# TeraHop Movable Wireless Sensor Networks and RFID Integration
# A General Discussion

This Application Note discusses how various types of Radio Frequency Identification (RFID) systems might be integrated with TeraHop's solutions to meet specific application requirements. As described in TeraHop Application Note AN-001, the different types of RFID systems and TeraHop's movable wireless sensor networks exhibit significantly different characteristics and meet very different user needs. However, when combined, the systems could offer users increased utility.

## Integration Alternatives

There are a number of alternative system configurations that could be implemented to integrate the TeraHop system with both passive and active RFID systems. The approach taken depends upon the specific user application. Only alternatives that do *not* require changes in the TeraHop or RFID products or fundamental changes in their operation are described.

The alternatives are based primarily in software, which can be refined for each customer's specific needs. These alternatives are designed to be both backward compatible with existing systems and capable of being implemented independently and then, later, integrated. It is also important to note that each of three systems (passive and active RFID and TeraHop) are appropriate for fundamentally different uses and meet fundamentally different system requirements. None is a completely effective replacement for the others. Simple, descriptive names have been given to each of the alternatives described below.

## Basic Piggyback Integration

This is the most basic and loosest form of integration. In it, either a passive or active RFID tag would be attached to the TeraHop RSN or to the target asset itself. In this arrangement, when an asset with an RSN and an RFID tag comes within range of an RFID reader, the reader could report the asset's portal-passage (or arrival/departure) to a user application. That application, in turn, could pass the portal-passage data to an application associated with the TeraHop RSNs. The advantage of this approach is that it could provide precise portal-location and timing data to the TeraHop application. Conversely, when the RSN sensed its presence in a Gateway coverage area, a message from the TeraHop application could update the RFID application to inform it that the asset was now present in the area. This would be quite useful for assets that may not arrive through designated portals or that may have been misread when they traveled through a portal.

RFID readers could also be placed at specific points of interest in an area and act as so-called "sign posts" to provide precise location as tagged assets passed by those particular points.

The major advantage of this approach is that the TeraHop system can monitor the *continued presence* of an asset by periodically receiving "I am still here" check-in messages from the RSN directly or from analysis of routing information associated with RSN message hopping. This capability addresses the serious limitation of passive RFID-based systems that they *cannot* detect continued presence – they can detect only that a tag passed a particular point, at a

specific time. That is for example, a passive RFID-based system can tell a user that Bob used the door at 10:05, but they cannot tell whether Bob is now in the building.

**As-Loaded Contents Transport Record**

In this arrangement, at an origin, item-level data from each RFID tag of goods on a pallet, in a box, or in another bulk package would be read by some number of readers. That accumulated data, in the form of a file, could then be sent via a TeraHop Gateway to and stored in an RSN that is attached to the bulk package (or to a shipping container door). At the destination, the item-level data file stored in the RSN would be read by a Gateway, and the list of contents that "should be" in the bulk package would be available to users. If the TeraHop device were an RSN Container Seal, the destination network could also determine whether and when the container door had been opened prior to arrival, to help determine liability of any missing contents. Essentially, the RSN becomes an in-transit electronic packing list.

**Common Application Translator**

TeraHop has developed a Complementary Network Connection architecture that will support multiple different types of asset-management systems and technologies. In this model, specialized servers called Gateway Emulators will be developed that act as protocol converters to link "foreign" systems to the TeraHop message management and routing system. These emulators will cause tags from other systems to appear to be TeraHop RSNs to customer applications. This conversion relieves the suppliers of various user applications of having to develop ways to accommodate many disparate message types and protocols that correspond to the various systems that may be generating data. For example, an RFID reader would be connected to a Gateway Emulator. When an RFID tag is read by a reader, the Gateway Emulator would pass along the asset's "presence" to the user application just as if the RFID tag were a TeraHop RSN.

With the availability of a royalty free-license to use the TeraHop Application Program Interface (API), a third-party applications vendor could enable its system to exchange messages through a TeraHop network to/from an application designed to support RFID-based systems. In this arrangement, any time that an RSN is detected in a Gateway coverage area, a message could be sent to the RFID-fed user application that would be interpreted as an asset having passed in proximity to an RFID reader.

**Reader Tracking**

In this alternative, an RSN could be attached to a portable RFID reader. As the reader is moved from coverage area to coverage area (location to location) during a field inventory process, the RSN could forward both the presence and location of that reader to a user application; perhaps through a "suitcase" or vehicle-mounted TeraHop Gateway.. Since all TeraHop Gateways have GPS capability, the GPS-generated coordinates and common user name of the location would be appended to every message sent to the user application, for each reading made by that reader. Consequently, the user would know what inventory is at which location without needing extensive RFID infrastructure at each location.

**Composite Integration and Summary**

All four of the alternatives listed above could be used in any combination to meet the needs of a specific application. As an example, consider the hypothetical use of such a system for the Federal Emergency Management Agency (FEMA) in responding to a large-scale incident:

- A FEMA container is loaded with material that would be useful in an emergency, for pre-positioning. The individual items all have passive RFID tags.
- As items are loaded into the container, the tags are read by a dock-side reader.
- The resultant as-loaded contents record is then passed to a TeraHop Gateway that, in turn, downloads the record as a file to the TeraHop RSN Container Seal that is attached to the container door.
- When the container door is closed and the TeraHop Seal put in place and armed, a message through the TeraHop network is generated, notifying FEMA.
- When the container leaves the loading area, its "lack of presence" is detected and forwarded to the appropriate application, again notifying FEMA.
- As the container traversed its route to its destination, the container's presence is detected and reported as it passed through coverage areas of TeraHop sites.
- With the RSN's constant monitoring, any severe shock, prolonged lack of motion, or breaking of the container seal would be recorded by the RSN as each event occurred and would be reported by the RSN when the container next arrived at a coverage location.
- If the container were stored at a site without Gateway coverage, the would RSN continue to monitor the integrity of the container.
- At any time, an operator with a vehicle-mounted Gateway could arrive at the site and then query all RSNs that were there and receive notification of which containers were there without having to physically inspect each, nor roam the entire site.
- Knowing which containers were present, the vehicle operator or a remote operator could then query the RSNs of individual containers to read their RFID as-loaded contents data.
- Actual contents could be compared to as-loaded contents by using an RFID reader on the site. If it were discovered that contents had been removed from a container, the location and time of the discovery would be reported via the reader’s RSN, back through the mobile Gateway and routed to FEMA.

There are, of course, many variations to the above scenario, including the encryption of the data file, the use of a combination of passive and active RFID tags, and the integration of external sensors into the system. TeraHop RSNs could also be used as gate and perimeter sensors placed around the site with their alerts integrated into the system.

**Final Comment**

The successful integration of systems requires that all of the subsystems maintain their basic functionality and requires that there be no changes to fundamental operations. It is also required that system designers clearly understand the strengths and weakness of each system and their optimum usage. TeraHop clearly understands that its system offering may not be the

best for certain applications. The Company has, therefore, taken into account the need to be flexible and work in integrated environments in a manner that best meets the needs of each customer. Finally, TeraHop understands that it is unreasonable to expect users to either discard their existing systems and practices or to attempt to implement complex systems simultaneously. The alternatives described above take these factors into account. Over time, other alternatives will certainly arise and, hopefully, will follow the same simple and straightforward integration model.

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