Intel® RSP SW Toolkit - Gateway

Installation & User's Guide

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Revision History

Version	Revision	Description
	2018.11.14	Initial draft.
	2018.12.11	Updated screenshots.
	2018.12.13	Branding updates.
338443-001	2018.12.20	Fixed missing reference for behavior. Removed stale TODO comment
338443-002	2019.04.14	Updated contents for clusters, web admin, aliases and software update capability. Addressed path discrepancies in build/deploy instructions. Updated Windows installation instructions. Added Quick Start section.

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1 Introduction

This document is a guide to the installation, setup and use of the Gateway Application Reference Design, which is one component of the Intel® RSP SW Toolkit. The features and functionality included are intended to showcase the capabilities of the Intel® RFID Sensor Platform (Intel® RSP) by demonstrating the use of the API to collect and process RFID tag data. THIS SOFTWARE IS NOT INTENDED TO BE A COMPLETE END-TO-END INVENTORY MANAGEMENT SOLUTION.

1.1 Terminology

Term	Description
RSP	RFID Sensor Platform
NFC	Near Field Communications
Deep Scan Behavior	A particular set of RFID protocol parameters that is intended to read as many tags as possible but the read rate is lower.
Mobility Behavior	A particular set of RFID protocol parameters that is intended to read tags in motion as quickly as possible.

1.2 Reference Documents

Document	Document No./Location
RSP-Hx000_User_Guide	338088-002
RSP-Hx000_Message_API	338178-001
Intel® RSP SW Toolkit - Sensor NFC App User Guide	338454-001

2 Quick Start

This section provides abbreviated instructions on the installation and setup of the Intel® RSP SW Toolkit – Gateway. These instructions contain links to later in the document.

2.1 Linux Installation

- Install OS (i.e. Ubuntu 18.04, Debian 9)
- Install dependencies (Section 6.1.1)
    - default-jdk
    - git
    - gradle
    - mosquitto (or use a public broker tor testing)
    - mosquitto-clients
    - avahi-daemon
    - ntp (or use a public time server)
    - ssh
- Clone the github repository (Section 6.1.2)
- Build and deploy the project (Section 6.1.3)
- Verify the Project Runtime Folders (Section 6.3)
- Change the Optional Configuration Parameters (Section 6.4)
- Generate Security Certificates (Section 6.5.1)
- Run the software (Section 6.6)
- Connect the sensor hardware or use the RSP simulator (Section 6.7)
- Open the Wed Admin (Section 8)
- Use the Command Line Interface (Section 9)

2.2 Windows Installation

- Install dependencies (Section 6.2.1)
    - OpenJDK
    - Git
    - OpenSSL
    - Mosquitto
- Edit Path Environment Variable (Section 6.2.2)
- Clone, Build and Deploy the project (Section 6.2.3)
- Verify the Project Runtime Folders (Section 6.3)
- Change the Optional Configuration Parameters (Section 6.4)
- Generate Security Certificates (Section 6.5.2)
- Run the software (Section 6.6)
- Connect the sensor hardware or use the RSP simulator (Section 6.7)
- Open the Wed Admin (Section 8)
- Use the Command Line Interface (Section 9)

3 Sensor Product Description

The RSP-9000, RSP-H1000, RSP-H3000 and RSP-H4000 are members of the Intel® RFID Sensor Platform (Intel® RSP) family of devices. These devices have capabilities for several on-board sensors including an EPC Gen 2 UHF RFID Interrogator (reader). These Sensors are designed to work stand-alone, or in a network of other "Smart Sensors" as part of an Internet-of-Things (IoT) system where computing power is pushed out to the edge devices.

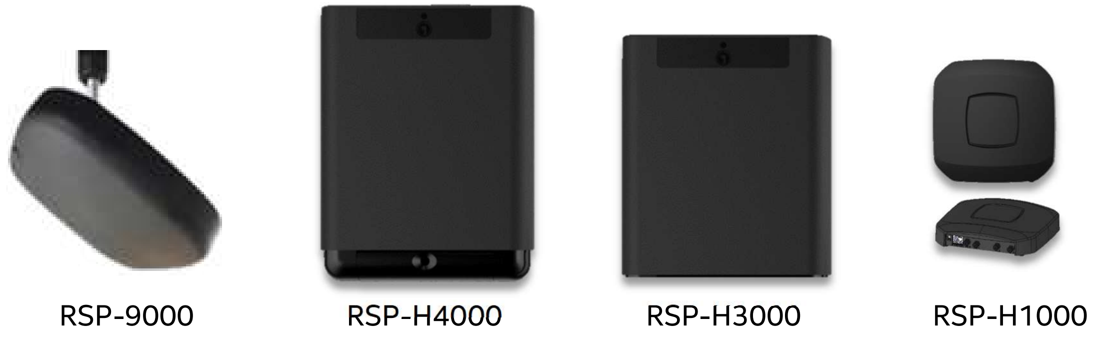


Figure 1: Intel® RFID Sensor Platform (Intel® RSP)

The Gateway Reference is an application that demonstrates the use of the API to collect and process RFID tag data and acts as the IOT Gateway between one or more RSP's and an Inventory Management or Asset Tracking application. The Gateway Reference Design creates the credentials used by the Sensor NFC Application (another component of the Intel® RSP SW Toolkit).

4 System Description

A complete end-to-end Inventory Management solution might look something like the figure below. One or more Sensors sending raw data to a Gateway that processes the raw data and creates meaningful events, which are sent to an Inventory Management Application that can exist locally or in the Cloud.

4.1 Data Flow

From a data flow perspective, the Sensor interrogates the RFID tag population within its field of view and passes information regarding the tags as well as information from other various on-board sensors to the Gateway. The Gateway aggregates this Sensor data and generates inventory events, alerts, and system status notifications available for consumption on an upstream channel to applications running in a customer's cloud infrastructure. The figure below illustrates the flow of data and control within the system.

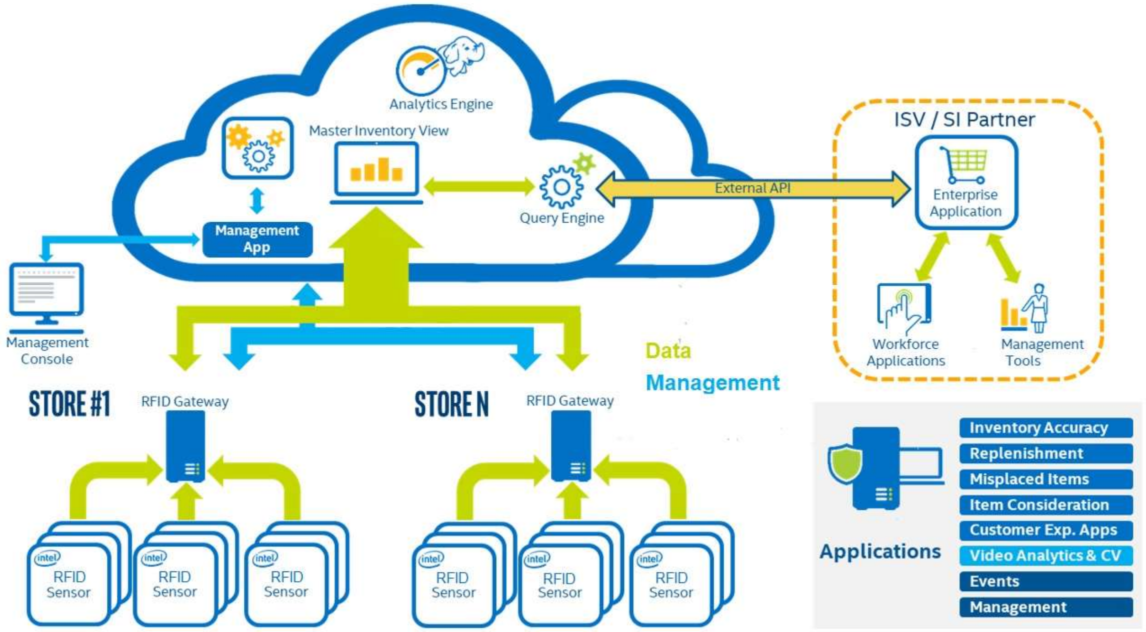


Figure 2: Example System Data Flow

4.2 Applications

Customers may utilize their own infrastructure for applications that ingest the events from the Gateway allowing them to determine item identification, location, movement and status. CUSTOMERS ARE SOLELY RESPONSIBLE FOR THEIR OWN CLOUD INFRASTRUCTURE AND APPLICATIONS, INCLUDING FOR IDENTIFYING AND IMPLEMENTING THE APPROPRIATE LEVEL OF SECURITY FOR THE DATA COLLECTED VIA THE DEVICES.

4.3 Gateway

The Gateway performs Sensor control, management, data aggregation, data processing, and event management as well as event generation for upstream consumption all over a secure data channel. It also supports configuration and management from a local interface. CUSTOMERS ARE SOLELY RESPONSIBLE FOR CONFIGURING THEIR MQTT BROKER FOR THE APPROPRIATE LEVEL OF SECURITY FOR THE DATA COLLECTED VIA THE DEVICES.

4.4 Intel® RFID Sensor Platform (Intel® RSP)

The RSP devices provide the ability to remotely and securely command, control, status, and data collection via Ethernet. Data from RFID tag reads as well as data from other on-board sensors is published to an MQTT broker. The data API is based on JSON RPC requests, responses and notifications. JSON-RPC is a text based, stateless, lightweight remote procedure call (RPC) protocol.

4.5 JSON RPC

A secure remote capability for command, control, status and data collection exists via JSON Remote Procedure Call (RPC) over an encrypted MQTT channel. CUSTOMERS ARE SOLELY RESPONSIBLE FOR CONFIGURING THEIR MQTT BROKER FOR THE APPROPRIATE LEVEL OF SECURITY FOR THE DATA COLLECTED VIA THE DEVICES.

The Gateway Command set follows the JSON RPC 2.0 specification. JSON-RPC is a stateless, lightweight protocol that is transport agnostic.

4.5.1 Request Object

The Request object has the following members:

- **jsonrpc**
    - A String specifying the version of the JSON-RPC protocol.
- **method**
    - A String containing the name of the method to be invoked.
- **params**
    - A Structured value that holds the parameter values to be used during the invocation of the method.
    - This member may be omitted.
- **id**
    - An identifier containing a String or Number value (if included).
    - This member is used to correlate the context between requests and responses.

4.5.2 Notification Object

A Notification is a Request object without an "id" member. A Request object that is a Notification signifies that a corresponding Response object is not expected.

4.5.3 Response Object

The Response is expressed as a single JSON Object, with the following members:

- **jsonrpc**
    - A String specifying the version of the JSON-RPC protocol.
- **result**
    - The presence of this member indicates successful execution of the corresponding method.
    - This member is not present when the execution of the method resulted in an error.
- **error**
    - The presence of this member indicates unsuccessful execution of the corresponding method.
    - This member is not present when the execution of the method was successful.
    - When present, the error Object contains the following members:
        - **code**
            - An integer that indicates the error type that occurred.
        - **message**
            - A String providing a short description of the error.
        - **data**
            - A Primitive or Structured value that contains additional information about the error (optional).
    - See table below for supported error codes.
- **id**
    - This member is always present on a response and contains the same value as the id member in the corresponding Request Object.
    - This member is not present on indications.

4.5.4 Error Codes

The RSP provides one of the following error codes when an error occurs.

Table 1 JSON RPC Error Code Fields

Code	Message	Meaning
-32001	Wrong State	Cannot be executed in the current state
-32002	Function not supported	The requested functionality is not supported
-32100	No facility assigned	The RSP has no Facility ID assigned yet
-32601	Method not found	The method does not exist
-32602	Invalid Parameter	Out of range or invalid format
-32603	Internal Error	RSP application error
-32700	Parse error	Invalid JSON Object

4.6 MQTT

The Sensor supports the MQTT machine-to-machine "Internet of Things" connectivity protocol. By subscribing and publishing to a set of "topics", the Sensors coordinate with the Gateway. Sensors support TLS encrypted MQTT connections by using the server certificate and MQTT credentials assigned by the Gateway.

NOTE: Certificate management is important when using TLS encryption on the MQTT broker. If the root certificate used for the MQTT broker is not publicly trusted, it must be the same root certificate used by the Gateway's REST endpoints.

4.7 REST

The Sensor obtains necessary configuration data via REST endpoints. These endpoints are provided to the Sensor by the Gateway as part of the "zeroconf" discovery process described later in this document. A simple data architecture diagram is shown below. The Gateway endpoints are secured using the root certificate and the server certificate.

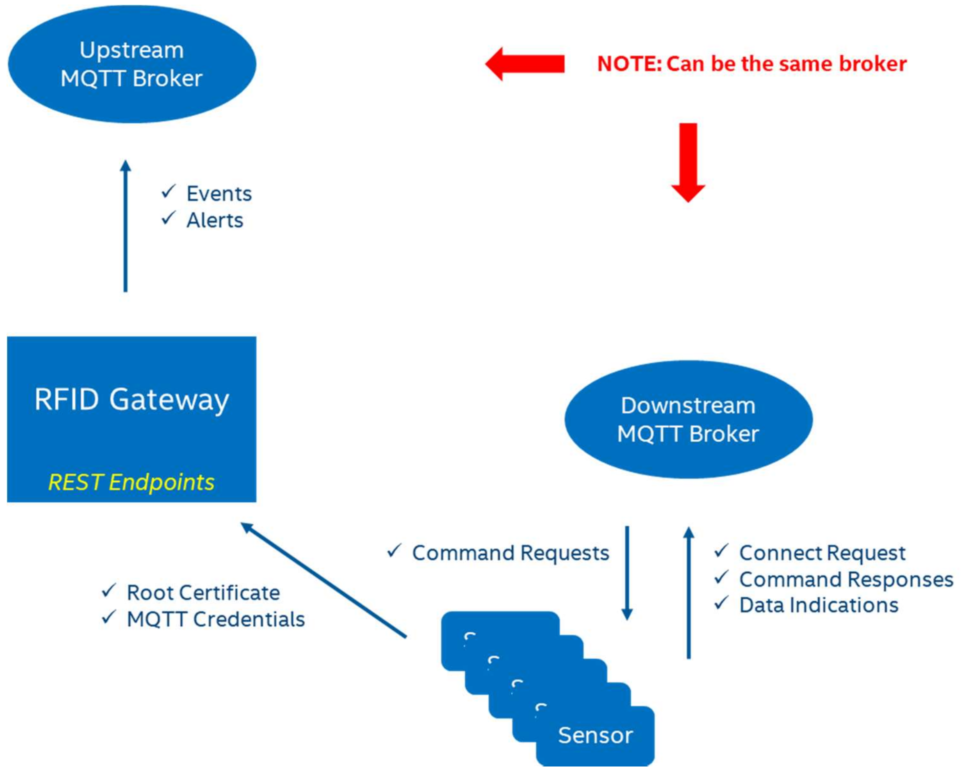


Figure 3: Simple Data Flow Architecture

4.8 System Requirements

To ensure proper functionality of the Gateway, the following requirements should be observed for both the hardware platform that the application is running on and the network to which it's attached.

4.8.1 Hardware Requirements

To support the complex algorithms necessary for real-time tag location and dynamic Sensor management, it is recommended the Gateway should be installed on a machine with the following minimum configuration.

- ✓ CPU: Intel® Core© i5, 8MB Cache, Intel® vPro, Intel® AMT Technology
- ✓ RAM: 16 GB minimum
- ✓ SDD: 80 GB minimum

4.8.2 Software Requirements

The Gateway is a Java application. As such, it can run on any OS that supports a Java Runtime Environment version 8 or greater. The development of the Gateway software has been done on an Ubuntu Linux platform and there are several bash scripts supporting installation and configuration, so to enable out of the box (repository) operation, a Linux OS is recommended.

4.8.3 Network Requirements

To facilitate the "zeroconf" discovery process between Gateway and Sensors, it is recommended that all the devices be on the same LAN segment. The table below lists the protocols and typical ports used for the network communications between the Gateway and Sensors.

Table 2 Local Network Protocols and Ports

Port	Protocol	Purpose
5353	mDNS	Service discovery of Gateway and Sensors
1883, 9883	tcp, ssl	MQTT message transport
80, 443, 8080, 8443	tcp	http, https for software management
22, 62939, 5222	ssh	Gateway and Sensor shell connectivity for trouble shooting and log viewing
123	ntp	Time synchronization across Sensors

5 Concept of Operation

The following functionalities are supported by this reference design.

- Configuration and management of a population of Sensors which includes actively coordinating the reading of tags by each Sensor using scheduling and behaviors.
- Processing tag data produced by each Sensor.
- Determining an approximate tag location via algorithms that consider the signal strength, the behavior used to generate the tag read, and a mobility profile that enables customization of the algorithm.
- Generating various tag events (arrived, moved, departed, returned) depending on changes of a tag's location. The generation of these events are influenced by Sensor facility and personality configurations. These events are published to an upstream MQTT broker.
- Providing real time visibility into the performance of the system by presenting aggregated statistics for Sensors and tags.

There are two Communication channels identified for the gateway

- *Downstream* - between Sensor(s) and gateway
- *Upstream* - between gateway and any 3rd party applications consuming data from the Upstream MQTT broker.

5.1 Configuration: Sensor Facility

Facilities are used to create zones that govern tag event generation i.e. a tag will arrive in a facility, a tag will depart one facility and arrive in another facility. A tag will move within a facility. Each Sensor must be assigned to one, and only one facility and the tags read by that Sensor are associated with that facility. The Gateway can support multiple facilities. It is acceptable to assign all Sensors managed by a Gateway to the same facility.

Facilities can be assigned to Sensors either via the command line interface or a schedule configuration.

5.2 Configuration: Sensor Personality

Personalities are used to optionally identify special functionality for a Sensor. Tag reads from these Sensors have unique meaning and are handled differently by the tag processing algorithms.

5.2.1 EXIT Personality

As the name implies, an EXIT personality indicates that the Sensor is located at or near the exit of a facility. Tags that are from these are highly likely to be on their way out. A

DEPARTED event is generated by the Gateway when RFID tags are last seen by an EXIT Sensor and are not seen again for a configurable amount of time.

5.2.2 Point of Sale (POS) Personality

A POS (Point-of-Sale) personality is used when tag reads coming from these Sensors will immediately generate a departed event. The use-case for configuring a Sensor with a POS Personality might be either a store checkout or exit portal. The time delay for when a tag is allowed to depart and when it is allowed to re-enter the inventory is configurable. See the INVENTORY section of the gateway.cfg file.

5.2.3 FITTING_ROOM Personality

This personality is only useful as a reference. There is no special handling of tag reads associated with it.

5.3 Configuration: Sensor Aliases

Aliases can be used to identify a specific Sensor/Antenna-Port combination. This tuple is used to identify the location of tags in the inventory (as discussed in section 5.7.1). Aliases can be explicitly assigned using the CLI or automatically assigned when using Cluster Tokens (as discussed in section 7).

5.4 Configuration: RFID Behaviors

RFID Behaviors, in general, contain ISO 18000-6C protocol specific parameters as well as other information regarding the RF behavior of the Sensor. See the Example Behavior section for details of the parameters. The gateway includes several default behaviors that are appropriate for tag read scenarios such as mobility which emphasizes reading tags that are in motion and deep scan which emphasizes long scan times and reading as many unique tags as possible.

The Gateway also supports adding custom behaviors by simply adding JSON files to the behaviors configuration directory. See the Deployment section for details of where to add new behavior configurations.

Specific naming criteria is used to differentiate some of the default behaviors including influencing the behavior of the Sensor based on keywords included in the behavior id. NOTE!! The behavior id and the filename must match, excluding the .json extension.

5.4.1 WITH_TID

Any behavior that includes this token in the id will cause the sensor to read the TID memory bank of the RFID tags.

NOTE!! Reading TID requires additional RFID protocol activity and as such, tag read rates are much lower.

5.4.2 PORTS_#

Any behavior that includes this token in the id indicates the minimum number of antenna ports required. For example, the H1000 has four antenna ports available. The installation requirements are for three ports to be connected. The system should send alerts if one of the cables is loosened or damaged and unusable.

Create and use a behavior with PORTS_3 in the id. When the sensor sees this behavior, it will verify that there are at least 3 good antenna connections. If there are less ports available, the sensor sends an alert to the gateway.

5.4.3 Example Behavior

Here is an example of the contents of a behavior.

git repo: config/behaviors/DefaultAllOn.json

```
{
  "id": "DefaultAllOn",
  "operation_mode": "NonContinuous",
  "link_profile": 1,
  "power_level": 30.5,
  "selected_state": "Any",
  "session_flag": "S1",
  "target_state": "A",
  "q_algorithm": "Dynamic",
  "fixed_q_value": 10,
  "start_q_value": 7,
  "min_q_value": 3,
  "max_q_value": 15,
  "retry_count": 0,
  "threshold_multiplier": 2,
  "dwell_time": 5000,
  "inv_cycles": 0,
  "toggle_target_flag": true,
  "repeat_until_no_tags": false,
  "perform_select": false,
  "perform_post_match": false,
  "filter_duplicates": false,
  "toggle_mode": "OnInvCycle",
  "auto_repeat": false
}
```

5.5 Configuration: Clusters

Cluster Configurations are used to manage a population of Sensors. Several configuration topics are all combined into one text file which handles assigning facilities personalities and aliases, grouping of Sensors to minimize interference, and selecting behaviors to apply for the Sensor to use when reading tags. The following concepts help to understand the configuration.

- A Sensor Group is a collection of one or more sensors that will be managed as a group. Sensors in the group will all read tags at the same time.
- A Cluster contains one or more Sensor Groups and has an associated Facility, Behavior, and optional Personality.

The following JSON is an example of a cluster configuration using sensor device ids:

git repo: src/test/resources/clusters/sample_sensor_cluster_config.json

```
{
  "id": "SampleSensorClusterConfig",
  "clusters": [
    {
      "id": "BackStock",
      "facility_id": "BackStock",
      "behavior_id": "ClusterDeepScan_PORTS_1",
      "sensor_groups": [
        ["RSP-150000"],
        ["RSP-150001"]
      ]
    }, {
      "id": "SalesFloorMobility",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterMobility_PORTS_1",
      "sensor_groups": [
        ["RSP-150002", "RSP-150004", "RSP-150006"],
        ["RSP-150003", "RSP-150005", "RSP-150007"]
      ]
    }, {
      "id": "SalesFloorExit",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterExit_PORTS_1",
      "personality": "EXIT",
      "sensor_groups": [
        ["RSP-150008"]
      ]
    }, {
      "id": "SalesFloorPOS",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterPOS_PORTS_1",
      "personality": "POS",
      "sensor_groups": [
        ["RSP-150009"]
      ]
    }, {
      "id": "SalesFloorFittingRoom",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterFittingRoom_PORTS_1",
      "personality": "FITTING_ROOM",
      "sensor_groups": [
        ["RSP-150010"]
      ]
    }
  ]
}
```

5.6 Scheduling Tag Reads

Scheduling a population of Sensors tag reading activity is important because of the following:

- *Managing Interference* - When nearby Sensors are actively reading at the same time, the RF energy can cause interference. It is important to recognize and minimize this interference. This can be done by the location of the Sensors and also by grouping Sensors together based on non-interference and then scheduling these groups to actively read at the same time.
- *Managing RFID Read Parameters (Behaviors)* - Behaviors are used to describe a set of parameters that can be applied to a Sensor while it executes tag reads. As described below, a Sensor is sent a behavior configuration when commanded to start reading tags. See section 5.4.3 for more details of a behavior.

The schedule manager coordinates different modes of Sensor read activity including starting and stopping Sensors according to a configurable sequence. This manager is controlled via the command line interface and any changes applied from there are persistent across restarts of the gateway. The following describe the possible run states of the schedule manager.

5.6.1 INACTIVE

The scheduler is not actively commanding any Sensors to read tags.

5.6.2 ALL_ON

All Sensors will be reading constantly using the ***default_all_on*** behavior.

5.6.3 ALL_SEQUENCED

A single Sensor at a time will be reading using the ***default_all_sequenced*** behavior. This mode does a round robin sequence of every Sensor connected to the gateway.

5.6.4 FROM_CONFIG

The schedule manager will create a cluster runner for each of the clusters defined in the configuration. The Facility and (optional) Personality will be assigned to the Sensors in the cluster and then a control algorithm is used to iterate through the groups of Sensors. For each group, the behavior is applied and all Sensors are commanded to start reading tags. After all Sensors in the group have finished reading tags or timed out, as determined by the Behavior parameters, the next group of Sensors is started. The groups are continuously looped until the schedule manager changes run state.

It is perfectly fine to have a cluster with just a single sensor group that contains a single sensor.

To manage RFID interference, Sensors need to be placed in groups such that interfering Sensors are not in the same group in the cluster.

5.7 Processing Tag Reads

Tag read data includes information such as the EPC, RSSI of the read and includes the antenna port that the Sensor used. These tag reads are ingested from the Downstream MQTT broker and processed as Inventory data using the EPC as a unique key. Sensor and tag read statistics are aggregated and updated and then location and event generation algorithms are executed on the updated tag data.

5.7.1 Tag Location

An RFID tag's location is associated with a particular Sensor and antenna port. A location is determined based on the "quality" of the tag reads (i.e. RSSI, read rate) averaged over time. For a tag's location to move from one Sensor/antenna to another Sensor/antenna, the reported new RSSI must be better than a calculated threshold that is added to the current location's RSSI. A "mobility profile" defines the parameters of the RSSI slope formula used to calculate this threshold.

If the tag is read with a Deep Scan behavior, the threshold value itself is used, otherwise the threshold value decays over time according to the parameters in the mobility profile. Mobility profiles are configurable by the user.

Parameters:

```
T - RSSI threshold (dBm) that must be exceeded for the tag to move from the previous sensor
M - Slope (dBm per millisecond) used to determine the weight applied to older RSSI values
A – Hold-off time (milliseconds) to shift the slope such that when time == A, the weight = T
```

Algorithm:

```
// find b such that at 60 seconds, y = 3.0
// b = y - (m*x)
B = T - (M * A);
// weight used in the RSSI comparison
w = (M * (System.currentTimeMillis() - _lastReadMillis)) + B;
// weight cannot be more than the absolute threshold
if (w > T) { w = T; }
```

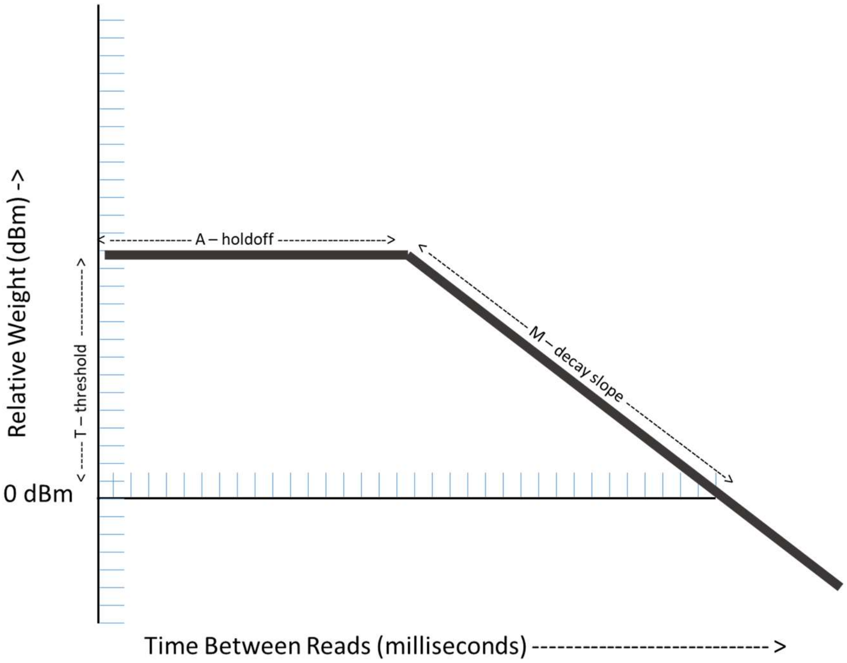


Figure 4 Mobility Profile

These profiles are JSON files and customized profiles can be used by adding the file to the “<DEPLOY_DIR>/config/mobility” directory. The following profiles exist by default with the RSP-Gateway-Demo software.

config/mobility/asset_tracking_default.json

```
{
  "id" : "asset_tracking_default",
  "a" : 0.0,
  "m" : -8.0E-3,
  "t" : 6.0
}
```

config/mobility/retail_garment_default.json

```
{
  "id" : "retail_garment_default",
  "a" : 60000.0,
  "m" : -5.0E-4,
  "t" : 6.0
}
```

5.7.2 Tag States

There are five possible states for a tag.

- *unkown* - This is an initial state that only exists momentarily upon tag data creation. It should actually never be visible from any user perspective.
- *present* - The tag has been read and is currently in the inventory.
- *exiting* - The tag has been read by a Sensor with an Exit personality and potentially will be departing.
- *departed exit* - An exiting tag that has not been seen for some amount of time is assumed to no longer be in the inventory.
- *departed pos* - A tag that is read by a Sensor with POS personality will immediately enter this state.

5.7.3 Tag Events

The transition of tags between states will generate events that are sent Upstream. The events types include the following:

- *arrival* - Indicates tag is "new".
- *moved* - Indicates a tag has changed location.
- *departed* - Indicates a tag has "left".
- *returned* - Indicates a tag that was previously departed has shown up again.

NOTE: tag location changes generate moves if both sensors are in the same facility, otherwise they generate departure / arrival pairs.

5.7.4 Tag Processing Algorithm

The following pseudo code describes the logic flow that occurs for every tag read after tag location is recomputed based on the tag state. Event generation occurs for any step with event[EVENT_NAME] and tag state changes are indicated similarly by state[NEW_STATE}.

```
UNKNOWN:
  is not POS ?
    event[ARRIVAL]
    state[PRESENT]

PRESENT:
  is POS ?
    is read time > inventory.POS.departed.threshold.millis ?
      event[DEPARTED]
      state[DEPARTED_POS]
    else
      is location changed ?
        is facility changed ?
          event[DEPARTED]
          event[ARRIVAL]
        else
          event[MOVED]
  else
    is EXIT ?
      is shedule ALL_ON or FROM_CONFIG ?
        state[EXITING]
    is location changed ?
      is facility changed ?
        event[DEPARTED]
        event[ARRIVAL]
      else
        event[MOVED]

EXITING:
  is POS ?
    is inventory.POS.departed.threshold.millis exceeded?
      event[DEPARTED]
      state[DEPARTED_POS]
    else is not EXIT and is location changed ?
      state[PRESENT]
      is facility changed ?
        event[DEPARTED]
        event[ARRIVAL]
      else
        event[MOVED]

DEPARTED_EXIT:
  is not POS ?
    is facility changed ?
      event[ARRIVAL]
    else
      event[RETURNED]
    state[PRESENT]
    is EXIT ?
      is shedule ALL_ON or FROM_CONFIG ?
        state[EXITING]

DEPARTED_POS:
  is not POS and is inventory.POS.return.threshold.millis exceeded ?
    is facility changed ?
      event[ARRIVAL]
    else
      event[RETURNED]
    state[PRESENT]
    is EXIT ?
      is shedule ALL_ON or FROM_CONFIG ?
        state[EXITING]
```

5.8 Upstream Events

The Gateway generates JSON RPC Notifications on the Upstream MQTT broker for inventory events and device alerts.

Table 3 RSP (RSP) Gateway Indications

Indication	Brief Description
inventory_event	Indicates that an inventory "event" has been detected. These indications are sent to the following MQTT topic < upstream mqtt topic prefix >/events
device_alert	Indicates an alert condition exists with either the Gateway or one of the connected Sensors. These indications are sent to the following MQTT topic < upstream mqtt topic prefix >/alerts

5.8.1 Inventory Event

Table 4 Inventory Event Notification Parameters

Parameter	Definition
sent_on	The millisecond timestamp of this indication.
data	An array of RFID tag records.

Each Data record contains the following fields.

facility_id	The ID assigned to the facility where the event occurred.
epc_code	The EPC of the tag associated with this record.
epc_encode_format	Reserved for future use, currently "tbd".
tid	The TID of the tag associated with this record.
event_type	Values are "arrival", "departed", “moved” and "returned".
timestamp	The millisecond timestamp of this event.
location	The alias assigned to the particular sensor and antenna port associated with this tag.

```
{
   "jsonrpc":"2.0",
   "method":"inventory_event",
   "params":{
      "sent_on":1424976117309,
      "data":[
         {
            "facility_id":"store-front"
            "epc_code":"100000000000000000002A1",
            "epc_encode_format":"tbd",
            "tid":"E28011606000020BCEC36DC1",
            "event_type":"arrival",
            "timestamp":1424976117895,
            "location":"RSP-9b472d-1"
         }
      ]
   }}
```

5.8.2 Gateway Device Alert

Table 5 Gateway Device Alert Parameters

Parameter	Definition
sent_on	The millisecond timestamp of this indication.
device_id	The ID assigned to the reporting RFID Sensor Platform.
alert_number	A unique number identifying the type of alert. The valid range of values is… 100 – RF_MODULE_ERR 101 – HIGH_AMBIENT_TEMP 102 – HIGH_CPU_TEMP 103 – HIGH_CPU_USAGE 104 – HIGH_MEMORY_USAGE 151 – DEVICE_MOVED 195 – RSP_CONNECTED 196 – RSP_SHUTTING_DOWN 197 – RSP_FACILITY_NOT_CONFIGURED 198 – RSP_LOST_HEARTBEAT 199 – RSP_LAST_WILL_AND_TESTAMENT 240 – GATEWAY_STARTED 241 – GATEWAY_SHUTTING_DOWN
alert_description	A corresponding human readable text description.
severity	A prioritized severity level of the alert. The valid range of values is… *"info"*, *"warning"*, *"urgent"*, and *"critical"*.
optional	A series of optional number or string parameters providing further information about the alert.
facilities	A list of facility_id's that may be affected by this alert.

```
{
   "jsonrpc":"2.0",
   "method":"device_alert",
   "params":{
      "sent_on":1424976117309,
      "device_id":"RSP-abcdef",
      "alert_number":101,
      "alert_description":"HighAmbientTemp",
      "severity":"warning",
      "optional":{
         "string":"degrees_c",
         "number":51
}
      "facilities": [
         "store-front"
      ]
   }
}
```

6 Build and Deploy

The source code and more information regarding the Gateway can be downloaded from the Intel® Open Source Portal https://01.org/rsp-sw-toolkit. The project sources are located on Github at https://github.com/intel/resp-sw-toolkit-gw.

The Linux instructions can also be found in the Github README.md file. They assume an Ubuntu 18.04 LTS installation. This section will cover both Linux and Windows® 10 installation procedures.

6.1 Linux

6.1.1 Install Dependencies

```
# development dependencies
sudo apt-get install default-jdk git gradle

# runtime dependencies
sudo apt-get install mosquitto avahi-daemon ntp ssh
```

6.1.2 Clone the Project

```
# the cloned repo can be anywhere but as a suggestion,
# create a projects directory
mkdir -p ~/projects
cd ~/projects
git clone https://github.com/intel/rsp-sw-toolkit-gw.git
```

6.1.3 Build and Deploy

```
# build an archive suitable for deployment
cd ~/projects/rsp-sw-toolkit-gw/
gradle deploy
```

6.2 Windows® 10

6.2.1 Install Dependencies

6.2.1.1 OpenJDK

Follow the instruction to download and install Open JDK for Windows® from the following website.

https://openjdk.java.net/

6.2.1.2 Git

Follow the instructions to download and install Git for Windows® from the following website. Be sure to include the OpenSSL option.

https://gitforwindows.org/

6.2.1.3 OpenSSL

With Git installed, the openssl binary can be found here.

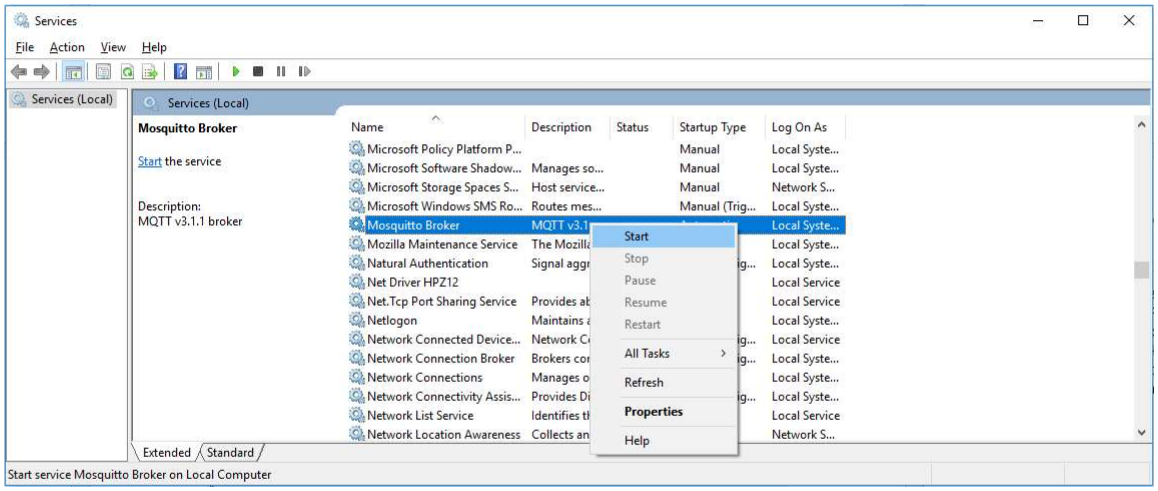
C:\Program Files\Git\usr\bin\openssl.exe

6.2.1.4 MQTT

Follow the instruction to download and install the mosquitto MQTT broker for Windows® as a service from the following website.

https://mosquitto.org/download/

Once installed, start the broker service as shown below.



Mosquitto Broker

Start the service

Description:
MQTT v3.1.1 broker

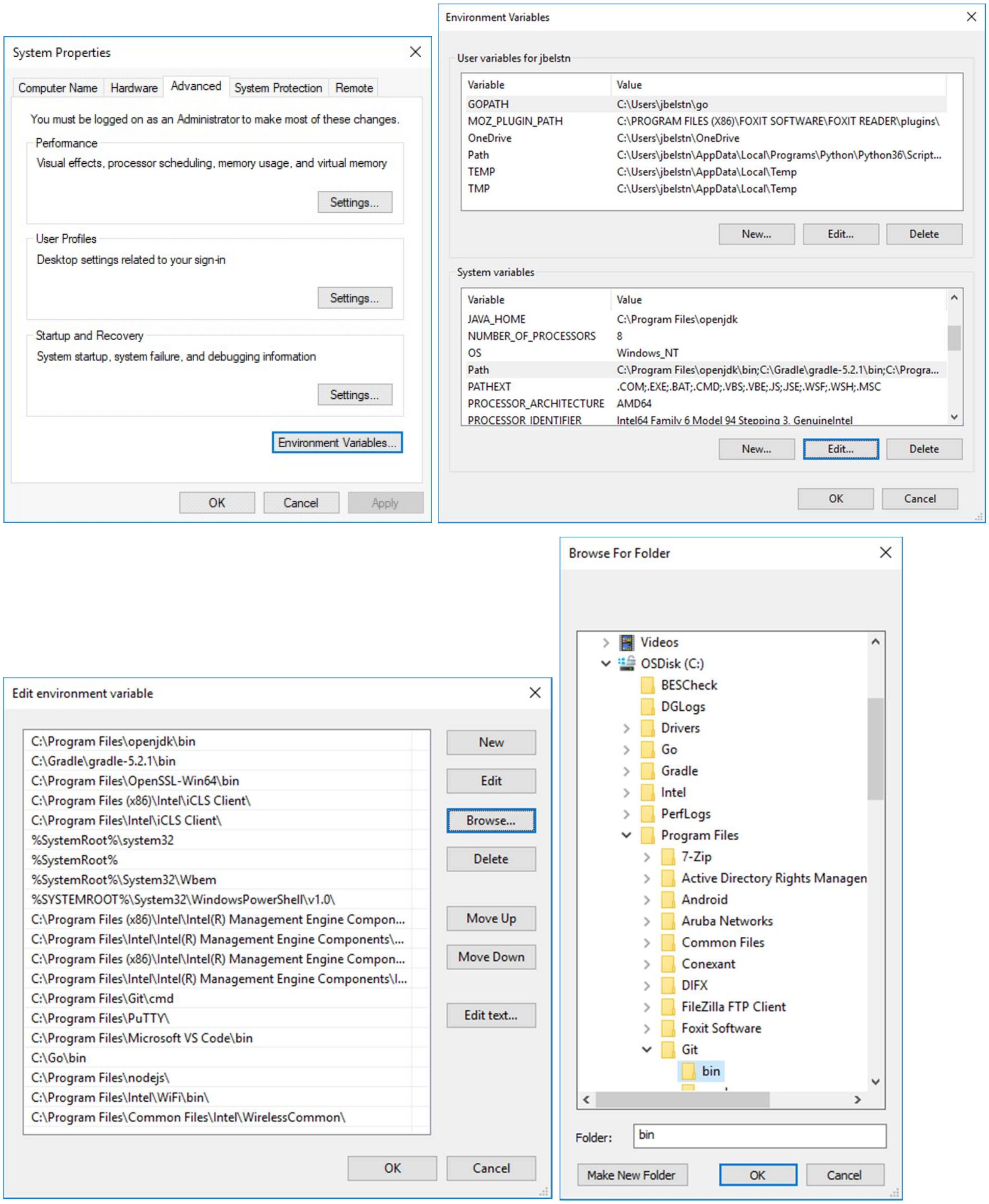
Name	Description	Status	Startup Type	Log On As
Microsoft Policy Platform P...			Manual	Local Syste...
Microsoft Software Shadow...	Manages so...		Manual	Local Syste...
Microsoft Storage Spaces S...	Host service...		Manual	Network S...
Microsoft Windows SMS Ro...	Routes mes...		Manual (Trig...	Local Syste...
Mosquitto Broker	MQTT v3.1			Local Syste...
Mozilla Maintenance Service	The Mozilla			Local Syste...
Natural Authentication	Signal aggr		ig...	Local Syste...
Net Driver HPZ12				Local Service
Net.Tcp Port Sharing Service	Provides ab			Local Service
Netlogon	Maintains a			Local Syste...
Network Connected Device...	Network C		ig...	Local Service
Network Connection Broker	Brokers cor		ig...	Local Syste...
Network Connections	Manages o			Local Syste...
Network Connectivity Assis...	Provides Di		ig...	Local Syste...
Network List Service	Identifies th			Local Service
Network Location Awareness	Collects an			Network S...

Start service Mosquitto Broker on Local Computer

Figure 5 Starting the Windows® Mosquitto Broker

6.2.2 Edit the Path Environment Variable

Add the paths for **both** the Open JDK and to the OpenSSL bin directories to your "Path" environment variable as shown below.



User variables for jbelstn

Variable	Value
GOPATH	C:\Users\jbelstn\go
MOZ_PLUGIN_PATH	C:\PROGRAM FILES (X86)\FOXIT SOFTWARE\FOXIT READER\plugins\
OneDrive	C:\Users\jbelstn\OneDrive
Path	C:\Users\jbelstn\AppData\Local\Programs\Python\Python36\Script...
TEMP	C:\Users\jbelstn\AppData\Local\Temp
TMP	C:\Users\jbelstn\AppData\Local\Temp

System variables

Variable	Value
JAVA_HOME	C:\Program Files\openjdk
NUMBER_OF_PROCESSORS	8
OS	Windows_NT
Path	C:\Program Files\openjdk\bin;C:\Gradle\gradle-5.2.1\bin;C:\Progra...
PATHEXT	.COM;.EXE;.BAT;.CMD;.VBS;.VBE;.JS;.JSE;.WSF;.WSH;.MSC
PROCESSOR_ARCHITECTURE	AMD64
PROCESSOR_IDENTIFIER	Intel64 Family 6 Model 94 Stepping 3, GenuineIntel

Edit environment variable

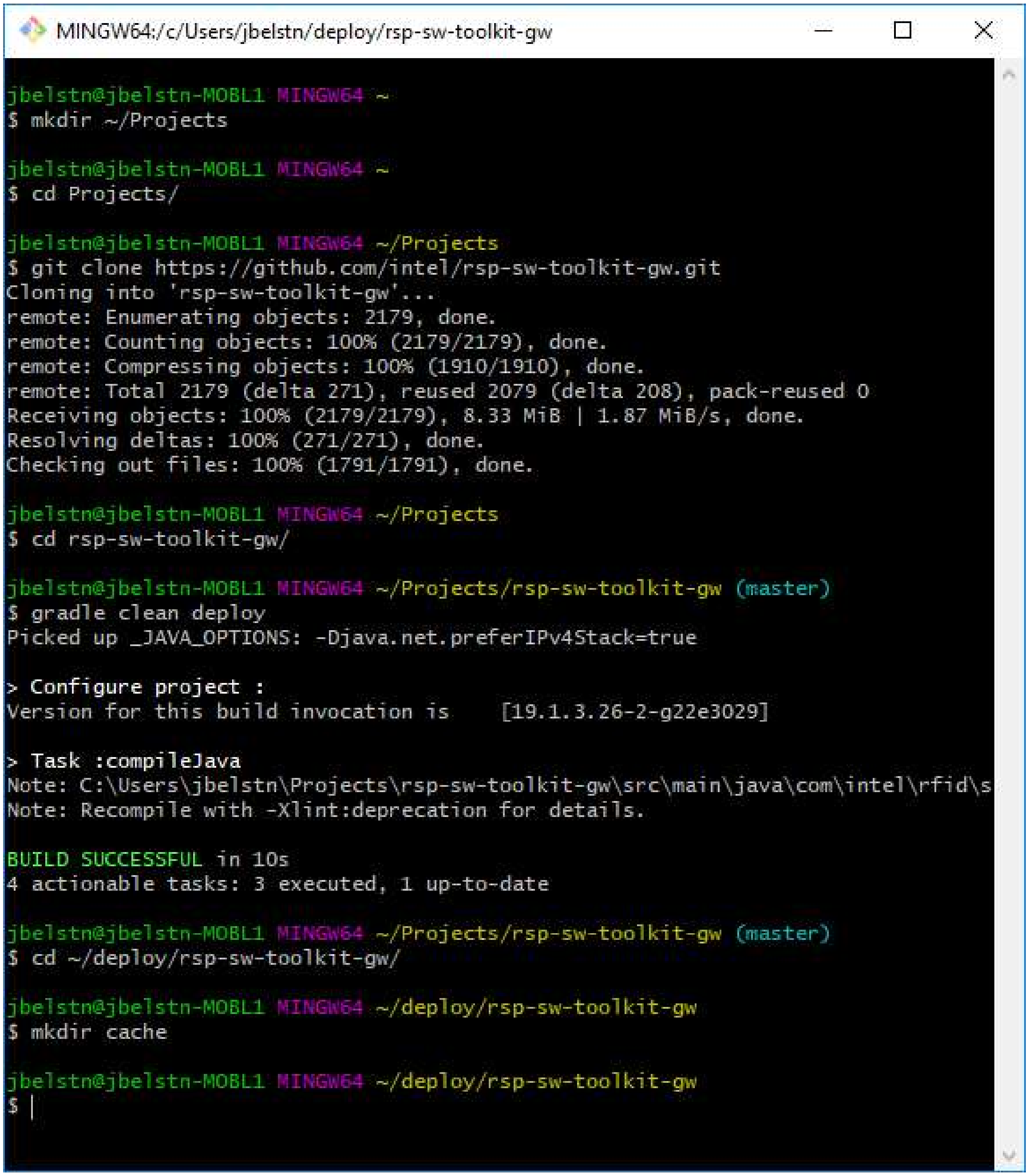
```
C:\Program Files\openjdk\bin
C:\Gradle\gradle-5.2.1\bin
C:\Program Files\OpenSSL-Win64\bin
C:\Program Files (x86)\Intel\iCLS Client\
C:\Program Files\Intel\iCLS Client\
%SystemRoot%\system32
%SystemRoot%
%SystemRoot%\System32\Wbem
%SYSTEMROOT%\System32\WindowsPowerShell\v1.0\
C:\Program Files (x86)\Intel\Intel(R) Management Engine Compon...
C:\Program Files\Intel\Intel(R) Management Engine Components\...
C:\Program Files (x86)\Intel\Intel(R) Management Engine Compon...
C:\Program Files\Intel\Intel(R) Management Engine Components\I...
C:\Program Files\Git\cmd
C:\Program Files\PuTTY\
C:\Program Files\Microsoft VS Code\bin
C:\Go\bin
C:\Program Files\nodejs\
C:\Program Files\Intel\WiFi\bin\
C:\Program Files\Common Files\Intel\WirelessCommon\
```

Folder: bin

Figure 6 Editing the Windows® Path Variable

6.2.3 Clone, Build and Deploy the Project

From a Git Bash terminal, clone, build and deploy the project as shown below. Manually add the cache directory as shown below.



```
jbelstn@jbelstn-MOBL1 MINGW64 ~
$ mkdir ~/Projects

jbelstn@jbelstn-MOBL1 MINGW64 ~
$ cd Projects/

jbelstn@jbelstn-MOBL1 MINGW64 ~/Projects
$ git clone https://github.com/intel/rsp-sw-toolkit-gw.git
Cloning into 'rsp-sw-toolkit-gw'...
remote: Enumerating objects: 2179, done.
remote: Counting objects: 100% (2179/2179), done.
remote: Compressing objects: 100% (1910/1910), done.
remote: Total 2179 (delta 271), reused 2079 (delta 208), pack-reused 0
Receiving objects: 100% (2179/2179), 8.33 MiB | 1.87 MiB/s, done.
Resolving deltas: 100% (271/271), done.
Checking out files: 100% (1791/1791), done.

jbelstn@jbelstn-MOBL1 MINGW64 ~/Projects
$ cd rsp-sw-toolkit-gw/

jbelstn@jbelstn-MOBL1 MINGW64 ~/Projects/rsp-sw-toolkit-gw (master)
$ gradle clean deploy
Picked up _JAVA_OPTIONS: -Djava.net.preferIPv4Stack=true

> Configure project :
Version for this build invocation is    [19.1.3.26-2-g22e3029]

> Task :compileJava
Note: C:\Users\jbelstn\Projects\rsp-sw-toolkit-gw\src\main\java\com\intel\rfid\s
Note: Recompile with -Xlint:deprecation for details.

BUILD SUCCESSFUL in 10s
4 actionable tasks: 3 executed, 1 up-to-date

jbelstn@jbelstn-MOBL1 MINGW64 ~/Projects/rsp-sw-toolkit-gw (master)
$ cd ~/deploy/rsp-sw-toolkit-gw/

jbelstn@jbelstn-MOBL1 MINGW64 ~/deploy/rsp-sw-toolkit-gw
$ mkdir cache

jbelstn@jbelstn-MOBL1 MINGW64 ~/deploy/rsp-sw-toolkit-gw
$ |
```

Figure 7 Clone, Build and Deploy in Git Bash for Windows®

6.3 Project Runtime Folders

The following is a list of the top level folders of a deployment.

path in this example: ~/deploy/gateway/

- cache - the contents of this folder are intended to support maintaining the runtime state of the application. For example, the inventory manager will write a file to preserve the state of the inventory across restarts of the gateway. The same goes for schedule manager and other app components.
- config
  - behaviors - Behavior configuration files in this directory are available for use in the application. NOTE: the behavior id should match the filename.
  - mobility - The location for mobility profile configurations.
- exported-tokens - Location for the gateway to write out tokens used in provisioning Sensors with mutual authentication
- lib - Location of java libraries. All .jar files in this directory are available in the runtime classpath.
- log - Location for gateway logs
- sensor-sw-repo - Location of the sensor's software package repo files
- snapshot - Location for inventory snapshots.
- stats - Location for tag and Sensor statistics
- tagread - Location for raw tag read files (when enabled)
- web-admin - Location for web-admin resources

6.4 Configure

The configuration file located at “~/deploy/rsp-sw-toolkit-gw/config/gateway.cfg”. For initial testing, it is generally not necessary to modify this file from its defaults.

```
#-------------------------------------------------------------------------
#-- GATEWAY configuration
#--
#-- Default values used by the application are included
#-- here but commented out as reference (except for ntp)
#--
#-- Configuring Hosts:
#-- For configuration items that refer to a host,
#-- leaving that entry blank will have the effect
#-- of using the server hostname and the expectation
#-- that the corresponding service is available on
#-- the same host as the gateway
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- GATEWAY
#--
# gateway.device_id =
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- NTP
#--
ntp.server.host = pool.ntp.org
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- MQTT
#--
#-- NOTE: that supported protocols are either 'tcp' or 'ssl'
#--
#-- NOTE: if used, the 'downstream' password is also sent to
#-- the sensors and they will attempt to connect to the
#-- broker using their device id and this password.
#--
# mqtt.downstream.protocol = tcp
# mqtt.downstream.host =
# mqtt.downstream.port = 1883
# mqtt.downstream.username =
# mqtt.downstream.password =
#--
# mqtt.upstream.protocol = tcp
# mqtt.upstream.host =
# mqtt.upstream.port = 1883
# mqtt.upstream.username =
# mqtt.upstream.password =
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- RSP SOFTWARE PACKAGE REPO
#--
#-- The RSP is sent this information and will attempt to update itself
#-- using the packages in this repo.
#-- NOTE: the packages must be signed by Intel to be installed.
#--
# repo.rsp.protocol = http
# repo.rsp.host =
# repo.rsp.port = 8080
# repo.rsp.archs = all,armv7at2hf-neon,armv7at2hf-neon-mx6qdl,hx000
#-------------------------------------------------------------------------
#-------------------------------------------------------------------------
#-- CONSOLE
#--
```

```
#-- The ssh connection parameters used to log in to the gateway CLI
#--
# console.port = 5222
# console.userid = gwconsole
# console.password = gwconsole
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- INVENTORY
#--
#-- Ageout: Tags that have not been read in this amount of time
#-- will be removed from the inventory database.
#--
# inventory.ageout.hours = 336
#--
#-- Departed: Tags that have been read by an EXIT sensor will
#-- generate a departure if they have not been read by any sensor
#-- for this amount of time
#--
# inventory.aggregate.departed.threshold.millis = 30000
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- POINT OF SALE
#--
#-- Departed: the amount of time that a tag must be in the inventory before
#-- it can depart from a POS sensor
#-- default is 1 hour (1 * 60 * 60 * 1000)
#--
# inventory.POS.departed.threshold.millis = 3600000
#--
#-- Returned: for tags that have departed by POS,
#-- this time threshold must be exceeded before the tag will be
#-- 'returned' to inventory
#-- default is 1 day (24 * 60 * 60 * 1000)
#--
# inventory.POS.return.threshold.millis = 86400000
#-------------------------------------------------------------------------

#-------------------------------------------------------------------------
#-- PROVISIONING
#--
#-- Root CA Cert: if configured as https, the sensor uses Debian
#-- ca cert store for authentication
#--
# provision.ca.cert.protocol = http
#--
#-- Sensor Credentials: if configured as https, the sensor authenticates
#-- this connection using the downloaded root CA
#--
# provision.sensor.credentials.protocol = https
#--
#-- Ports used by the local REST server for the certificate and credentials
#--
# provision.http.port = 8080
# provision.tls.port = 8443
#--
#-- Sensor Token:Indicates whether mutual authentication is required
#-- between the sensor and gateway upon connection.
#-- For more details, please consult the user guide.
#--
# provision.sensor.token.required = false
#
#-- password for the pcs12 java keystore
provision.keystore.password = server123store456
#-------------------------------------------------------------------------
```

6.5 Certificate Generation

The Gateway supports encrypted communication protocols for both the Sensor REST endpoints and the MQTT data. To support this, a root certificate and a properly signed server certificate are required. The “gen_keys” script generates the keys and certificates required. This script uses openssl and keytool operations to generate a set of certificates and a Java keystore for use by the Gateway.

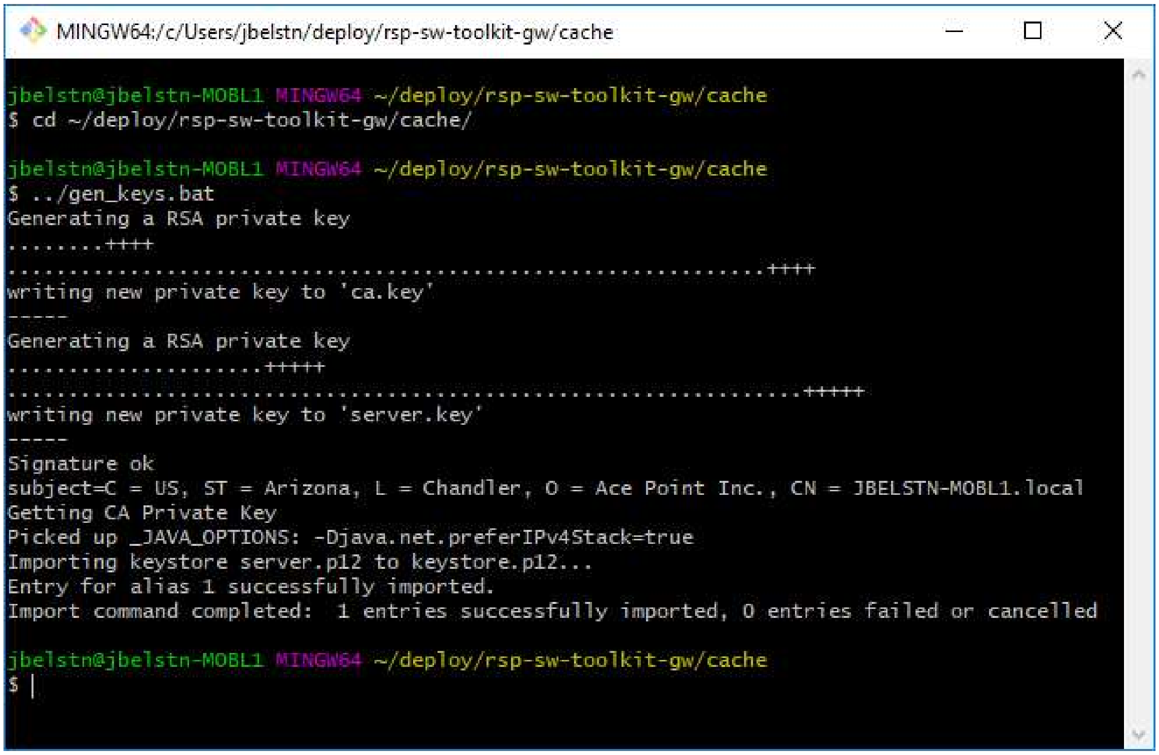
The pertinent files created by gen_keys are listed below.

- *ca.crt* - the root CA public certificate
- *server.crt* - a certificate signed by the root CA
- *keystore.p12* - a pkcs12 java keystore for the server certificate, used by the Jetty REST endpoints of the Gateway

6.5.1 Linux

```
mkdir -p ~/deploy/rsp-sw-toolkit-gw/cache
cd ~/deploy/rsp-sw-toolkit/cache
~/deploy/rsp-sw-toolkit-gw/gen_keys.sh
```

6.5.2 Windows® 10



```
jbelstn@jbelstn-MOBL1 MINGW64 ~/deploy/rsp-sw-toolkit-gw/cache
$ cd ~/deploy/rsp-sw-toolkit-gw/cache/

jbelstn@jbelstn-MOBL1 MINGW64 ~/deploy/rsp-sw-toolkit-gw/cache
$ ../gen_keys.bat
Generating a RSA private key
........++++
..............................................................++++
writing new private key to 'ca.key'
-----
Generating a RSA private key
.....................+++++
.................................................................+++++
writing new private key to 'server.key'
-----
Signature ok
subject=C = US, ST = Arizona, L = Chandler, O = Ace Point Inc., CN = JBELSTN-MOBL1.local
Getting CA Private Key
Picked up _JAVA_OPTIONS: -Djava.net.preferIPv4Stack=true
Importing keystore server.p12 to keystore.p12...
Entry for alias 1 successfully imported.
Import command completed:  1 entries successfully imported, 0 entries failed or cancelled

jbelstn@jbelstn-MOBL1 MINGW64 ~/deploy/rsp-sw-toolkit-gw/cache
$ |
```

Figure 8 Certificate Generation using Windows® Git Bash

6.6 Run

Start the Gateway using the "run" script (run.sh in Linux, run.bat in Windows®). A nominal startup sequence is shown below.

```
$ cd ~/deploy/rsp-sw-toolgit-gw
$ ./run.sh
04/24 10:39:12.198 INFO  Main.java:28: --
04/24 10:39:12.223 INFO  Main.java:29: -- RFID Gateway
04/24 10:39:12.235 INFO  Main.java:30: -- 19.2.4.14
04/24 10:39:12.235 INFO  Main.java:31: --
04/24 10:39:12.235 INFO  Main.java:32: -- Starting gateway services...
--
-- RFID Gateway
-- 19.2.4.14
--
-- Starting gateway services.04/24 10:39:12.251 INFO  Gateway.java:53: Gateway 19.1.3.26-1-
gb6854bf-dirty software initializing
04/24 10:39:12.771 INFO  RssiAdjuster.java:83: Restored /home/jbelstne/deploy/ace-point-
gateway/cache/mobility_profile.json
04/24 10:39:12.983 INFO  ConfigManager.java:38: loaded default configuration from:
/home/jbelstne/deploy/ace-point-gateway/config/gateway.cfg
04/24 10:39:13.000 INFO  ConfigManager.java:104: returning default value 1883 for property
mqtt.downstream.port
04/24 10:39:13.012 INFO  ConfigManager.java:104: returning default value 8080 for property
provision.http.port
04/24 10:39:13.018 INFO  ConfigManager.java:104: returning default value 8443 for property
provision.tls.port
04/24 10:39:13.028 INFO  ConfigManager.java:104: returning default value 1883 for property
mqtt.upstream.port
04/24 10:39:13.038 INFO  Gateway.java:103: Gateway initialized
04/24 10:39:13.038 INFO  Gateway.java:107: Gateway 19.1.3.26-1-gb6854bf-dirty starting
04/24 10:39:13.039 INFO  ClusterManager.java:218: started
04/24 10:39:13.039 INFO  AlertManager.java:30: AlertManager started
04/24 10:39:13.069 INFO  SensorManager.java:454: Restored /home/jbelstne/deploy/ace-point-
gateway/cache/sensors.json
04/24 10:39:13.107 INFO  SensorManager.java:111: Sensor Manager started
04/24 10:39:13.150 INFO  InventoryManager.java:734: Restored /home/jbelstne/deploy/ace-point-
gateway/cache/current_inventory.json
04/24 10:39:13.154 INFO  InventoryManager.java:457: inventory ageout removed: 36
04/24 10:39:13.166 INFO  InventoryManager.java:161: InventoryManager started
04/24 10:39:13.169 INFO  MQTT.java:80: MQTTUpstream started
04/24 10:39:13.169 INFO  UpstreamManager.java:30: UpstreamManager started
04/24 10:39:13.170 INFO  MQTT.java:80: MQTTDownstream started
04/24 10:39:13.247 INFO  JmDNSService.java:137: attempting to register mdns: RFID-Gateway-debian-
vbox on 10-0-2-15.local. (10.0.2.15)...
04/24 10:39:14.171 INFO  MQTT.java:173: setting MQTTUpstream userName: RFID-GW-UPSTREAM
04/24 10:39:14.172 INFO  MQTT.java:191: Attempting to connect to mqtt broker tcp://debian-
vbox.local:1883 with clientId MQTTUpstream20190424_103913...
04/24 10:39:14.178 INFO  MQTT.java:173: setting MQTTDownstream userName: RFID-GW-DOWNSTREAM
04/24 10:39:14.179 INFO  MQTT.java:191: Attempting to connect to mqtt broker tcp://debian-
vbox.local:1883 with clientId MQTTDownstream20190424_103912...
04/24 10:39:14.390 INFO  MQTT.java:165: MQTTUpstream connected tcp://debian-vbox.local:1883
04/24 10:39:14.391 INFO  MQTT.java:229: Subscribed to[rfid/rsp/connect]
04/24 10:39:14.392 INFO  MQTT.java:229: Subscribed to[rfid/rsp/response/#]
04/24 10:39:14.393 INFO  MQTT.java:229: Subscribed to[rfid/rsp/rsp_status/#]
04/24 10:39:14.393 INFO  MQTT.java:229: Subscribed to[rfid/rsp/data/#]
04/24 10:39:14.393 INFO  MQTT.java:165: MQTTDownstream connected tcp://debian-vbox.local:1883
04/24 10:39:14.399 INFO  MQTTDownstream.java:53: Published GatewayStatusUpdate.READY
......04/24 10:39:20.945 INFO  JmDNSService.java:147: registered mdns: RFID-Gateway-debian-vbox on
10-0-2-15.local. (10.0.2.15) with
{"sensor_token_required":false,"mqtt_credentials_url":"https://debian-
vbox.local:8443/provision/sensor-credentials","root_cert_url":"http://debian-
vbox.local:8080/provision/root-ca-cert","ntp_host":"pool.ntp.org"}
04/24 10:39:20.945 INFO  JmDNSService.java:70: JmDNSService started
04/24 10:39:20.945 INFO  DownstreamManager.java:55: DownstreamManager started
04/24 10:39:20.952 INFO  ScheduleManager.java:102: Restored /home/jbelstne/deploy/ace-point-
gateway/cache/schedule_manager.json
```

```
04/24 10:39:20.952 INFO  ScheduleManager.java:105: cached runState is INACTIVE
04/24 10:39:20.993 INFO  Log.java:193: Logging initialized @9911ms to
org.eclipse.jetty.util.log.Slf4jLog
04/24 10:39:21.075 INFO  ConfigManager.java:104: returning default value 8080 for property
provision.http.port
.04/24 10:39:21.518 INFO  SecurityContext.java:105: excluded cipher suites:
^.*_(MD5|SHA|SHA1)$
^TLS_RSA_.*$
^SSL_.*$
^.*_NULL_.*$
^.*_anon_.*$

04/24 10:39:21.519 INFO  SecurityContext.java:110: included cipher suites:
TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384
TLS_RSA_WITH_AES_256_GCM_SHA384
TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256
TLS_RSA_WITH_AES_128_GCM_SHA256
TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA384
TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384
TLS_RSA_WITH_AES_256_CBC_SHA256
TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA256
TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256
TLS_RSA_WITH_AES_128_CBC_SHA256

04/24 10:39:21.519 INFO  SecurityContext.java:115: excluded protocols:
SSL
SSLv2
SSLv2Hello
SSLv3

04/24 10:39:21.519 INFO  SecurityContext.java:120: included protocols:

04/24 10:39:21.519 INFO  ConfigManager.java:104: returning default value 8443 for property
provision.tls.port
04/24 10:39:21.571 INFO  EndPointManager.java:132: adding RootCACertEndPoint on /provision/root-
ca-cert
04/24 10:39:21.573 INFO  EndPointManager.java:138: adding SensorCredentialsEndPoint on
/provision/sensor-credentials
04/24 10:39:21.575 INFO  EndPointManager.java:148: adding AdminWebSocketServlet on /web-admin-
socket
04/24 10:39:21.576 INFO  EndPointManager.java:157: adding web-admin-servlet on
/home/jbelstne/deploy/ace-point-gateway/web-admin
04/24 10:39:21.576 INFO  EndPointManager.java:164: adding DefaultServlet on
/home/jbelstne/deploy/ace-point-gateway/sensor-sw-repo
04/24 10:39:21.579 INFO  Server.java:370: jetty-9.4.16.v20190411; built: 2019-04-11T15:03:03.392Z;
git: e0aa4ae4c0fe2e6bb3ecde2eb3e54bc3087b2f52; jvm 1.8.0_212-8u212-b01-1~deb9u1-b01
04/24 10:39:21.706 INFO  ContextHandler.java:855: Started
o.e.j.s.ServletContextHandler@6e2829c7{/,null,AVAILABLE}
04/24 10:39:21.763 INFO  AbstractConnector.java:292: Started
ServerConnector@821330f{HTTP/1.1,[http/1.1]}{0.0.0.0:8080}
04/24 10:39:22.124 INFO  SslContextFactory.java:369: x509=X509@2f67a4d3(1,h=[debian-
vbox.local],w=[]) for
SslContextFactory@5e3f861[provider=null,keyStore=file:///home/jbelstne/deploy/ace-point-
gateway/cache/keystore.p12,trustStore=null]
.04/24 10:39:22.295 INFO  AbstractConnector.java:292: Started ServerConnector@461ad730{SSL,[ssl,
http/1.1]}{0.0.0.0:8443}
04/24 10:39:22.300 INFO  Server.java:407: Started @11219ms
04/24 10:39:22.301 INFO  EndPointManager.java:72: EndPointManager started
04/24 10:39:22.301 INFO  Gateway.java:121: Gateway started

--
04/24 10:39:22.592 INFO  ConfigManager.java:104: returning default value 5222 for property
console.port
```

6.7 Sensor Connection Sequence

Once power-on and boot is complete, the Sensor uses the information contained in the gateway mDNS announcement to synchronize time via NTP and then download the root certificate. If the gateway is configured to require the use of provisioning tokens, the sensor must have been provisioned with an NFC provisioning tag that contains a matching sha256 hash of the root certificate. Then the sensor sends a post to the gateway's sensor credentials endpoint to retrieve the MQTT connection credentials. If provisioning token is required, the token value is included in the post request and the gateway refuses to provide credentials if the token is invalid. The sensor connects to the downstream MQTT broker instance and sends a connect request to the gateway. The gateway responds with a connect response and the sensor signals that it is "ready". At this point, the sensor is connected.

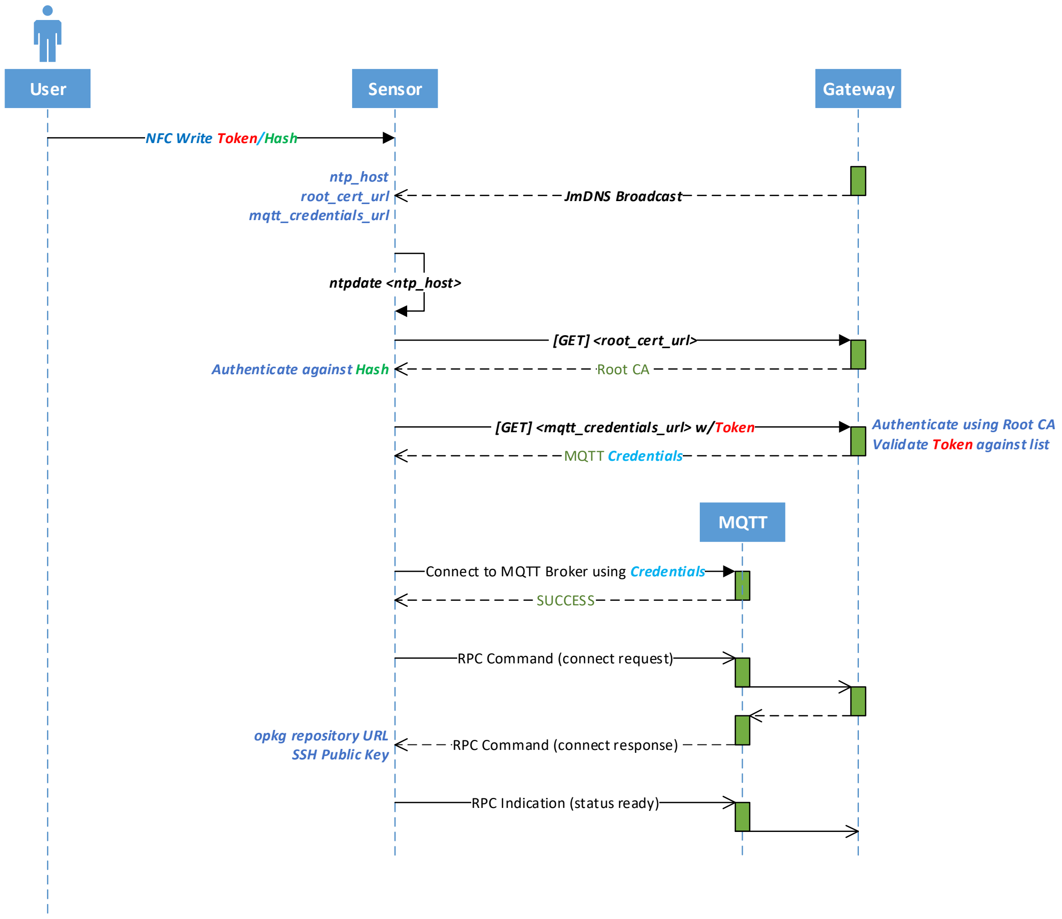

User
Sensor
Gateway
NFC Write Token/Hash
ntp_host
root_cert_url
mqtt_credentials_url
JmDNS Broadcast
ntpdate <ntp_host>
[GET] <root_cert_url>
Authenticate against Hash
Root CA
[GET] <mqtt_credentials_url> w/Token
Authenticate using Root CA
Validate Token against list
MQTT Credentials
MQTT
Connect to MQTT Broker using Credentials
SUCCESS
RPC Command (connect request)
opkg repository URL
SSH Public Key
RPC Command (connect response)
RPC Indication (status ready)

Figure 9 Discovery and Mutual Authentication Process

7 System Provisioning Cluster Tokens

As described in the previous section, the gateway optionally supports a mutual authentication scheme with Sensors by requiring provisioning tokens. To enable mutual authentication, set the following configuration variable in the file gateway.cfg to “true”.

```
provision.sensor.token.required = true
```

When this feature is enabled, the “Sensor NFC App” must be used to program provisioning credentials into a Sensor before the Sensor connects to the Gateway. The credentials are programmed into the Sensor via an NFC capable device. See the “Intel® RSP SW Toolkit – Sensor NFC App” documentation for detailed instructions on programming the Sensor.

Leveraging the tokens used for authentication, clusters can have their sensor groups replaced by a single token. In this case, after the gateway validates the token, it maps that sensor to the corresponding cluster configuration via the token reference. Adopting this practice supports enterprise scalability as a single cluster configuration can be used across gateway installations. When the sensors are installed, the NFC App is used to essentially "program" the sensor with the facility, personality, aliases, and scheduling parameters. A unique token is required for each sensor group.

A similar cluster configuration is shown here using tokens instead of sensor groups.

git repo: src/test/resources/clusters/sample_provisioning_cluster_config.json

```
{
  "id": "SampleProvisioningClusterConfig",
  "clusters": [
    {
      "id": "BackStock",
      "facility_id": "BackStock",
      "behavior_id": "ClusterDeepScan_PORTS_1",
      "tokens": [
        {
          "username": "BS_DEFAULT_001",
          "token": "BackStockDeepScan001UUWWYYBBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        },
        {
          "username": "BS_DEFAULT_002",
          "token": "BackStockDeepScan002UUWWYYBBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        }
      ]
    }, {
      "id": "SalesFloorMobility",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterMobility_PORTS_1",
      "tokens": [
        {
          "username": "SF_DEFAULT_001",
          "token": "SalesFloor01Default001WWYYBBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        },
        {
          "username": "SF_DEFAULT_002",
          "token": "SalesFloor01Default002WWYYBBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        }
      ]
    }, {
      "id": "SalesFloorExit",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterExit_PORTS_1",
      "personality": "EXIT",
      "aliases": ["ExitLeft", "ExitOverhead", "ExitRight", null],
      "tokens": [
        {
          "username": "SF_EXIT_001",
          "token": "SalesFloor01Exit001SUUWWYYBBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        }
      ]
    }, {
      "id": "SalesFloorPOS",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterPOS_PORTS_1",
      "personality": "POS",
      "aliases": "[Register1, Register2, Register3, Register4]",
      "tokens": [
        {
          "username": "SF_POS_001",
          "token": "SalesFloor01POS001TSUUWWYYBBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        }
      ]
    }, {
      "id": "SalesFloorFittingRoom",
      "facility_id": "SalesFloor",
      "behavior_id": "ClusterFittingRoom_PORTS_1",
      "personality": "FITTING_ROOM",
      "aliases": "[FittingRoom1, FittingRoom2, FittingRoom3, FittingRoom4]",
      "tokens": [
        {
          "username": "SF_FITTING_ROOM_001",
          "token": "SalesFloor01FittingRoom001BBDDFFE3DA5098692CE27945AA367189B52C58",
          "generatedTimestamp": 0,
          "expirationTimestamp": -1
        }
      ]
    }
  ]
}
```

The credentials include a sha256 hash of the root certificate and the token value of a provisioning token.

The certificate hash is used by the Sensor to verify the root CA certificate that the Sensor downloads as part of the connection sequence. If using the gen_keys script provided with the toolkit, the root CA certificate will be located in the deployment directory under the cache folder ~/deploy/gateway/cache/ca.crt.

The parameters of a provisioning token are

- **username**: string used only as reference for the token.
- **token**: 64 character ASCII utf-8 character string. stored on sensor, transmitted to gateway in the connect request if tokens are required by the gateway.
- **generatedTimestamp**: seconds since the epoch.
- **expirationTimestamp**: seconds since the epoch, gateway will reject a connection attempt from sensors if this timestamp is invalid.

After a cluster configuration is loaded into the gateway, the tokens needed for the NFC Sensor App can be extracted to the exported tokens folder.

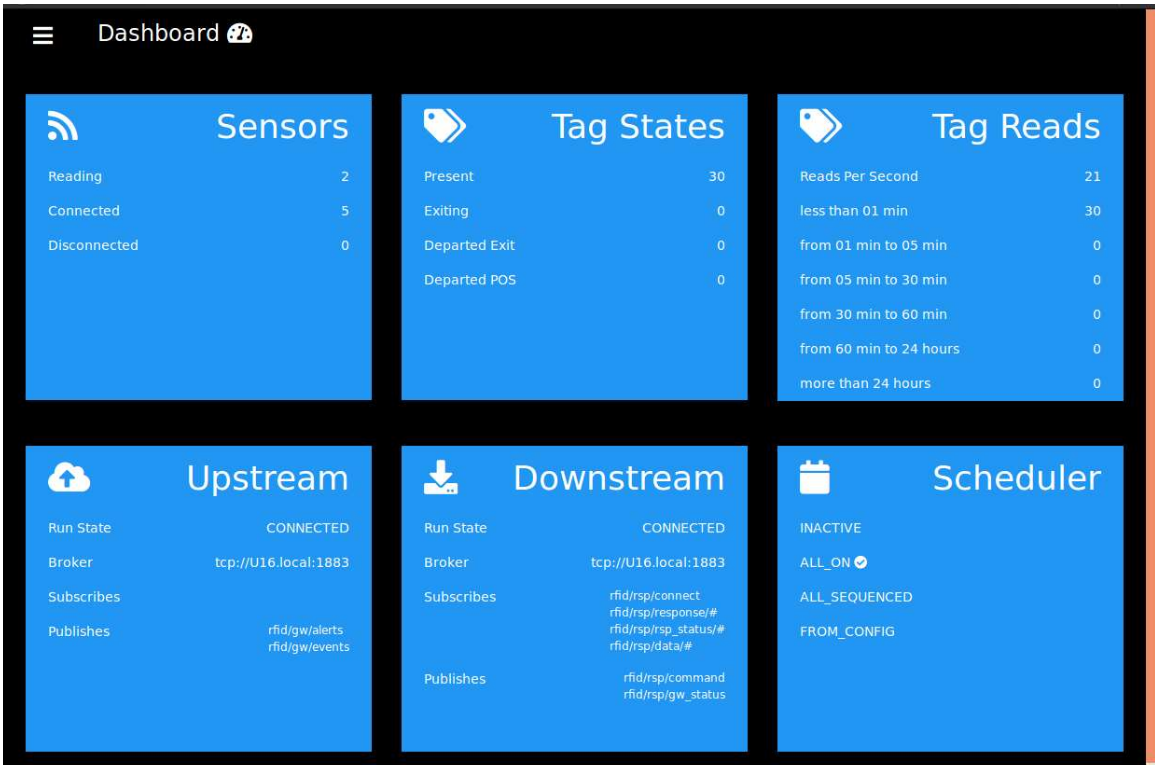
```
rfid-gw> clusters load.file /home/userid/projects/rsp-sw-
toolkit/gateway/src/test/resources/clusters/sample_provisioning_cluster_config.json
--------------------------------------------------------------------------------------------
completed
--------------------------------------------------------------------------------------------

rfid-gw> clusters export.tokens
--------------------------------------------------------------------------------------------
exported: /home/userid/deploy/gateway/exported-tokens/token_SF_DEFAULT_002.json
exported: /home/userid/deploy/gateway/exported-tokens/token_SF_POS_001.json
exported: /home/userid/deploy/gateway/exported-tokens/token_BS_DEFAULT_002.json
exported: /home/userid/deploy/gateway/exported-tokens/token_BS_DEFAULT_001.json
exported: /home/userid/deploy/gateway/exported-tokens/token_SF_FITTING_ROOM_001.json
exported: /home/userid/deploy/gateway/exported-tokens/token_SF_DEFAULT_001.json
exported: /home/userid/deploy/gateway/exported-tokens/token_SF_EXIT_001.json
--------------------------------------------------------------------------------------------
```

8 Web Administration

A web based administration interface is enabled on the gateway. If running the gateway locally, the following URL can be used. The port is determined by the provision ports in the gateway configuration file.

http://127.0.0.1:8080/web-admin/



Dashboard

Sensors

Reading	2
Connected	5
Disconnected	0

Tag States

Present	30
Exiting	0
Departed Exit	0
Departed POS	0

Tag Reads

Reads Per Second	21
less than 01 min	30
from 01 min to 05 min	0
from 05 min to 30 min	0
from 30 min to 60 min	0
from 60 min to 24 hours	0
more than 24 hours	0

Upstream

Run State	CONNECTED
Broker	tcp://U16.local:1883
Subscribes	
Publishes	rfid/gw/alerts rfid/gw/events

Downstream

Run State	CONNECTED
Broker	tcp://U16.local:1883
Subscribes	rfid/rsp/connect rfid/rsp/response/# rfid/rsp/rsp_status/# rfid/rsp/data/#
Publishes	rfid/rsp/command rfid/rsp/gw_status

Scheduler

INACTIVE

ALL_ON ✓

ALL_SEQUENCED

FROM_CONFIG

Figure 10 Web Admin Dashboard

The Web Admin Dashboard and associated pages provide a friendly way to get sensor status and tag information from the Gateway as well as control the RFID scheduling. The goal is to expose nearly all of the CLI functionality from the Web Admin.

9 Command Line Interface (CLI)

The Command Line Interface (CLI) provides a means of interacting with the Gateway to configure and manage the Sensors. The CLI is accessed using a secure shell login from either a Linux terminal or Windows® PuTTY session. Check the gateway configuration file for the username, password, and port number.

The CLI supports auto command completion at any point by pressing the <tab> key to complete the command or to view a list of available commands or options. Pressing <enter> prior to the completion of a command will display command usage and parameter definitions. Generous use of the <tab> and <enter> keys is the best way to learn the available options of the CLI.

```
$ ssh -p5222 gwconsole@localhost
Password authentication *********

RFID Gateway console session

<tab> to view available commands
'clear' to clear the screen/console
'quit' to end

rfid-gw>
exit         quit         scheduler    system       upstream     downstream  log   sensor
inventory    version      clusters
```

9.1 exit - quit

Causes the CLI console session to terminate. Does not affect the running Gateway application.

9.2 scheduler

```
--------------------------------------------------------------------------------------------
USAGE

> scheduler info <topic>
    Displays info about the topic

> scheduler show
    Displays info about current state of the schedule manager

> scheduler activate.all.on
    Transitions to all sensors reading tags at the same time

> scheduler activate.all.sequenced
    Transitions to each sensor reading tags one at a time

> scheduler activate.from.config
    Transitions to running per the existing cluster configuration

> scheduler deactivate
    Deactivates any scheduling activities and causes the sensors to stop reading

--------------------------------------------------------------------------------------------
```

9.3 system

```
--------------------------------------------------------------------------------------------
USAGE

> system info
    Displays processor and memory information
--------------------------------------------------------------------------------------------
```

9.4 upstream

```
--------------------------------------------------------------------------------------------
USAGE

> upstream show
    Show the status and topics of the Upstream MQTT
--------------------------------------------------------------------------------------------
```

9.5 downstream

```
--------------------------------------------------------------------------------------------
USAGE

> downstream show
    Show the status and topics of the Downstream MQTT
--------------------------------------------------------------------------------------------
```

9.6 log

```
--------------------------------------------------------------------------------------------
USAGE

> log show
    Shows the current log level settings for all active loggers

> log set <log id> <level>
    Sets the level of the logger associated with the log_id
--------------------------------------------------------------------------------------------
```

9.7 sensor

NOTE: Before using the individual start.reading or stop.reading commands from the CLI, set the scheduler to INACTIVE.

```
--------------------------------------------------------------------------------------------
USAGE

> sensor show [ regex ]
    Displays a list of all known sensors
    Optional regex will match against the sensor id
    A sensor is known to the gateway by the following:
        Listed in facility group configuration
        Listed in personality group configuration
        Listed in schedule group configuration
        Actively connects to the gateway regardless of facility, personality, or schedule
inclusion

> sensor start.reading <device_id>...
```

```
    Start reading using the currently configured behavior(s)

> sensor stop.reading <device_id>...
    Stop reading

> sensor reset <device_id>...
    Command device to perform a reset

> sensor reboot <device_id>...
    Command device to perform a reboot

> sensor shutdown <device_id>...
    Command device to perform an OS shutdown
    CAUTION: Do this ONLY prior to physically removing the device!

> sensor remove <device_id>...
    Removes device from ALL configurations (faciility, personality, schedule)
    The device must be in the DISCONNECTED state

> sensor get_bist_results <device_id>...
    Retrieve Built-In-Self-Test results

> sensor get.last.comms <device_id>...
    Display last heard time

> sensor get_state <device_id>...
    Retrieve device capabilities

> sensor get_sw_version <device_id>...
    Retrieve device software version

> sensor set.alert.threshold <type> <severity> <device_id>...
    Change a Device Alert Threshold

> sensor set.behavior <behavior> <device_id>...
    Apply a predefined RFID behavior

> sensor set.facility <facility_id> <device_id>...
    Assign the Facility ID

> sensor set.personality <personality> <device_id>...
    Add a personality

> sensor clear.personality <device_id>...
    Clears a personality

> sensor set.alias <alias> <antenna-port> <device_id>...
    Add an alias to a device:antenna-port combination

> sensor get.alias <antenna-port> <device_id>...
    Retrieve the alias assigned to a device:antenna-port combination

> sensor set.led <led_state> <device_id>...
    Apply a visual indicator behavior

> sensor set.motion send.events <true|false>capture.images <true|false> <device_id>...
    Enable or disable the sending of Motion Events
    Enable or disable the capture of .jpg images

> sensor ack.alert <alert_type> <true|false> <device_id>...
    Acknowledge a Device Alert

> sensor mute.alert <alert_type> <true|false> <device_id>...
    Disable a particular Device Alert

> sensor tokens <device_id>...
    Show the token associated with the device
--------------------------------------------------------------------------------------------
```

9.8 inventory

```
--------------------------------------------------------------------------------------------
USAGE

> inventory summary
    Shows the tags in summarized groupings

> inventory update.with </full/path/to/tag-scan-file.csv>
    Updates the current inventory with data from the specified csv file

> inventory replace.with </full/path/to/tag-scan-file.csv>
    Replaces the current inventory with data from the specified csv file

> inventory detail [ regex ]
    Shows details of each tag in the database
    Optional regex will match against the EPC

> inventory exiting
    Shows the tags in the exiting table, potential departed tags

> inventory snapshot
    Writes a snapshot of the current inventory to file

> inventory unload
    !! WARNING !! WARNING !! WARNING !! WARNING !! WARNING !! WARNING !! WARNING !!
    Clears all tag reads from the gateway including the cached file. No recovery available
    This will cause new arrival events to be generated for all tags

> inventory stats show [ regex ]
    Shows read statistics of each tag in the database
    Optional regex will match against the EPC

> inventory stats snapshot [ regex ]
    Writes a snapshot of tag read statistics to file
    Optional regex will match against the EPC

> inventory stats set.regex
    Sets a regular expression used for filtering stats during recording

> inventory stats check.regex
    Displays the stats the current regex will return and also shows the regex pattern

> inventory stats start.recording
    Starts taking stats sanpshots at a regular interval (5 seconds)

> inventory stats stop.recording


> inventory mobility.profile show
    Shows the mobility profile settings used in the moved event algorithm

> inventory mobility.profile set
    Sets the mobility profile used in the moved event algorithm

> inventory waypoints show
    Shows the tags waypoint history

> inventory waypoints snapshot
    Writes a snapshot of tag waypoints to file
--------------------------------------------------------------------------------------------
```

9.9 version

```
--------------------------------------------------------------------------------------------
USAGE

> version info
    Displays the software version information
--------------------------------------------------------------------------------------------
```

9.10 clusters

```
--------------------------------------------------------------------------------------------
USAGE

> clusters show
    Displays info about current state of the schedule manager

> clusters load.file
    Load a cluster configuration from the specified JSON file path

> clusters show.tokens
    Displays the tokens included in the configuration

> clusters export.tokens
    Exports the tokens included in the configuration as separate json files

--------------------------------------------------------------------------------------------
```

10 Sensor Software Update

Sensors utilize 'opkg' software package management to keep their software updated with an external package repository and the gateway can host this repository. The only thing needed is to install the repository files into the appropriate directory.

```
-------------------------------------------------------------------------------------------
$ tar -xf hx000-rrs-repo-19.1.2.7-5-gce5ed4f.tgz
$ mv ./hx000-rrs-repo-19.1.2.7-5-gce5ed4f/* ~/deploy/rsp-sw-toolkit-gw/sensor-sw-repo/
$ cd ~/deploy/rsp-sw-toolkit-gw/sensor-sw-repo
$ ls -la
total 60
drwxr-xr-x  5 user user 4096 Mar 21 16:31 .
drwxr-xr-x 14 user user 4096 Mar 21 15:21 ..
drwxr-xr-x  2 user user 4096 Mar 13 11:20 all
drwxr-xr-x  2 user user 24576 Mar 13 11:20 armv7at2hf-neon
drwxr-xr-x  2 user user 20480 Mar 13 11:23 hx000
-rw-r--r--  1 user user 0 Mar 13 11:14 Packages
-rw-r--r--  1 user user 3134 Mar 13 11:14 Packages.sig
$
-------------------------------------------------------------------------------------------
```

Sensors automatically check for updates in the repository every 5 minutes. Once new files are in place, the update will happen on the next cycle.

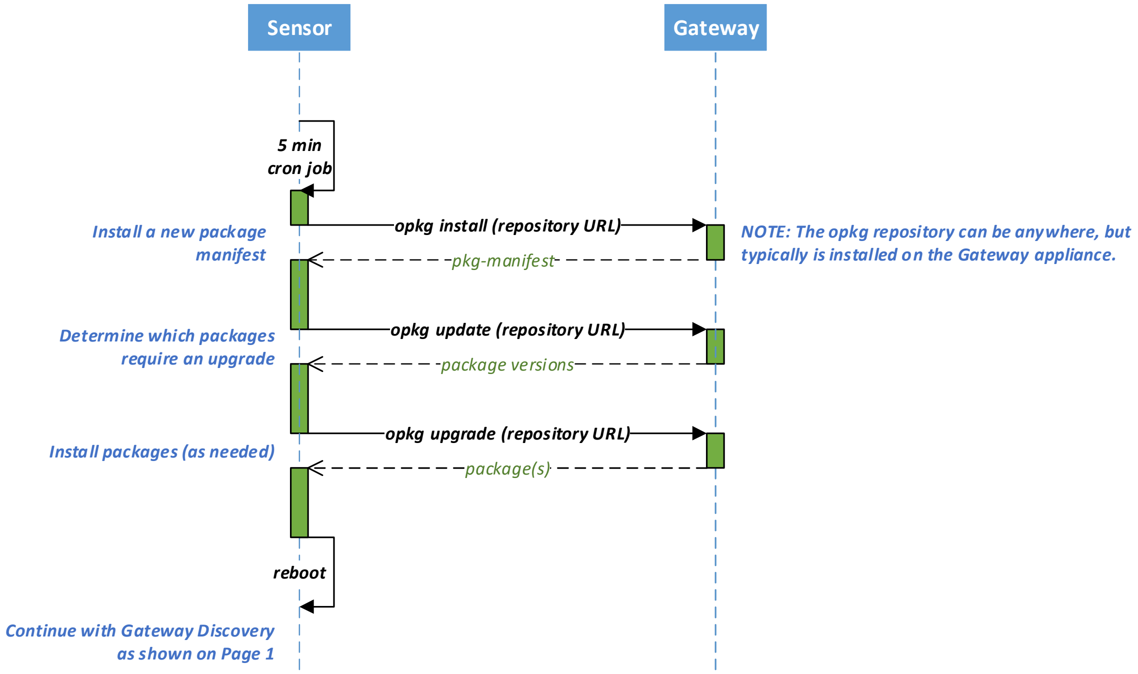

Sensor
Gateway
5 min
cron job
Install a new package
manifest
opkg install (repository URL)
pkg-manifest
NOTE: The opkg repository can be anywhere, but
typically is installed on the Gateway appliance.
Determine which packages
require an upgrade
opkg update (repository URL)
package versions
Install packages (as needed)
opkg upgrade (repository URL)
package(s)
reboot
Continue with Gateway Discovery
as shown on Page 1

Figure 11 Sensor Software Update