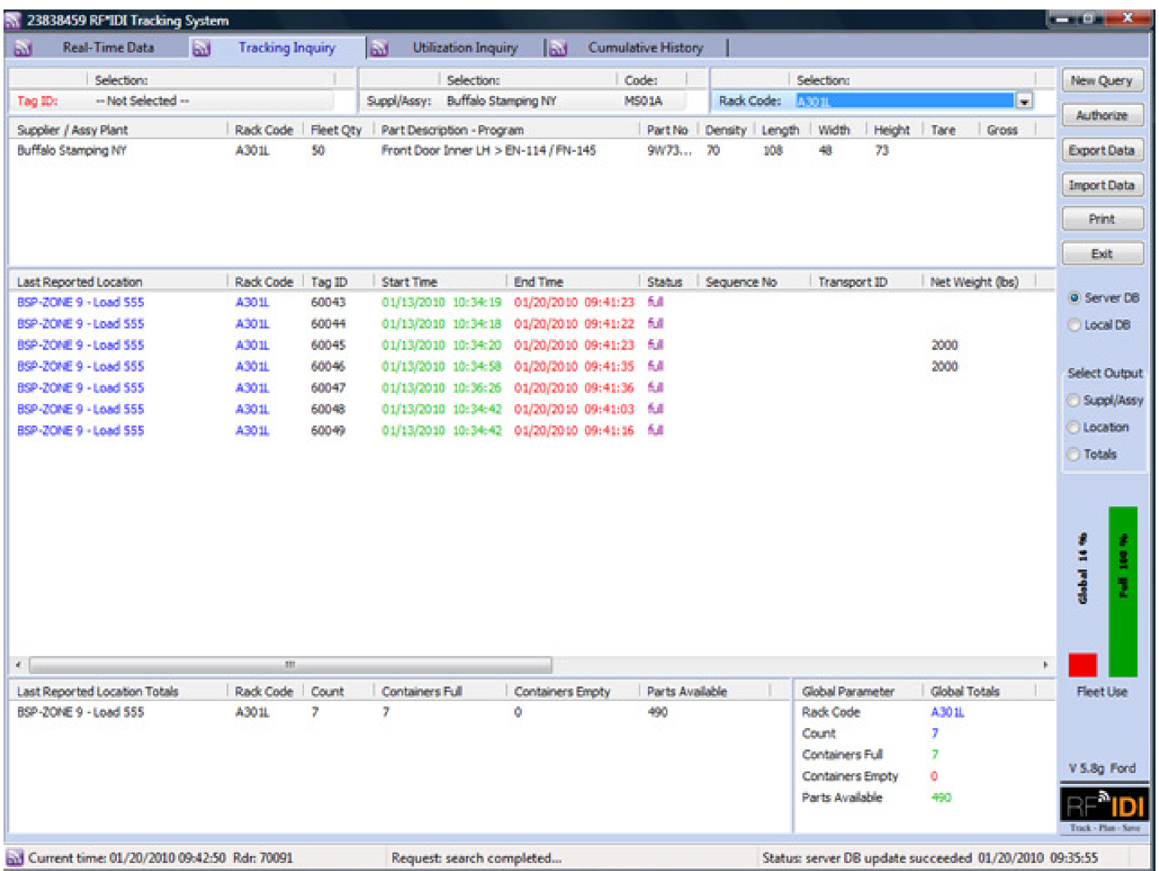
RF-IDI System Design and Deployment Considerations

The success of any RFID tracking system can be summed up in the value of the data provided by the system, versus the investment required to acquire said data. Accuracy of acquired data is critical, as inaccurate data provides little value no matter how low the cost. In addition to accurate data, the data must be presented in a way that enables actionable improvements in business processes that result in savings that go far beyond the cost of acquiring the data.

In addition, the target environment must be carefully considered to ensure that a technology is used that can deliver the needed accuracy. The RF-IDI System is specifically designed to perform well in the most difficult environments, including those with high metal / high electro-magnetic field content.

The most sophisticated system in the world will not provide much value if personnel that need to leverage the information find the system difficult or inconvenient to use. The RF-IDI user interface was designed with input from team members that have more than 20 years experience in material handling logistics.



Contact: info@rf-idi.net RF-IDI, LLC 10611 Haggerty Street Dearborn, MI 48126

Acquiring accurate data depends on several factors; the choice of tag / reader technology, design of middleware to filter & process the data and requirements for infrastructure to upload data from a variety of locations to a central source for data mining, analysis and formulation of action steps for process improvement.

Tag / Reader Technology

In broad terms, tag / reader technology can be divided into two categories; active and passive. Active means that the tag has an on-board power supply. While active tags are more expensive than passive tags, the fact that an active tag has an on-board power supply means that the tag does not require close proximity to a reader to signal its presence.

This provides all kind of benefits in terms of flexible deployment capabilities and lower overall infrastructure costs. With the RF-IDI system, tags continuously beacon their presence every 10 seconds and any tag within 300 feet of a reader is "present and accounted for". Any tag misreads due to a temporary obstacle in the radio frequency path are self-correcting, due to the frequency of reads. Data is accurate because it is sampled over a very high number of tag reads.

Passive tags are less expensive, but require rigid system design. Tags must come within three to five feet of a reader to get a successful one-time read of the tag. Any tag misreads are permanent errors in the system – not recoverable. All container traffic in the target environment must follow a rigid path to ensure that tags come within the required proximity of a given reader, since tags are "off line" most of the time.

Changes in the system to accommodate new business requirements are expensive to manage, as infrastructure has to be re-deployed and re-configured. The number of reader locations tends to be very high to generate granular data, since each reader has such a short range of influence relative to energizing and waking up the tag.

Since the reader must generate enough energy to "wake" the tag, metal containers tend to be particularly challenging, because the metal container acts as a radio frequency sponge, bleeding off the energy from the reader. This situation can result in a failed tag read, as the available energy from the reader (with energy bleed-off) is sometimes not sufficient to energize the tag.

Ability to Adjust Tracking Granularity

The RF-IDI Tracking System leverages a tag design that provides two forms of communication; radio frequency for wide-area "I'm here" detection and infrared for narrow-area, "this location-related event has occurred" detection. Narrow-area detection can be expanded to any number of locations, based on deployment of inexpensive infrared (IR) generators that only require a power source and no other form of infrastructure connection.

A specific IR location is transmitted as part of the wide-area radio frequency data stream. This capability provides incredible flexibility to change the nature of event tracking by simply adding or relocating IR generators and redefining the event(s) related to specific IR generator location(s). This kind of flexibility is not possible with a passive system.

The combination of wide-area detection of a container's presence, regardless of path of travel and the ability to capture "state" changes in the container, such as empty or full, provides unbeatable flexibility in system design, enabling implementation of specific business rules with very low deployment cost.

Middleware Design

Once a determination was made to use active technology for the RF-IDI system, we had to consider how to manage the collective data stream generated. To get very high accuracy, we need to field reads from all tags at as high a rate as practical; every 10 seconds for maximum data resolution. It is important to keep in mind that as the system scales to a wider and wider sphere of influence, the collective data stream becomes very substantial. For example, 500 tags can generate 10 million reads a day, depending on the amount of asset movement. A large manufacturing facility may have as many as 10,000 tags on site at a given time.

To achieve scalability, the RF-IDI system uses a modular smart-reader design that enables the addition of as many reader nodes as necessary to provide the desired coverage. Each reader node can manage signals from more than 1000 tags simultaneously within its 300 foot radius of detection.

Low-level data from the tags is processed at the smart reader node directly. Only processed, filtered data is forwarded upstream through a network, rather than all the raw tag data, resulting in much lower network load for a given resolution of data. This helps ensure that the Ethernet or wireless 802.11b network that you have today will be leveraged to maximum efficiency when data from 10,000 tags or more is forwarded upstream for storage and retrieval.

Contact: info@rf-idi.net RF-IDI, LLC 10611 Haggerty Street Dearborn, MI 48126

When considering systems that forward raw tag data through a network to be filtered and processed up stream, consider the network traffic required for high data resolution, which is required for accurate data at any given moment. Finding out that your network bandwidth capacity is insufficient after a system is installed and scaled to read 10,000 tags can result in costly changes and additions to your existing network.

What Kind of Data Should be Managed and How?

Whether a system is based on passive or active technology, a method of storing and retrieving data is a critical part of system design. Where will data be stored, and how much data should be stored?

In addition to location data, manifest data relevant to the stored contents of a container is critical to make location data meaningful. Typical location data might be as follows:

- Location history by time stamp to capture arrival and departure times
- Type of container and size / storage parameters of container
- Is the container empty or full?
- Unique container identifiers
- Method of container transport
- Identifiers relative to container sequencing, such as VIN
- Unique container contents, such as a new part prototype
- History of damaged parts relative to a specific container
- New container design prototype
- History of container damage
- History of container repair
- Container scheduled maintenance

Tag Data Storage Capability

Passive tags have very limited data storage capability. In addition, the amount of data stored has an impact on tag / reader communication reliability. When a passive tag's memory is full of manifest data, during the brief time the tag is energized, more data must be transmitted. This can result in data misreads as the tag – reader range reaches the outer limits of reliable communication, which is only about 5 feet.

Active tags have more storage capability, but this storage adds cost to the tag and adds complexity to the system to ensure that writing data to the tag is successful. In addition, since the reader – tag communication link now carries actual business data, there is a potential security issue relative to business data on a wireless link.

Confirming Data Written to the Tag

To ensure data integrity, when storing actual data on the tag itself, the system must confirm that all attempts to write to the tag were successful. Since the data write process involves RF communication, there is always a possibility that reader - tag communication can fail for a variety of reasons, such as "nearly out of range", or temporary physical or electrical interference in the environment. A data stream that includes data to be written to memory requires a longer data packet. Long data packets limit tag – reader range and are more prone to data corruption, simply because they have a larger footprint during transmission that allows for a higher level of exposure to environmental factors.

To confirm that a data write operation was successful, the system must do the following:

- Attempt to write data to the tag
- Request a data read-back from the tag to verify data was written successfully
- If the data write operation is not confirmed, continue write attempts for some defined period of time until confirmation is received or the write operation is logged as unsuccessful

A passive tag cannot perform the write validation process described above, because only one communication occurs between the reader and the tag. This is a crucial distinction between passive and active tags.

Even with active tags, this confirmation process is very expensive from a system resource standpoint and requires from 2 to 5 transmissions between the tag and reader to succeed, depending on how many other tags are present.

Active tags by design, negotiate their "place in line" to communicate with the reader, so even though a tag may normally transmit once every 10 seconds, if 1000 tags are present within the sphere of one reader, some tags may take as long as 30 seconds to 1 minute to "phone home", because a data collision occurred with other tags.

The RF-IDI Solution to Managing Data

The RF-IDI solution offers the best of all worlds, by employing virtual writes to the tag and storing and managing data within the smart reader network. When manifest data is written relative to a specific tag, that data is stored in a queue within the smart reader. The next time that specific tag "phones home" (to ensure that said tag is actually still present) this manifest data is written to an internal database within the smart reader.

The smart reader database is replicated at timed intervals to a global database. Other smart readers that detect said tag download the latest data relative to this tag. With the RF-IDI system, the data "follows the tag" as the tag moves between readers. This has a number of advantages:

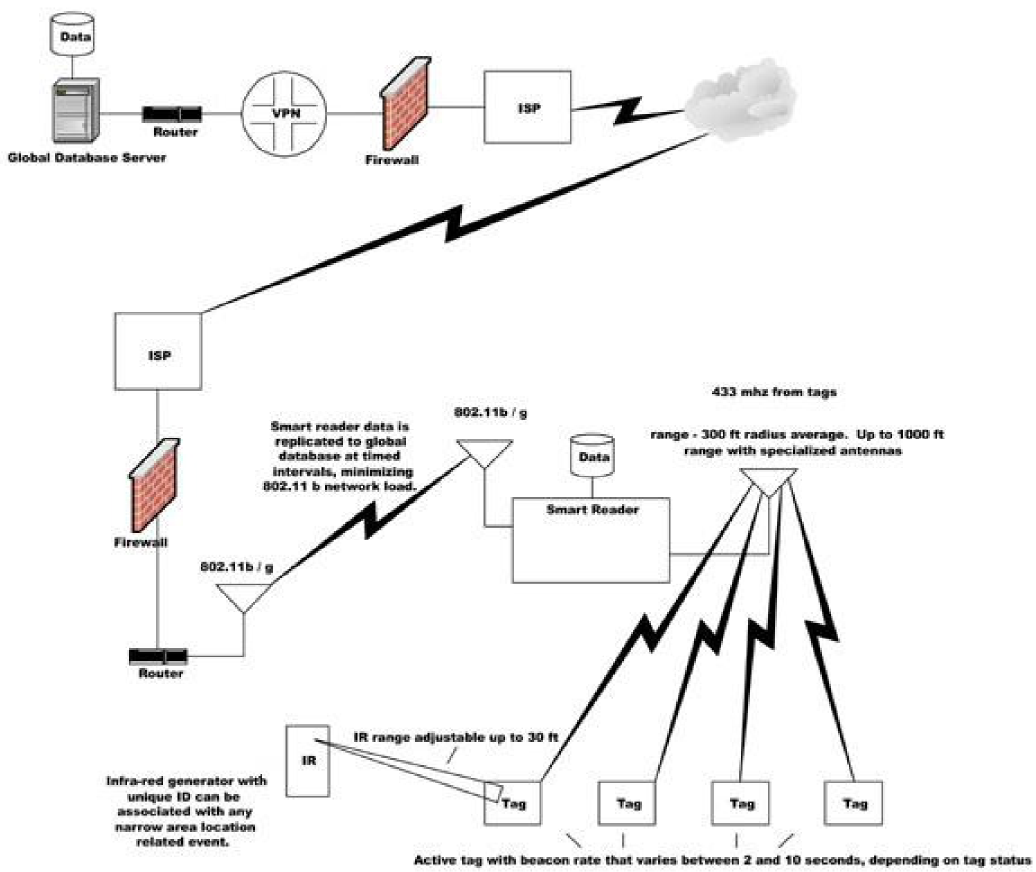
- Tag data packet remains small, since only unique Tag ID is transmitted
- The write confirmation process can be completed in 1 tag transmission
- No sensitive data being transmitted between the tag and reader
- No practical limit to the amount and type of data being stored
- Less expensive tag can be used for this level of capability, because on-board memory is not required.

The RF-IDI solution currently tracks 18 fields of data relative to a particular container and its contents. This can be customized per specific end user needs.

Infrastructure

Processed data is encrypted, forwarded and replicated to a regional or global server database that can be accessed through a secure web application front end to enable data viewing, analysis, data- mining and report generation as well as exporting data to other systems.

Since the RF-IDI system is a tiered design, the ability to scale is limited only by the server-side hardware capability and the server access bandwidth available. For very large deployments, server databases from regional locations can be further replicated to a single global database, using commonly available internet connectivity combined with virtual private network encryption for data security.



Because the smart-reader nodes apply the defined business intelligence to gather and forward actionable data, infrastructure is limited to that needed to replicate and view data. This results in very low cost and high functionality. Regional or Global database engines are enterprise-class, standards compliant Relational Database Management Systems that are commonly in deployment in today's business environment.

RFID systems that do not use the "distributed processing", smart-reader concept, push all the raw tag data up stream, to be processed by central network resources. This results in high network load and scalability problems as tag numbers become very high, requiring substantial investments in network resources capable of managing the data stream.

The RF-IDI system offers the best of all worlds – high read rate to eliminate the impact of occasional misreads due to environmental changes, distributed processing of data to keep network resource requirements low and flexible coverage capability, enabling changes in business rules that define tracking requirements, without re-deploying any RF readers or making network design changes.

Establishing Business Rules for Acquiring Data

RF-IDI has developed a very cost-effective technology framework to reliably acquire and manage data. Since every client has unique business rules, prior to system implementation, RF-IDI engages in a process of working with clients to define relevant business rules and system functionality. This process is typically defined as follows:

- A needs analysis to define the scope of processes to be monitored
- Criteria for triggering email alerts
- Definition of users and related level of authorization to perform actions on data
- Identification of existing client sources for relevant container data
- Definition of data sharing requirements with other existing systems
- Definition of physical installation process and network support infrastructure
- Other criteria identified through discussions with the client

RF-IDI will take the information acquired from discussion on the points above and develop an implementation blueprint for client approval. Final RF-IDI system development will implement business rules and functionality as defined by the client-approved blueprint document.