Technologies for Real-Time Monitoring and Surveillance of High-Valued Assets

C. A. Pickett, G. D. Richardson, B. J. Stinson, and J. R. Younkin
Oak Ridge National Laboratory*

ABSTRACT

The Oak Ridge National Laboratory (ORNL) has been working on technologies that can provide real-time monitoring and surveillance of high-valued assets. It is hoped through effective system design that some of these technologies can be utilized as the technical equivalent for the "two person rule" (required for many domestic safeguards operations). The major efforts associated with this work to date involve the integration and adaptation of commercial-off-the-shelf (COTS) radio frequency–based technologies into basic system elements that can be effectively layered into integrated unobtrusive monitoring systems that are specifically designed to detect unauthorized asset movements. Each system element is designed to provide real-time monitoring and surveillance of both protected assets and the people who have access to them. The goal is to accomplish up-to-the-minute status of monitored assets using site-specific, rules-based algorithms. The overall system concepts focus on early detection (of theft or diversion) at the asset, followed by appropriate alarms or notifications that can be used to initiate appropriate response(s).

INTRODUCTION

For many years, laboratories around the world have been working on technologies and methods that can provide improved diversion detection and accountability for protected assets. In many cases, the lack of technologies that support the real-time tracking of assets that move have hindered progress. There have also been concerns and restrictions on using technologies that transmit signals, especially for protected and accountable assets located or stored in secure areas. However, significant resources since the late 1970s have been invested in barcode-based technologies for inventory. These technologies have proven themselves as reliable, beneficial approaches for maintaining inventory. Unfortunately, they have not been very effective at providing timely information or much, if any, security benefits.

Today the market is being flooded with several types of radio frequency (RF)–based technologies that are designed to support timely monitoring and tracking of assets. Some of these technologies are designed primarily to support inventory functions, and some of the newer products are being built with security functions in mind. This paper discusses the basic aspects of both types of technologies and some approaches for applying them as system elements (or layers) to improve the monitoring and accountability of protected assets.

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It is the premise of the authors, that continuous real-time inventory methodologies can be properly utilized in a site security system to improve event detection and the associated response(s) to events involving potential theft or diversion of protected assets. This paper also presents a few examples of system components and approaches that illustrate this premise.

TRACKING AND SURVEILLANCE

Tracking and surveillance are security system elements designed to provide a continuity of knowledge of an asset's whereabouts and status. Many current security systems that are designed to protect assets do not provide real-time or continuous information of an asset's status or location. These systems typically monitor the periodic status of protection elements associated with these assets (e.g., vault doors, area access, motion in an area). The monitoring is not usually associated with the asset itself, but tends to be very focused on protecting the area where the asset is located. This approach works very well in detecting external threats or assets stored in vaults (that rarely move), but can be limited at detecting the activities associated with internal threats and monitoring assets that frequently move. Internal threats can involve insiders that may be colluding with other insiders and/or an external individual or group. Their approach may be to divert (protracted theft) and relocate an asset where it can later be taken.

The need for timely detection at the asset is based on scenarios that deal with evolving and increasing threats. Current physical security measures have long been designed to detect and respond to external threats by requiring timely detection at a perimeter. This timely detection at the outermost perimeter helps ensure that an appropriate response can occur with a high probability of stopping the theft. Our premise is that the same is true for insider threat protection: if the timely detection occurs at the innermost perimeter (the protected asset), then a high probability of a successful response and neutralization can be achieved.

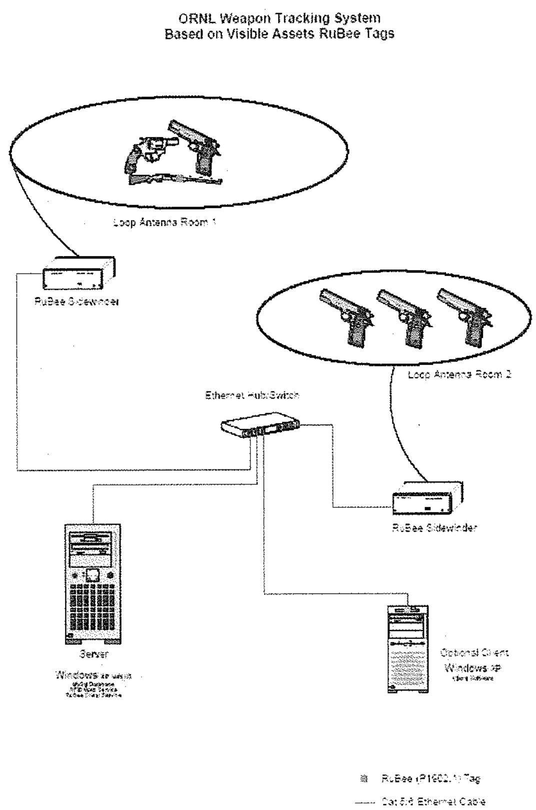
PROTECTED ASSET TRACKING SYSTEM (PATS)

Oak Ridge National Laboratory (ORNL) is working with the U.S. Department of Energy (DOE) Office of Health, Safety, and Security Office of Technology (HSS-82) to integrate and deploy technologies for maintaining the custodianship of certain accountable assets assigned to the protective force organizations within DOE and protected assets at the Pantex site. The objectives of these projects are to effectively integrate commercially available technology into working systems that provide timely and accurate information on the status and location of these protected assets. There is nothing that protective forces are more responsible for controlling than their firearms. Knowing the "who, what, when, and where" of all firearms movements is a necessity.

Strict requirements exist and must be followed regarding the issue, return, assignment, maintenance, custody, and inventory of equipment in an armory. Guidelines also exist for patrol-assigned equipment that stays with a patrol vehicle or at a patrol location. By using RF-based tags that can be embedded or securely attached to these assets, human errors associated with paper-based systems can be minimized. An effective RF-based inventory system can also greatly reduce the amount of time required to perform the multitude of inventories that must be maintained at DOE armories. These include the shift inventories, the weekly inactive service inventories, the monthly inventories, and the yearly inventories.

A fairly new technology called Rubee is being used for these tasks; it involves the use of a battery active-passive tag technology with low-frequency RF communication. Rubee technology offers many benefits over common radio frequency identification (RFID) protocols, including a much lower susceptibility to metals and water and extremely long battery life. A Rubee portal system was setup at ORNL for evaluation. The results indicate very high detection rates when tags are attached to metal objects.

One drawback to the Rubee Standard, IEEE P1902.1, "Rubee Standard for Long Wavelength Network Protocol," is limited bandwidth. The ability to communicate with multiple tags when passing through a reader portal is reduced because of the lower bandwidth. To address that issue, several alternative configurations to portal-based solutions have been tested based on the very inexpensive and simple loop antenna capabilities of the Rubee hardware. Shelf loop and room loop antennas are alternative approaches that have been tested with very good results. A shelf or room loop antennae allow more flexibility and can be installed at a substantially lower cost. Figure 1 is a depiction of loop antenna and portal-based systems.



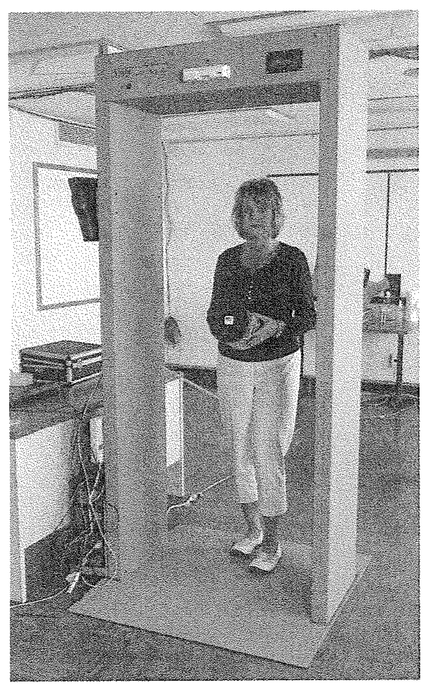


Figure 1. A depiction of a loop antenna and portal-based system.

The Rubee doorway portal system uses two passive infrared (PIR) detectors to sense motion on either side of the portal. These sensors signal the RF equipment to turn on and attempt to read the tags, indicating their direction of movement through the portal. The sensors are positioned and adjusted to optimize the desired detection area associated with the application.

Being able to embed the tags within parts of the equipment helps ensure that the tags are not easily or accidentally removed and that the tags do not interfere with the operation of the equipment.

As part of the software effort, several database tables have been set up for evalaution to determine an efficient database schema and user interface. The database tables created in MySQL includes a personnel table, a firearms description table, an inventory table, a duty equipment table, and an inventory-history table. Figure 2 shows some of the data obtained from user queries.

Repeated testing of the Rubee technology has facilitated writing the code that controls the hardware to obtain tag information. One component of the software that will be developed for a viable system will provide a service that communicates with the hardware when information requests are made by a user.

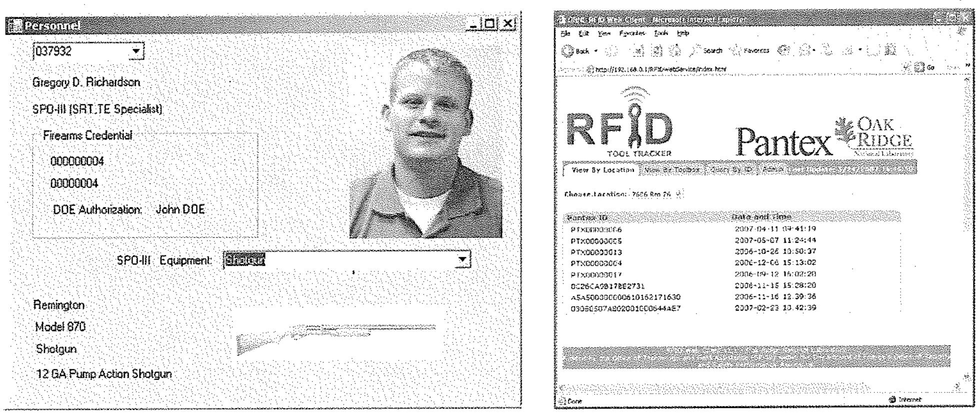


Figure 2. Personnel status/equipment record.

ZONE TRACKING

The active RFID tag system involves deploying an array of directional antennas that are mounted close to the ceiling of the facility and are directionally focused at the floor. This approach allows a facility to be set up with a grid of directional antennas that cover the entire facility or specifically designated areas. The system will then "track" the active RF-tagged materials and personnel as they move throughout the facility grid (or zones) into and out of each zone of detection. Event detection and assessment-based algorithms are then applied to a process scenario to ensure material and personnel move as planned. A depiction of the system is shown in Figure 3.

The low RF power required to operate this system (due to short distances of the tag to the receiver) provides information security benefits that are superior to other systems that broadcast RF throughout a facility. While the spatial resolution of this type of system may be less than a properly working triangulation-based system, it is expected to be more robust, less sensitive to RF interference or reflections, and much easier to set up in existing facilities.

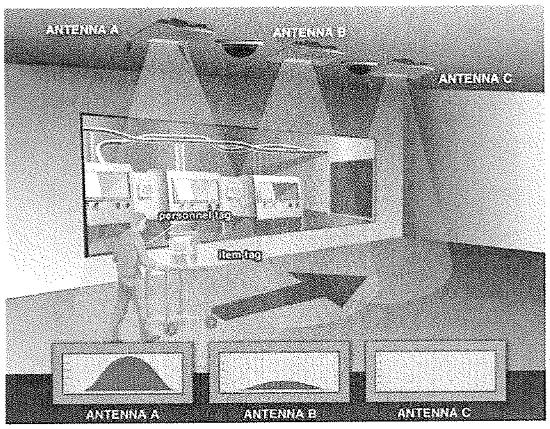


Figure 3. Active zone tracking system.

The technical goal of ORNL's zone tracking system is to be non-sensor specific. Most applications are hardware specific, and this is detrimental to their applicability for a wide range of problems. Some solutions don't require a high degree of accuracy. It might be that knowing the building and room an item is in is good enough. Other applications require tracking an asset to within a few feet or better. It would be useful to have the same application be capable of handling these different accuracy requirements. The zone tracker will define a common interface that supports the technology being used. When a new sensor type is added, this interface should be the only piece of custom software required. In addition to hardware independence, the goal is to use a rules-based approach that can be user defined.

Whereas accountability allows one to know the current location of an asset, traceability allows one to know where the asset has been since it was registered with the tracking system. This is important for several reasons. The first and probably most important is event resolution. Often there are actions preceding a security incident that are well within the norm and would generally be considered insignificant. After an incident has occurred, having a record of all the actions leading up to the incident can be the difference between immediate incident resolution and never knowing what really happened. Another important advantage of traceability is event correlation. If an operational facility has well defined processes, it is possible to define rules that certain assets should follow. These rules can be as simple or as complex as necessary, but the use of rules will allow the recognition of abnormal conditions more quickly than without. In fact, it may be possible to alert responders of a possible situation before an incident even occurs.

ZONE CAMERAS

A visual surveillance layer has been added to the RF active zone tracking. The zone camera concept was introduced by placing overhead cameras in a facility coinciding with the RF zone tracking zones. These network cameras are fitted with fish-eye lenses to obtain discernable images as objects approach the zone. Software has been evaluated for achieving the best viewing and recording of surveillance and event capture from these cameras. Testing the motion-detection capabilities of the cameras has also been performed. Integrating camera motion detection events offers another depth to the STAT software's defense-in-depth architecture. Zone cameras can be either a stand-alone layer or appended to other layers.

Several solutions have been developed for facilities with existing closed circuit television equipment (CCTV). Hardware exists that accepts the analog video signals from these cameras to make them appear as network cameras. This approach simplifies the camera interfacing. Another approach is to use fewer pan/tilt/zoom cameras. Commanding pant/tilt/zoom cameras to preset locations based on tracking zones has also been performed.

PEDESTRIAN RADIATION PORTAL SENSOR SYSTEM

RFID is a fairly new technology that allows the use of barcode-type identification remotely over short distances. There is an interest in using this technology for tracking nuclear materials. One way of doing this is to use RFID portals at access points between materials balance areas. The inclusion of a radiation monitor to this portal would allow a second level of confirmation of the item being moved. Radiation portal monitors are already in use to detect unauthorized movement of nuclear material. In order to demonstrate the integration of an RFID portal with a radiation portal, an RFID portal system was interfaced with an existing radiation portal monitor (Figure 4). The radiation portal monitor was connected to a local PC using a serial interface. Both MS Windows and the Web were used to log the data from the radiation portal into a remote database. The RFID Web interface is then able to use the database to compare the declared radiation status of the item with its measured radiation level, and alarm if they don't match. The system shows the potential for integrating other security systems with RFID, and shows promise for using RFID for improved nuclear inventory management. Web services make a good communications system to integrate security systems of this type because of the system's expandability and modularization. A similar method could be used for combining other types of systems with the RFID software as well.

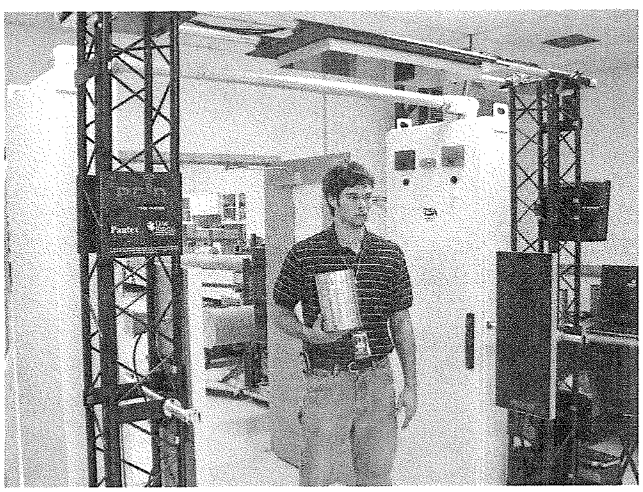


Figure 4. RF-based portal with radiation monitoring.

Software was developed that integrates a pedestrian radiation portal with an RF portal for identity and integrity detection of containment and personnel. The radiation portal continually reports the status of its gamma and neutron detectors, portal occupancy sensors, and portal tamper sensors via serial communications. This data stream is captured, parsed, and logged on a PC. The multithreaded application displays the current readings of the radiation detectors (Figure 5). This system provides local database support for sending and receiving events and triggers.

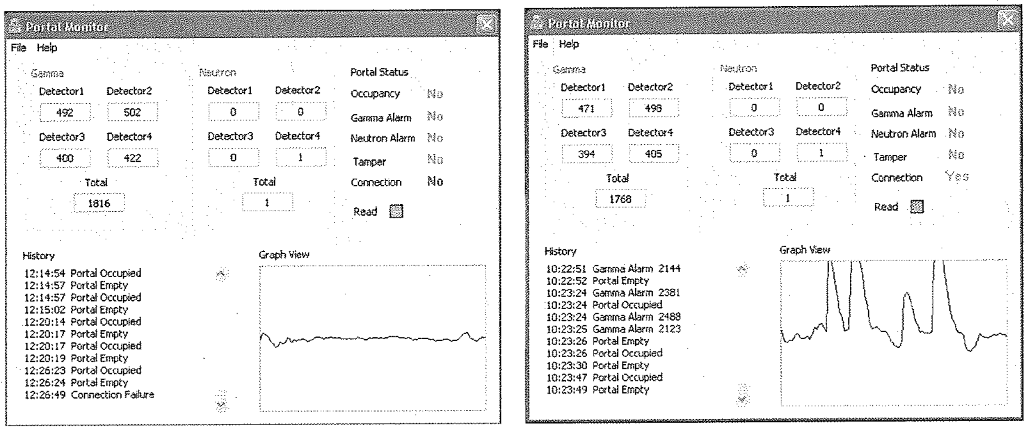


Figure 5. Radiation portal monitor user interface with no radiation and with radiation

Merging and integrating the pedestrian radiation portal and an RFID portal provides many mechanisms for tracking material. Rules are included for the items passing through the portal triggered on the events generated by each system. An item passing through the portal is identified by an RFID and any attributes of the item, such as radiation, can thus be verified. From the RFID, the system knows whether radiation should be detected or not. For initial testing, alerts were generated for the following conditions:

- A non-radiation item (according to the RF-TID) passes through the portal and radiation is detected.
- A radiation item (according to the RF-TID) passes through the portal and no radiation is detected.
- Anything passing through the portal without an RF-TID.
- An authorized personnel RF tag not accompanied by an RF-TID item authorized for passage through the portal.

CONCLUSION

This paper has communicated the potential of using RF-based technologies to improve the detection time and accountability of protected assets. It is known that there are security issues with RF tags, primarily that the tags cannot always be securely attached to assets. RF-based seals are a technology that can add security to the attachment scheme, but these technologies tend to be harder to install on an asset in an intrinsic manner that does not interfere with operations.

This paper also has indicated how RF-based technologies can be layered with other types of surveillance to provide a more robust and secure system.