFID data.
RFID transponder	(Also called RFID tag, transponder tag, tag) A miniaturized electrical assembly comprising an integrated circuit (IC) chip mated to a small antenna, the purpose of which is to communicate digital data stored in the IC chip to an RFID Interrogator.
Active	In the context of RFID, a transponder that is powered by a small battery.
Passive	In the context of RFID, a transponder powered by energy drawn from the RF carrier wave transmitted by the interrogator.
Tagged	Having attached an RFID transponder to an object or location.
Structural space	A two-dimensional area or three-dimensional volume having fixed boundaries defined by fences, walls, ceilings, floors, floor plans, rooms, entry and exit points, pathways, cubicles, grids, pillars, or other physical, structural elements. Examples include, but are not limited to, hospitals, multi-story buildings, factories, campuses, habitable areas, warehouses, office complexes, etc.
Time-stamp	A relative record of the current real time that a tag is detected; stored with the tag identifier in a database. Format: year, month, day, hour, minute, second, sub-second.
Reader	An RFID Interrogator

A P P E N D I X   A ,

TECHNICAL VENDOR QUESTIONNAIRE

IS Technical Team Review
Vendor Questions

Please provide a brief overview of the application's functionality and primary purpose. The purpose of the system is to track the movement of IV pumps as they move between monitored locations. Monitoring is done using RFID technology. IV Pumps are "tagged" with passive RFID transponders. Antennas at defined locations interrogate the tags when they become visible within a range of approximately 15 feet. The unique number stored in its RFID tag memory identifies the IV pump. That number is correlated with the antenna location and the time of recognition.

Please provide a Data Flow diagram.

Please provide an Access Authentication diagram.

Please provide a System Configuration diagram.

Please answer the following questions. Indicate those not applicable with N/A.

Security

Application Security

1. Does this application capture or store any information that uniquely identifies a patient, physician or employee at Emory Healthcare? NO, the application captures only the movement of medical equipment in the hospital.
2. Does the authentication security come from the application or the Security Access Manager or both? N/A
3. Who controls access? Access is restricted to the firmware that operates the RFID antennas.
4. Is security administration performed remotely or at the application/system? How is remote administration secured?
5. Does application require a unique user ID and password to access data? Yes
6. What are the criteria for the ID? Users are authorized by Arnold Barros
7. What are the criteria for the password? Users are authorized by Arnold Barros
8. Does application require users to change passwords at regular intervals? The application does not require that, but it is recommended. If desirable, MVS can add that functionality to the application.
9. Does application have an auto logoff/timeout feature? Not at this time, but MVS can easily add that feature if so desired.
10. Is the application capable of using Single-Sign-On (SSO)? If so, what products? N/A
11. Is the application capable of using Public Key infrastructure (PKI)? If so, what products? N/A
12. Can the authentication process be integrated with standard directory services (Novell, NT, LDAP)? The application can be accessed from any web browser. Authentication is accomplished at the application server.
13. Explain how each of these security controls are performed in the application:
    a. Auditing – What is audited?. How is auditing configured? N/A
    b. Authentications – What methods are used? Username and password. Can a third-party device be used? Yes, the application can be accessed from any web browser.
    c. Access Control – Is it based on roles? Is there any back-door access?
       There are three roles set. One is for a monitor group. This group will only have access to the asset monitor section of the application. There is a database administrator group responsible for adding new equipment into the database. There is finally an application administrator group responsible for changing settings within the application itself.

   d. Integrity – Is there message queuing, rollback and data integrity checks?
      Data integrity is checked via PERL script. Data is deemed healthy once it's inserted into the database.
   e. Intrusion detection/alarms – What alarms are setup? Are they real time?
      There is real time protection from the following attacks:
      - DoS
      - SQL Injection
      - XSS
      - System global variable pollution

14. What remote support models are supported by your company (Firewall to firewall VPN, modem, RAS)? N/A

15. What is the access authentication process for the application? Username / Password

16. What security controls are in place to ensure that the application code was not accidentally or maliciously modified?
    Files are hosted on a UNIX-based platform and are chmod to secure configuration.
    There is real time protection from the following attacks:
    - DoS
    - SQL Injection
    - XSS
    - System global variable pollution

17. Is the application HIPAA compliant? Yes

18. Is the application capable of using IP v6 when introduced? Communication does not use the 802.11(b/g) standard. Communication is via an RS232 air link at 115200 baud on a pulse modulated 900MHz carrier.

19. What type of code is in the application/system (examples include C, Pascal, HTML, XML, Java, JavaScript, ActiveX, CGI, Perl)? Have specific security weaknesses in the code been considered? Application is coded in VBScript, XML, PERL, and PHP. No security weaknesses have been identified in the code.

Wireless Security

20. Can Wired Equivalent Privacy or WEP 128-bit be turned on for encrypting data? Yes, the air link is WEP 128-bit encrypted.

21. Can the default SNMP community strings be changed? N/A

22. Can we change default AP Secure Set ID or SSID? The communication link between the wireless data modems is preset by MVS at installation. The modems communicate with each other over a secure data pipeline that is inaccessible to external devices or users.

23. Can we disable the broadcast SSID feature? N/A

24. Can we change default userid and password for ADMIN account? N/A

25. Does the device allow for use of MAC address filtering? N/A

26. Can we turn-off the AP to not answer "probe-response" requests. The modems communicate with each other over a secure data pipeline that is inaccessible to external devices or users.

27. On the WAP can we disable DHCP? N/A

28. Can we change default subnet? N/A

29. Does the WAP provide any SNMP auditing capabilities? N/A

30. If you answered no to any of the proceeding 10 questions, please explain:

Application Service Provider Security

PHYSICAL SECURITY

31. Describe the physical security and disaster recovery and prevention features of the ASP's data center. All data are backed up in near-real-time and will be transferred to Emory on a regular schedule. The ASP is on a dedicated server managed by 1and1.com

32. Who (including data center staff, other employees and vendors) have physical access to the host servers? 1and1.com technical staff.

NETWORK SECURITY

33. Are industry-standard Firewalls deployed? Yes
    a. Where are they deployed? Will be installed at Relay station
    b. How does the ASP keep the software for the Firewalls current? 1and1.com technical staff.
    c. Is administrative access to Firewalls and other perimeter devices allowed only through secure methods or direct serial port access? Yes, only at the workstation

34. What protocols and ports are allowed to traverse the network and firewall?
    Only port 21 for FTP upload of data stream.

35. Does the ASP use intrusion detection systems (IDSs)? 1and1.com technical staff.
    a. How long are the IDS logs kept?

36. Are formal incident response procedures in place? 1and1.com technical staff.
    a. Are they tested regularly?

37. Does the ASP engage third party security service providers to perform ongoing vulnerability assessments? N/A.

SYSTEM SECURITY

38. Are ongoing vulnerability assessments performed against the system?
    Yes, and the system is patched if security issues are identified.

39. Are file permissions set on a need-to-know basis only?
    Yes, file system permissions are set

40. How are operating systems kept up-to-date?
    a. How does the ASP keep abreast of software vulnerabilities?
    b. What is the procedure for installing software updates?
        These updates are handled by the 1and1.com technical staff.
41. Are audit logs implemented on all systems that store or process critical (PHI) information?
    a. Are "root" or "administrator" commands logged?
        All commands are logged.

42. What change managements procedures are in place? MVS is continually adding upgrades and new features to its products.

STAFF SECURITY

43. What are the credentials of the systems administration staff? See attached resumes of MVS personnel. Credentials of 1and1.com technical staff can be obtained from 1and1.com.

44. Has the system administration staff undergone complete background and criminal checks? Yes, none of our staff have ever had a criminal record.

45. Are hosting staff onsite or on call 24/7? Yes

SECURITY POLICY

46. Describe the user account and password policy? Access will be assigned by Emory Hospital administration.

47. Are screen blanking mechanisms deployed on all employee workstations? N/A
    a. Do sessions automatically time out after an idle period?

48. Are user accounts for contract personnel created with expiration dates? Yes
    a. How are user accounts closed after termination? User is deleted at application and server levels.

Network

1. What type of topology is the application limited to? (e.g., Ethernet, Token Ring, FDDI, CDDI, Arcnet, etc.) The application is hosted on a managed server that is external to the hospital's physical network. The application is accessible via Internet web browser to administered users only.

2. What protocol/transport does the application operate on? (e.g., TCP, UDP, IPX, NetBIOS, etc.)
   TCP/IP, FTP, HTTP

3. Does the application perform any transmission control or other lower level function that would burden the OS or host? No

4. Is there any protocol encapsulation necessary for the application? No

5. How does the application handles a network failure? No

6. What is the maximum number of network users for which the application is intended?

7. Is the application to be run on a LAN only? No

8. What WAN transmission type, if any, is the application limited to? N/A
   (Synchronous: T-1, ISDN, Fractional-T, Frame Relay, etc.)
   (Asynchronous: 300 baud, 28.8k baud, etc.)

9. Does the application have any SNMP/RMON management ability? Can it feed information to a manager of managers?
   N/A

10. What ports does the application use to transfer data? Are the ports used variable or static? Can the ports used be altered to fit different environments?
    Data is transferred via port 21; this is a static port.

11. Has the application been constructed to co-exist on the network with other high-end, bandwidth-demanding applications? If yes, what about the network command syntax was implemented to insure co-existence?
    Bandwidth throttling was not implemented, but data size is small and should not interfere with other applications.

12. Do you have a baseline for traffic that this application will generate?
    All data transferred will be logged and analyzed.

System Architecture

1. What is the minimum Server requirements? Pentium 4, 2.4 GHz
2. What is the minimum Client PC requirements? Pentium 4, 2.4 GHz
3. How much real memory is required for the Server? 512 mb RAM
4. How much real memory is required for the Client? 128 mb RAM
5. How many maximum concurrent users are recommended? N/A
6. Will the application reside and function fully within its server (no interface PC's needed for protocol or data translation)? Yes.

Operating System

1. If the application is written for or runs on Novell 4.1x: N/A
   a. Is it NLM based? If yes, is the NLM certified from Novell Labs?
   b. Does it load only on the server or is there also a client installation required?
   c. Does it require a consistent drive letter or a search drive or can it use UNC?
   d. What type of security access do the users need to the application directory?
   e. Can the application and the data files remain in separate locations with different levels of security (e.g., Read & File Scan only for the application directory)?

2. If the application is written for Windows NT 4.0/2000: Yes
   a. If the application is Client/Server will it start as a Windows NT Service? No
   b. Is the application certified for Windows NT from Microsoft Labs? No
   c. Does the application require a certain Service Pack? No

Application

1. Is the application Client/Server? Yes

2. Is the application UNC (Universal Naming Convention) compliant? .Yes

3. Does application make registry changes? No

4. Does application require administrative rights to install on Client PC? No

5. Can the executables reside on the client workstation instead of the server? Yes

6. What is the availability (uptime) for this computer system? 24/7

7. Is there any scheduled downtime? Patching

8. Can application support thin client environment?

9. If Web Services is a component of this application, please complete the following questions:
   a. Is the application dependent on a specific web or application server? If so, which. Does the application use applets? PHP, no applets
   b. Can the web and application servers reside on the same physical server or is there a need for separate servers? Same
   c. Does application use support 128-bit SSL for Internet access? N/A

10. If the application has a scheduler, briefly describe.
    a. What technology does the scheduler use? CRON
    b. Is the technology proprietary? No
    c. How does the scheduler control handshaking for its input and output prerequisites?N/A
    d. What other types of schedulers can the scheduler be configured to work with? (cron, at, Control-M, etc) All
    e. Can the scheduler be configured to be time or/and event driven?Only Time

11. How does the application handle data promotions between version upgrade and operating environments (test, training, production, etc)? N/A

12. Is the application compatible with Microsoft's SMS software distribution? No

13. Does the application have a Microsoft Installer (MDI) package? No

14. How many upgrades are released each year? N/A

15. Application patches are available and downloaded from where? N/A

Database

1. What databases does it support? MySQL

2. If application uses Oracle database: N/A
    a. What level of Oracle is the application certified to run on?
    b. Can the application's database reside in a shared instance?

3. If application uses an OLAP database: N/A
    a. Briefly describe.
    b. Does it use a standardized technology?
    c. Is the technology proprietary?
    d. Can the application use an OLAP database from another vendor?
    e. Can the application use the MicroStrategy Decision Support System (DSS) OLAP database?

4. If the database is Btrieve: N/A
    a. What plans does the vendor have in replacing it with something else?
    b. Does it use the Btrieve.nlm or client requestor?
    c. Does it require a specific version of the NetWare client or require bindery services?

Citrix

1. Is the application supported on Window's Terminal Server and/or Citrix MetaFrame? No

2. What version of Citrix MetaFrame does the application support (MetaFrame 1.8, XP, MPS3.0)?

3. How many concurrent users can typically run on a dual processing server?

4. Is there any workarounds that need to be implemented in order for the application to correctly function in a Citrix environment?

Interface

1. Does the application interface support HL7 protocol? No

2. If interfaces are in scope, does application support real time TCP/IP sockets interfaces? N/A

3. If the application has an Extract, Translate & Load (ETL) interface to import/extract information from various data sources: N/A
    a. Briefly describe.
    b. What technology does the ETL use?
    c. Is the technology proprietary?
    d. How does the ETL handle handshaking to confirm valid and unduplicated data transfers?
    e. What types of data sources can the ETL interface with?
    f. How does the ETL handle failures and outages for itself and the data sources?

    g. Does the ETL queue or stage data to handle failures and outages?

Printing

5. What is the print language used by application (PCL-5, Post Script)? No printing needs
6. Does application support network based LPR printing? N/A
7. Does application require any special printer hardware requirements such as duplex printing, legal trays, color? N/A
8. Does the application use scheduled or on-demand printing? N/A

Backup

1. What type of backup software is recommended from the vendor (I.E. Open Files)? N/A
2. What is the restore plan in the event of a server crash? MySQL data shall be backed up

Support

1. What types and levels of support are available (Tier1, Tier2…)? All levels
2. How much does it cost? Included as part of system contract.
3. Is e-mail, phone, remote and/or on-site support and/or consulting available? Yes
4. What hours of support are available? 24/7
5. What is the average cost per user? N/A
6. What steps are taken when troubleshooting a problem? Documentation of problem; live collaboration with customer to isolate problem; repair or patch of problem; customer follow-up; verification of repair or patch; closeout documentation. Documentation reviewed for patterns or recurrence.

References

1. Can a list of reference sites with similar configurations to those recommended for Emory Healthcare be provided? Yes, a similar application is in use by Atlanta Data Storage and can be viewed at www.e-2-V.com. Contact MVS for a secured demonstration tour of the website.

The proactive tracking of medical equipment using passive RFID tags delivers cost savings that are dramatic. During the past year Mountain View Systems LLC, in collaboration with Emory Hospital and Piedmont Hospital, has focused its resources toward the development of an RFID medical equipment tracking system that would provide improved visibility and substantial short- and long-term cost savings. That effort has culminated in a revolutionary product that we call **Pinnacle**.

The ROI for **Pinnacle** can be justified on the basis of managing Intravenous Medication Pumps (IV Pumps) *alone*. Once the system is in place, it can serve as the backbone for other user groups within the same facility to add other classes of assets, such as wheelchairs, surgical equipment, et al. Furthermore, the installed system uses the same RFID protocol standard that the FDA has mandated for tracking drugs and other products in the healthcare supply chain.

The **Pinnacle** system leverages RFID with the Internet to yield greater benefits and cost savings when compared with competitive systems:

- **Simplicity** – The ASP platform requires very little on-site IT support. Wireless transmission requires no expensive plenum grade cables and has a low power overhead. Interfaces to enterprise software are not necessary, but can be established to support existing equipment systems.
- **Scalability** – Facilities can start by tracking high value equipment to general areas, then gradually increasing population of tracked items and the resolution of location accuracy.
- **Flexibility** – Small form factor and proprietary wireless transceiver technology creates a flexible wireless network providing dynamic upgrade and reconfiguration options as resolution is adjusted.
- **Price/Performance** – Savings immediately begin to accrue as soon as visibility of mobile assets is implemented. Payback in less than one annual budget cycle in achieved by increasing utilization rates, lowering equipment rental charges, decreasing spending on unnecessary equipment, enabling more efficient use of critical nursing time, and improving the monitoring of maintenance and certification inspections.
- **Billing Simplicity** -- The system is subscription-based, which allows invoicing by class of asset, department, or cost center.
- **Security** – Encrypted Data transmission and User/Password control access.

Pinnacle has two major system components: *Radio Sherpa* and *e*^{2}*V*™. *Radio Sherpa* is our patent pending "wireless mobile asset tracking vehicle", an RFID reader built into a standard utility cart used by Central Distribution to deliver and recover medical equipment. As this "smart cart" is wheeled throughout the hospital by Central Distribution personnel, the built in RFID reader automatically detects any nearby equipment and correlates that RFID data with tags identifying fixed locations. Using *Radio Sherpa* makes possible greater visibility of equipment movement than could be achieved by installing tens, or even hundreds, of fixed RFID reader antennas throughout the hospital. A solid ROI forecast for the hospital can be made by tagging and tracking Intravenous Pumps (IVs) alone. Once the basic system shows real benefit, it can be scaled out to include other classes of assets such as PCA Pumps, portable pacemakers, and wheelchairs.

Supporting *Radio Sherpa* is our proprietary e^{2}V™ ASP software that processes, updates, and displays the RFID equipment database. Because e^{2}V™ is Internet-hosted on a secure server, authorized users can gain instantaneous access to the latest equipment status updates and statistics from any Internet browser. Value-added benchmarking across the customer's secure website, or across multiple customers' sites, offers powerful tools for process improvement and early warning of unplanned movement of assets. Our unique system design enables broad system functionality from the outset with minimal capital investment, positioning the client for expansion and adoption of the system by the whole institution.

The Healthcare Challenge

- Lower healthcare costs by tracking medical equipment.
- Make it easier to distribute and recover critical assets.
- Create an RFID infrastructure that will be ready to meet FDA mandates for pharma distribution management
- Do it inexpensively.

Overview

- Tracking Mobile Medical Devices
  - Current Approach –
    - Determine Need
    - Determine Inventory On-hand
    - Physically Search The Facility Floor-by-floor, Area-by-area
    - Purchase Or Rent The Shortfall
  - RFID-enabled Approach –
    - Determine Need
    - Determine Inventory On-hand
    - Check System For Extras
    - Go Directly To Excess
    - Avoid Purchasing Or Renting Extra Equipment

Overview

- **Tracking Mobile Medical Devices**
  - **Current Approach –**
    - **Determine Need**
    - **Determine Inventory On-hand**
    - **Physically Search The Facility Floor-by-floor, Area-by-area**
    - **Purchase Or Rent The Shortfall**
  - **RFID-enabled Approach –**
    - **Determine Need**
    - **Determine Inventory On-hand**
    - **Check System For Extras**
    - **Go Directly To Excess**
    - **Avoid Purchasing Or Renting Extra Equipment**

Introducing Pinnacle

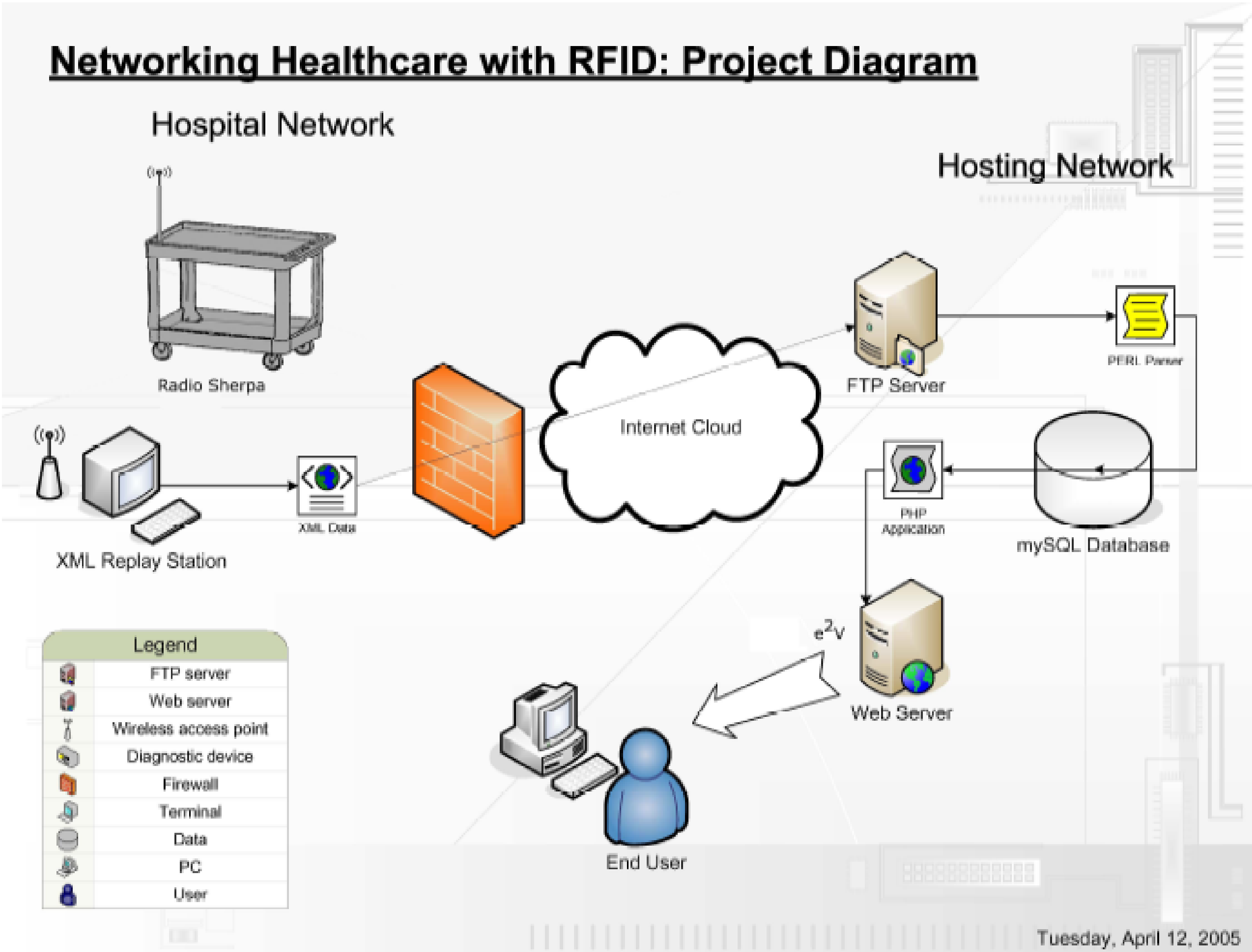
Pinnacle is a patent pending system that monitors the movement of tagged medical equipment by correlating equipment tags with tagged fixed locations.

Pinnacle has 3 major system components:

- ***Radio Sherpa***
- **Fixed Wireless Readers**
- **Application Service Provider (ASP)**

Radio Sherpa

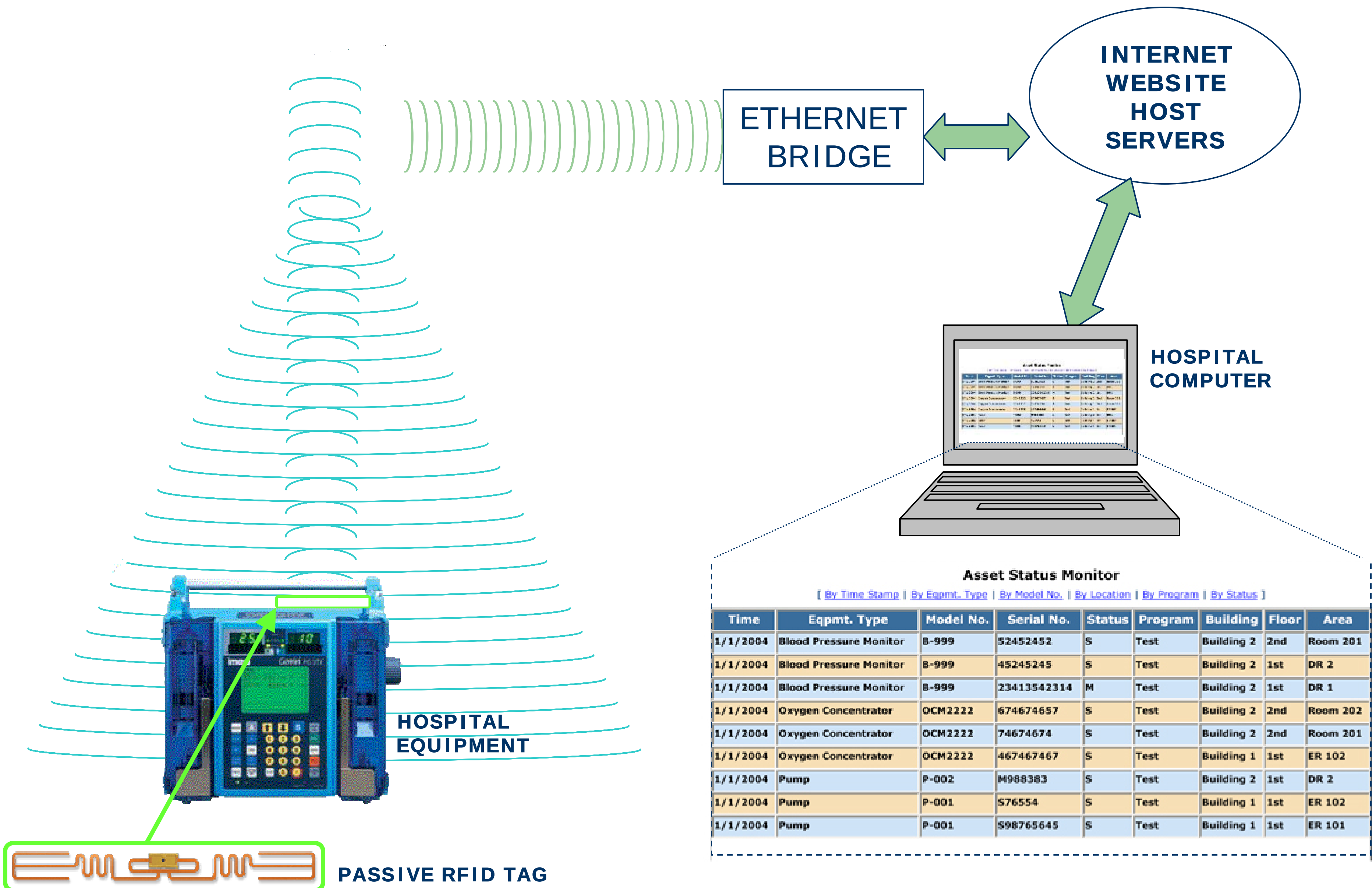
- Patent pending "wireless mobile asset tracking vehicle", an RFID reader built into a standard utility cart
- Automatically detects any nearby equipment and correlates that RFID data with tags identifying fixed locations.
- *Radio Sherpa* makes possible greater visibility of equipment movement than could be achieved by installing tens, or even hundreds, of fixed RFID reader antennas throughout the hospital.


Networking Healthcare with RFID: Project Diagram
Hospital Network
Hosting Network
Radio Sherpa
XML Replay Station
XML Data
Internet Cloud
FTP Server
PERL Parser
PHP Application
mySQL Database
Web Server
e2v
End User
Legend
FTP server
Web server
Wireless access point
Diagnostic device
Firewall
Terminal
Data
PC
User
Tuesday, April 12, 2005

Fixed Wireless Reader

- 6” x 6” unit complete with
  - RFID Interrogator
  - Antenna
  - Wireless data modem
- Requires only a power plug, can be placed anywhere needed for instant visibility.

WIRELESS READER



Asset Status Monitor

[By Time Stamp | By Eqpmt. Type | By Model No. | By Location | By Program | By Status]

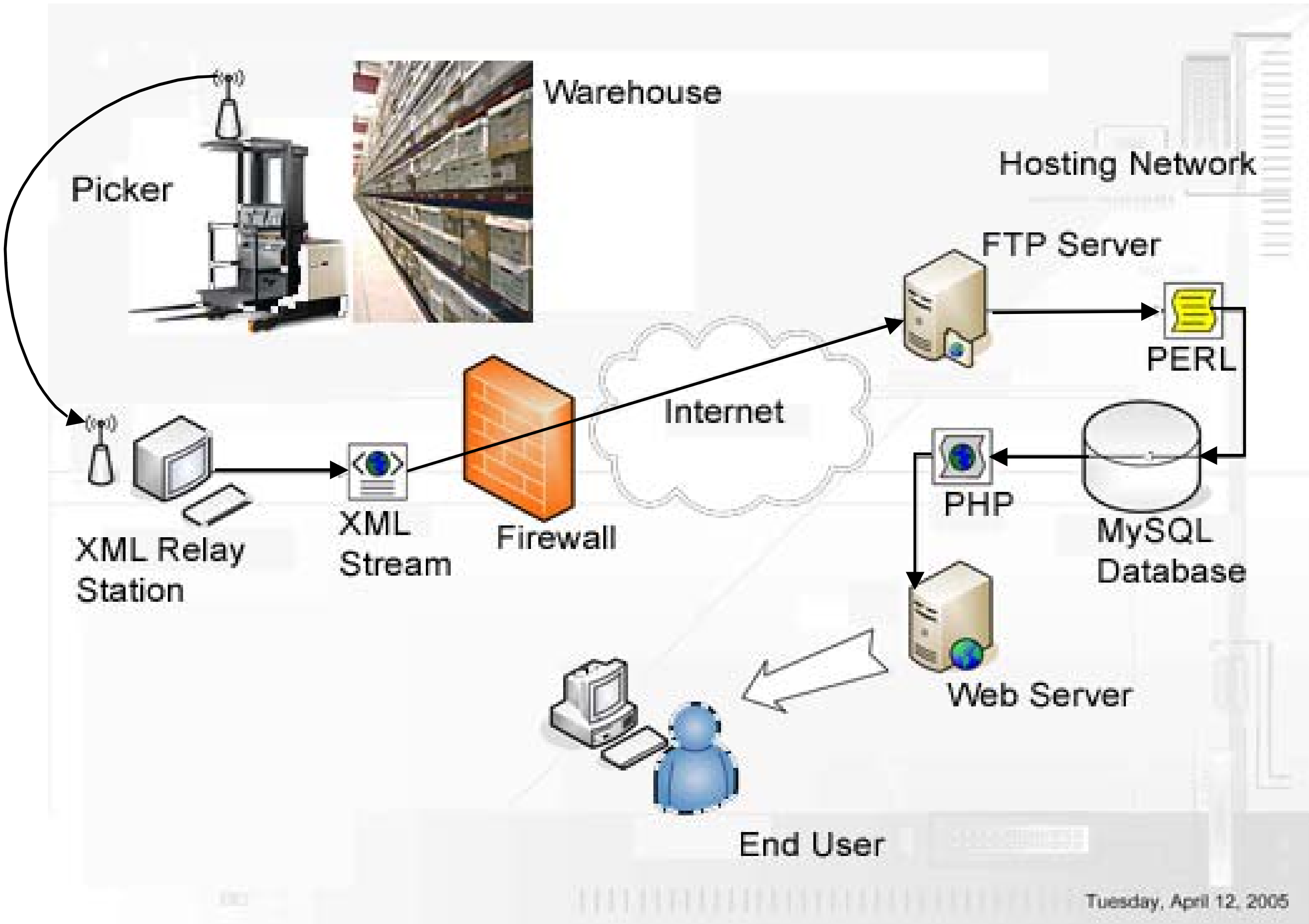
Time	Eqpmt. Type	Model No.	Serial No.	Status	Program	Building	Floor	Area
1/1/2004	Blood Pressure Monitor	B-999	52452452	S	Test	Building 2	2nd	Room 201
1/1/2004	Blood Pressure Monitor	B-999	45245245	S	Test	Building 2	1st	DR 2
1/1/2004	Blood Pressure Monitor	B-999	23413542314	M	Test	Building 2	1st	DR 1
1/1/2004	Oxygen Concentrator	OCM2222	674674657	S	Test	Building 2	2nd	Room 202
1/1/2004	Oxygen Concentrator	OCM2222	74674674	S	Test	Building 2	2nd	Room 201
1/1/2004	Oxygen Concentrator	OCM2222	467467467	S	Test	Building 1	1st	ER 102
1/1/2004	Pump	P-002	M988383	S	Test	Building 2	1st	DR 2
1/1/2004	Pump	P-001	S76554	S	Test	Building 1	1st	ER 102
1/1/2004	Pump	P-001	S98765645	S	Test	Building 1	1st	ER 101

The Document Storage Challenge

RFID System currently in operation at Atlanta Data Storage, Norcross, Georgia

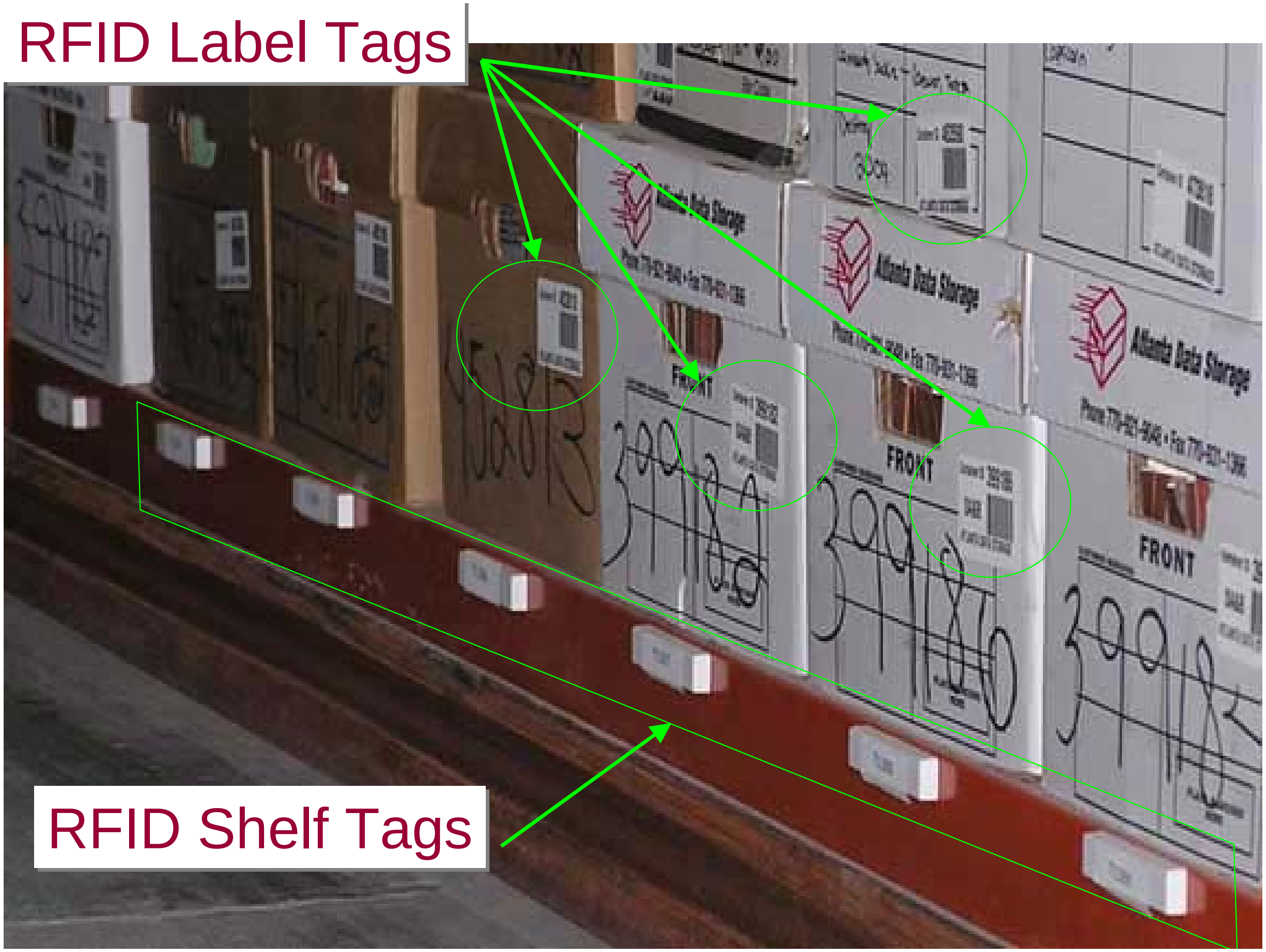
Contacts:
Marc Gray, General Partner, 770-921-9048
Bill Oppenheimer, Sales Manager, 770-921-9048

RFID Document Warehouse System

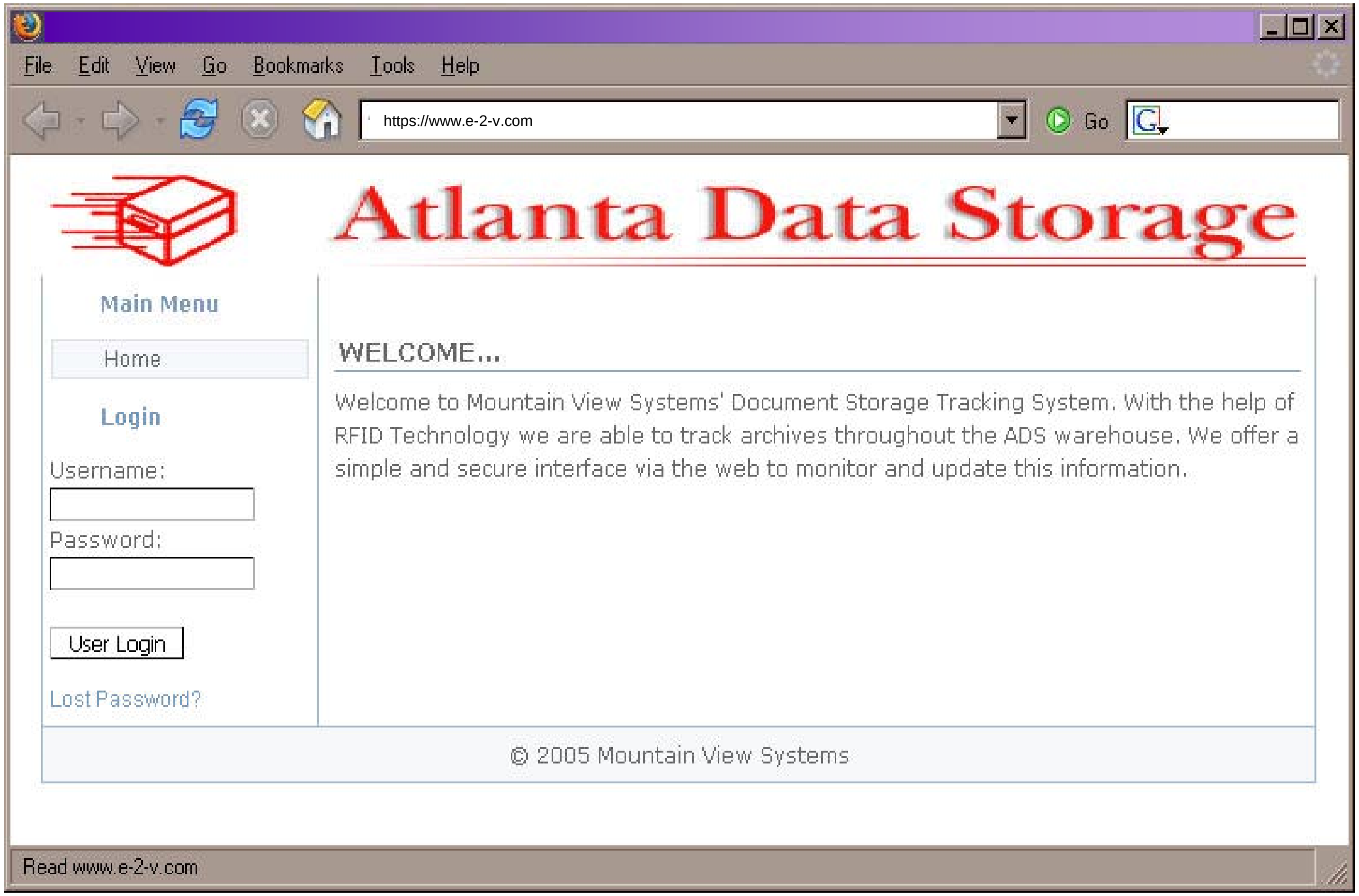


System Detail

RFID Antennas


RFID Label Tags
RFID Shelf Tags
Atlanta Data Storage
FRONT

ASP Website


File Edit View Go Bookmarks Tools Help
https://www.e-2-v.com
Go
Atlanta Data Storage
Main Menu
Home
Login
Username:
Password:
User Login
Lost Password?
WELCOME...
Welcome to Mountain View Systems' Document Storage Tracking System. With the help of RFID Technology we are able to track archives throughout the ADS warehouse. We offer a simple and secure interface via the web to monitor and update this information.
© 2005 Mountain View Systems
Read www.e-2-v.com