DNP3 Concentrator Configuration Guide

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DNP3 Concentrator Configuration Guide

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Contents

Figures

Tables

Revision History

Revision	Release Date	Change Description
A	February 10, 2014	Initial release.
B	December 12, 2014	Updated: ■ Operational behavior information. Added new sections for: ■ Managing multiple DNP3 masters. ■ SEL WSO-11, Gen 2b ■ DNP3 Bridge (ORW uConnect) Added: ■ Appendix describing On-Ramp Wireless uConnect (DNP3 Bridge)

1 Overview

The On-Ramp Wireless DNP3 Concentrator allows efficient management of thousands of DNP3-enabled Total Reach devices. The function of a concentrator is that it condenses (concentrates) the attributes of many devices to appear as a single DNP3 slave device to the DNP3 master. The benefits of this concentrator model include the following:

- Optimizes overall DNP3 network traffic by only mapping DNP3 points of interest.
- Reduces overall DNP3 master resources allocation.
- Reduces the overall number of DNP3 outstations that would otherwise have to be directly managed periodically.

To allow for maximum flexibility, a number of concentrators can be created.[1] Each concentrator can support up to M outstations, where M is set by the DNP3 network operator. Additionally, each concentrator is addressed independently using a unique 3-tuple comprising the concentrator's IP address, its TCP port number, and its DNP3 link address.

Figure 1 represents a logical DNP3 network layout. For simplicity, the wireless components of the On-Ramp Total Reach Network have been omitted.

[1] The number of concentrators created is limited by the number of DNP3 resources available in the HES process.

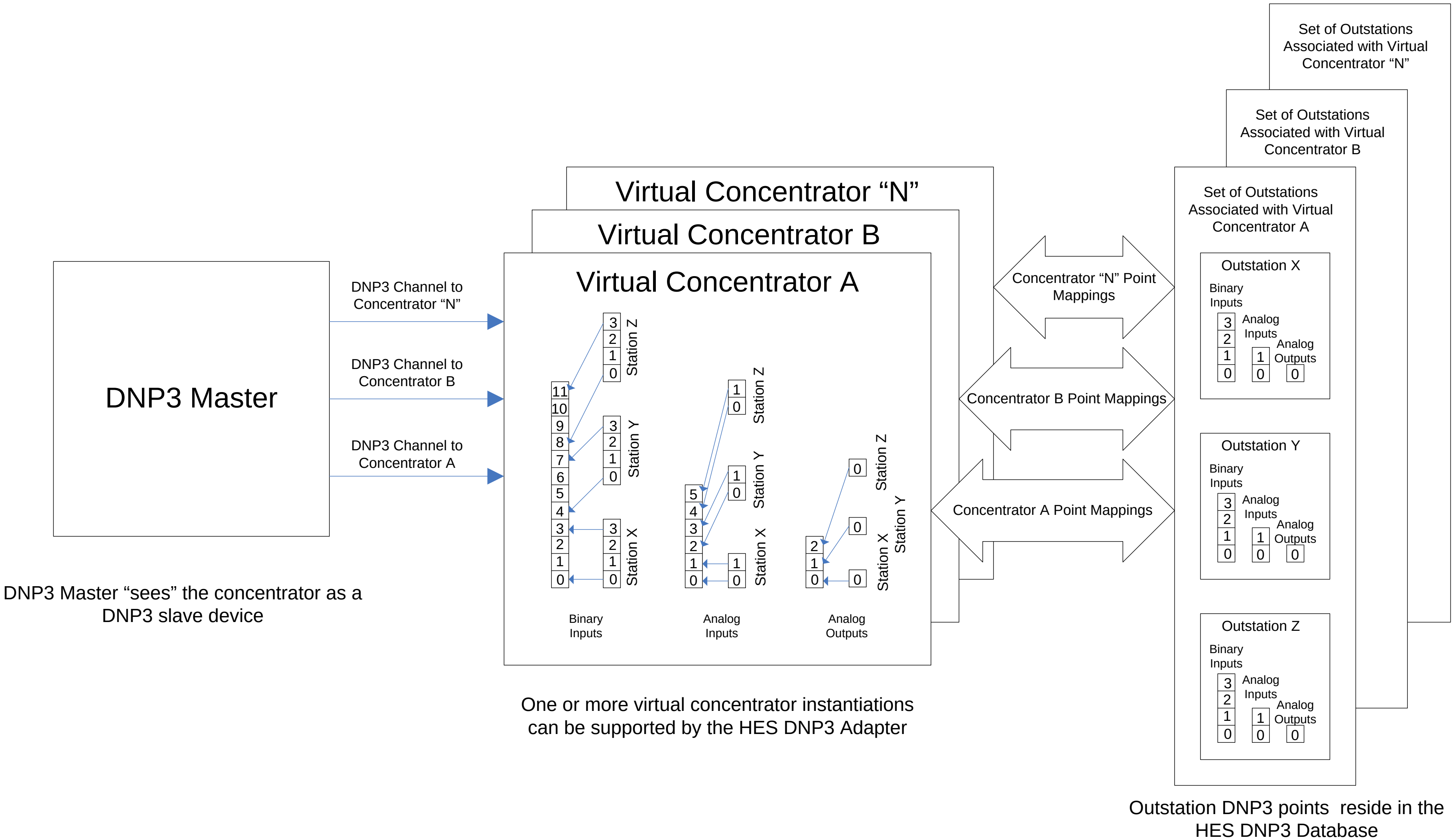

Figure 1. Logical Architecture of the On-Ramp Wireless DNP3 Concentrator

2 DNP3 Concentrator Configuration

This chapter summarizes the configuration options available to the DNP3 network operator.

2.1 DNP3 Concentrator Settings

Table 1 summarizes the DNP3 concentrator settings that can be changed. The parameters tabulated are DNP3 global settings which can be set from the hes_config.properties file. The HES configuration properties file is located on the HES server as /opt/onramp_apps/hes/instance_1/hes_config.properperites.

The change does not take effect until the On-Ramp Wireless HES is restarted.

Table 1. Configurable DNP3 Concentrator Global Parameters

HES DNP3 Configuration	Definition
adapter.dnp3.reject_incoming_request_if_gw_unreachable	If set to true, the DNP3 adapter rejects DNP3 master requests if the OTR gateway is offline. Default is false.
adapter.dnp3.max_uplink_redelivery_attempts	DNP3 application layer maximum retry count for unsolicited response sent by the DNP3 adapter. Default is 5 attempts
adapter.dnp3.min_uplink_redelivery_delay	Specifies the minimum confirmation timeout interval, in ms, of an unsolicited response before the DNP3 adapter attempts a retry. Default is 3000 [ms].
adapter.dnp3.max_downlink_no_response_time_seconds	No Connect
adapter.dnp3.ssl.enable	Enables the Secure Socket Layer security protocol. Default is false.
adapter.dnp3.ssl.ca.cert	Certificate Authority (CA) certificate file required when SSL is enabled.
adapter.dnp3.ssl.key.cert	Client SSL certificate file required when SSL is enabled.
adapter.dnp3.ssl.key.password	SSL password required when SSL is enabled.
adapter.dnp3.master.linkaddress.uselast	Set to true for implicit (auto) addressing, or false for explicit addressing of unsolicited NULL responses. When auto addressing is enabled, the outstation uses the DNP3 link address of the master station last communicated with; otherwise it uses the value specified by the configuration parameter "adapter.dnp3.master.linkaddress.expected". Default is true.
adapter.dnp3.master.linkaddress.expected	The DNP3 link address of the master station for unsolicited NULL responses when the parameter "adapter.dnp3.master.linkaddress.uselast" is set to false. If "adapter.dnp3.master.linkaddress.uselast" is set to true, then this field becomes invalid after a master/outstation link has been established. Default is 3.
adapter.dnp3.unsolicited.enabled	Enables DNP3 outstation unsolicited response capabilities. Default is false.
adapter.dnp3.event.class1.size	Number of queued events, unique per device, before the DNP3 adapter initiates an unsolicited response for Class 1 events. Default is 0 (immediate response)

HES DNP3 Configuration	Definition
adapter.dnp3.event.class1.holdtime	Hold time, unique per device, before the DNP3 adapter initiates an unsolicited response relative to when the event is actually generated for Class 1 events. Default is 0 (immediate response)
adapter.dnp3.event.class2.size	Number of queued events, unique per device, before the DNP3 adapter initiates an unsolicited response for Class 2 events. Default is 0 (immediate response)
adapter.dnp3.event.class2.holdtime	Hold time, unique per device, before the DNP3 adapter initiates an unsolicited response relative to when the event is actually generated for Class 2 events. Default is 0 (immediate response)
adapter.dnp3.event.class3.size	Number of queued events, unique per device, before the DNP3 adapter initiates an unsolicited response for Class 3 events. Default is 0 (immediate response)
adapter.dnp3.event.class3.holdtime	Hold time, unique per device, before the DNP3 adapter initiates an unsolicited response relative to when the event is actually generated for Class 3 events. Default is 0 (immediate response)

2.2 Unsolicited Mode Selection

The predominant data model for a DNP3 network is that of a “polled” system. Typically an “integrity” poll (a request for all outstation points) is issued whenever the DNP3 master or slave device is reset, or periodically at a relatively slow rate to ensure long term system integrity. Other types of polls such as a “report by exception” can be sent at higher polling frequencies, where only changes at the outstation are requested.

The unsolicited mode is a user-selectable option which can be enabled. In this data model, the DNP3 outstations are free to initiate communications to the DNP3 master at any time. Such a model may be suitable for monitoring high priority alarm conditions in an otherwise slow DNP3 polling configuration.

Unsolicited messaging is disabled by default. To enable unsolicited messaging, set the **adapter.dnp3.unsolicited.enabled** parameter to true.

2.3 Outstation Point Mapping

There are two primary point mapping modes: auto point mapping or manual point mapping.

1. **Auto Point Mapping**

   Auto point mapping is enabled by setting the **adapter.dnp3.generation.points** value to **auto** in the hes_config.properties file. If auto point generation is enabled, the mapping of a DNP3 outstation’s point indexing to a concentrator point indexing is automatically assigned. If the auto point indexing is disabled, then it is up to the DNP3 network operator to manually assign all outstation points to the DNP3 concentrator point index.

2. **Manual Point Mapping**

   Any value other than “auto” enables the concentrator’s manual point mapping mode. The HES configuration properties file is located on the HES server as /opt/onramp_apps/hes/instance_1/hes_config.properties. The change does not take effect until the On-Ramp Wireless HES is restarted.

2.3.1 Auto Point Mapping

Using the DNP3 concentrator in auto point mapping mode is summarized in the following steps.

1. Select the points of interest to be auto point mapped. Refer to the device's DNP3 profile document or Appendix B of this document for the list of available points.
2. Edit the DNP3 device's DNP3 profile file to include only the points of interest. Unused DNP3 points should be commented out by preceding the line with a '#' character. The DNP3 profile file for various DNP3 enabled Total Reach devices can be found on the HES server as /opt/onramp_apps/hes/instance_1/dnp3-profiles.
3. The DNP3 network operator needs to decide the DNP3 outstation to concentrator associations. Given an outstation population size of M devices, a decision should be made as to how many concentrators should be instantiated, and the number of outstation devices allowed per concentrator. Typically these decisions are made based on DNP3 resource limitations.
4. Create a concentrator to outstation association list. The procedure for doing this is outlined in Section 4.2. This concentrator-to-outstation association list can then be imported into the DNP3 concentrator using a REST post command. All concentrators and outstation entities are created as required.
5. It is recommended to immediately perform a point listing query to confirm the DNP3 concentrator configuration is correct. Querying for a point list via the REST interface is described in Section 5.3

Required Conditions for Auto Point Mapping

The automatic point mapping of outstation points to a concentrator can only occur if all of the following conditions are met:

1. The outstation to be mapped must be associated with a single concentrator. This association is ***not automatic***.
2. The outstation currently does not have any DNP3 point entities defined.
3. The auto point mapping parameter must be set to **auto** in the hes_config.properties file.

If these three conditions are met, the DNP3 outstation points are created upon the next received UL SDU sent by a particular outstation.

2.3.2 Manual Point Mapping

Using the DNP3 concentrator in manual point mapping mode can be summarized in the following steps.

1. Select the points of interest to be manual point mapped. Refer to the device's DNP3 profile document or Appendix B of this document for the list of available points.
2. The DNP3 network operator needs to decide the DNP3 outstation to concentrator associations. Given an outstation population size of M devices, a decision should be made as to how many concentrators should be instantiated, and the number of outstation devices

allowed per concentrator. Typically these decisions are made based on DNP3 resource limitations.

3. Create a DNP3 point indexing list. This list implicitly contains the outstation to concentrator associations (decided from step 2) as well as the manual DNP3 point assignments. The procedure for manually creating a point indexing list is described in Section 4.3. This point indexing list can then be imported into the HES DNP3 adapter using a REST post command. All concentrators, outstations and DNP3 points are then created as required when the master point indexing list is posted via the OTV REST interface.
4. It is recommended to immediately perform a point listing query to confirm the DNP3 concentrator configuration is correct. Querying for a point list via the REST interface is described in Section 5.3

NOTE: It is strongly recommended that when configuring DNP3 points using a manual method, that the **DNP3 points are specified in a contiguous fashion**. If “point gaps” exist in the point map, the DNP3 concentrator reports DNP3 points that aren’t originally mapped in order to “point fill.” These fill points do not represent valid values but consume DNP3 network bandwidth during integrity polls.

3 OTV REST Interface

In order to configure the On-Ramp Wireless DNP3 Concentrator, a REST client is required. REST is an acronym for Representational State Transfer and is a stateless, client-server communications protocol model. It was created as an architectural style for designing networked applications.

The REST interface makes use of standard HTTP requests to Create/Read/Update/Delete data (CRUD). Within the REST framework, a messaging mechanism is used to facilitate data exchange between the server and the client. One such mechanism could be the Extended Markup Language (XML). Another mechanism could be the simple comma separated value (CSV) text format. The DNP3 concentrator REST interface utilizes XML for initial login. Post login commands (i.e., GET, POST, DELETE) require a csv text format for the payload body.

This section only provides an overview of REST commands, mainly in the form of examples. The intent is for the REST examples to allow the operator to perform all DNP3 concentrator configuration operations. Details and semantics of the REST interface and language is intentionally kept to a minimum; the interested reader is encouraged to read the online documentation located on the OTV server accessible at http://<OTV_IP_ADDR>:<PORT>/otv/rest/api/resources, where OTV_IP_ADDR represents the IP address of the OTV web interface, and PORT represents the OTV web interface port. Additional information is provided in the On-Ramp Wireless *OTV REST API Guide (010-0038-00)*.

3.1 OTV Account Prerequisites

REST users require an OTV account with REST privileges. To create a proper account, the OTV administrator shall log into the OTV web interface and access the “Admin → Users” tab and click on the “Add User” icon as shown in Figure 2. This user account must then be given the assigned role of “Service” to have REST services made available. Finally, the OTV administrator shall assign the applicable device types to the REST enabled user account. Figure 3 highlights the appropriate setting in OTV.

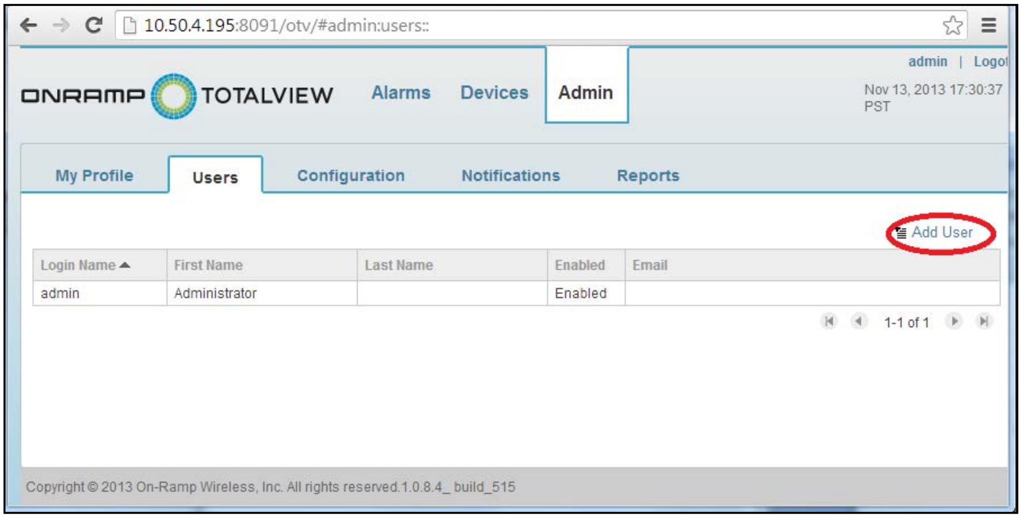

Figure 2. Adding an OTV User with REST Privileges

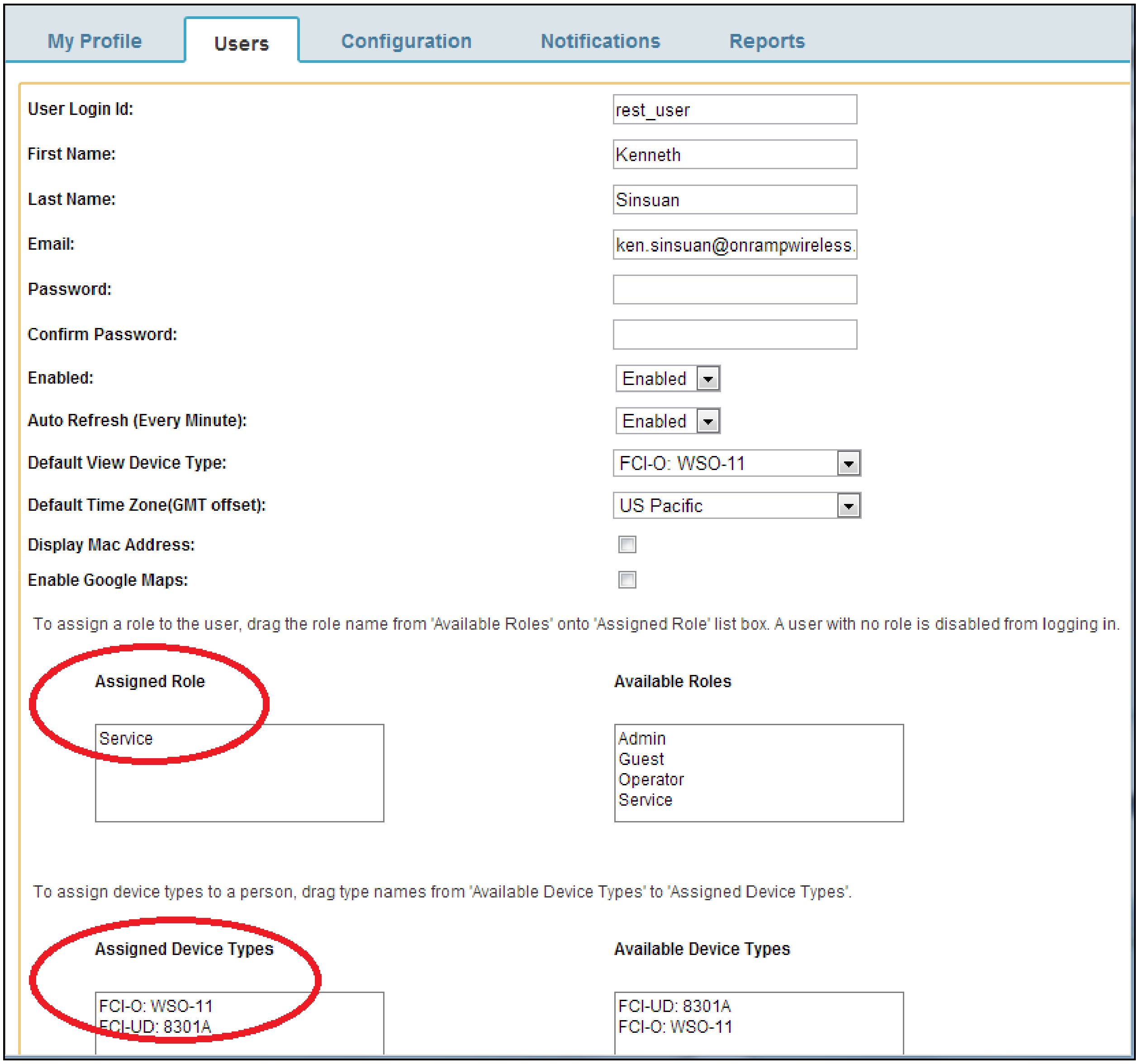

Figure 3. Adding an OTV User with REST Privileges (Continued)

3.2 REST Client Installation

The easiest way to get started using REST to communicate with the On-Ramp Wireless' DNP3 Concentrator, is to use a REST client plug-in available for Mozilla FireFox or Google Chrome web browsers. This document references the Chrome browser in the examples. The Chrome REST client can be obtained from the Chrome App store by searching for "Advanced REST Client."

https://chrome.google.com/webstore/category/apps

Install the application and restart the Chrome browser. After restarting the Chrome browser, the REST client can be launched by clicking on the browsers "Apps" button, as shown in Figure 4, and then selecting the "Advanced REST Client" application as highlighted in Figure 5.

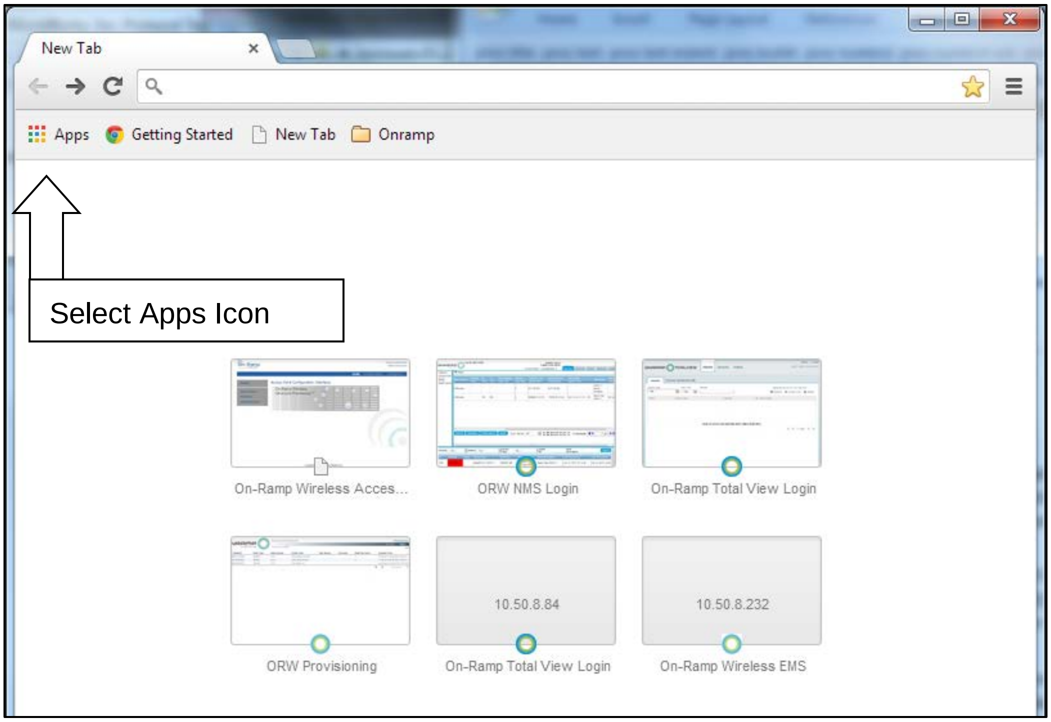

Figure 4. Location of Chrome Apps

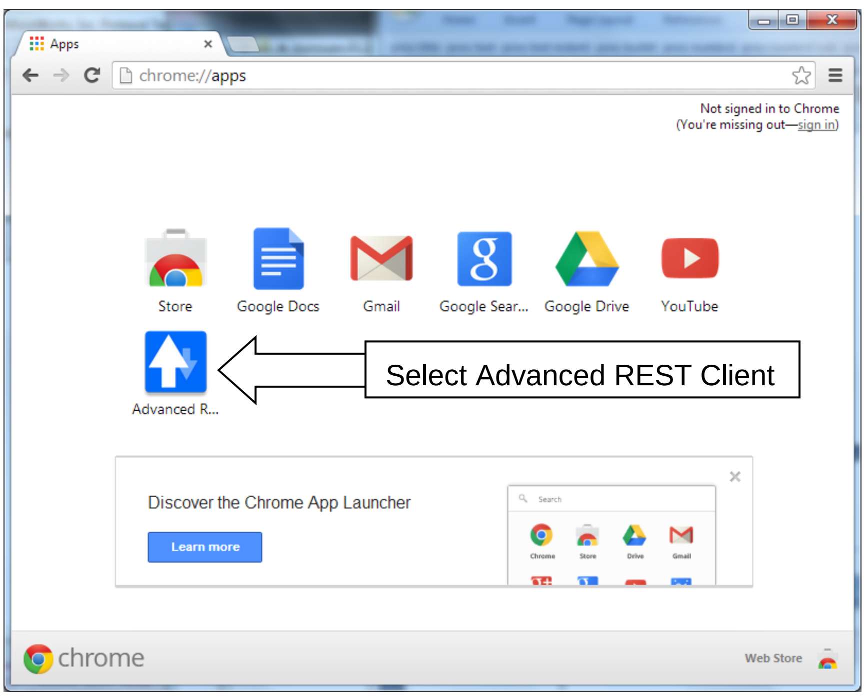

Figure 5. Advanced REST Client

Figure 6 shows the Advanced REST client user interface; the REST client is now ready to operate.

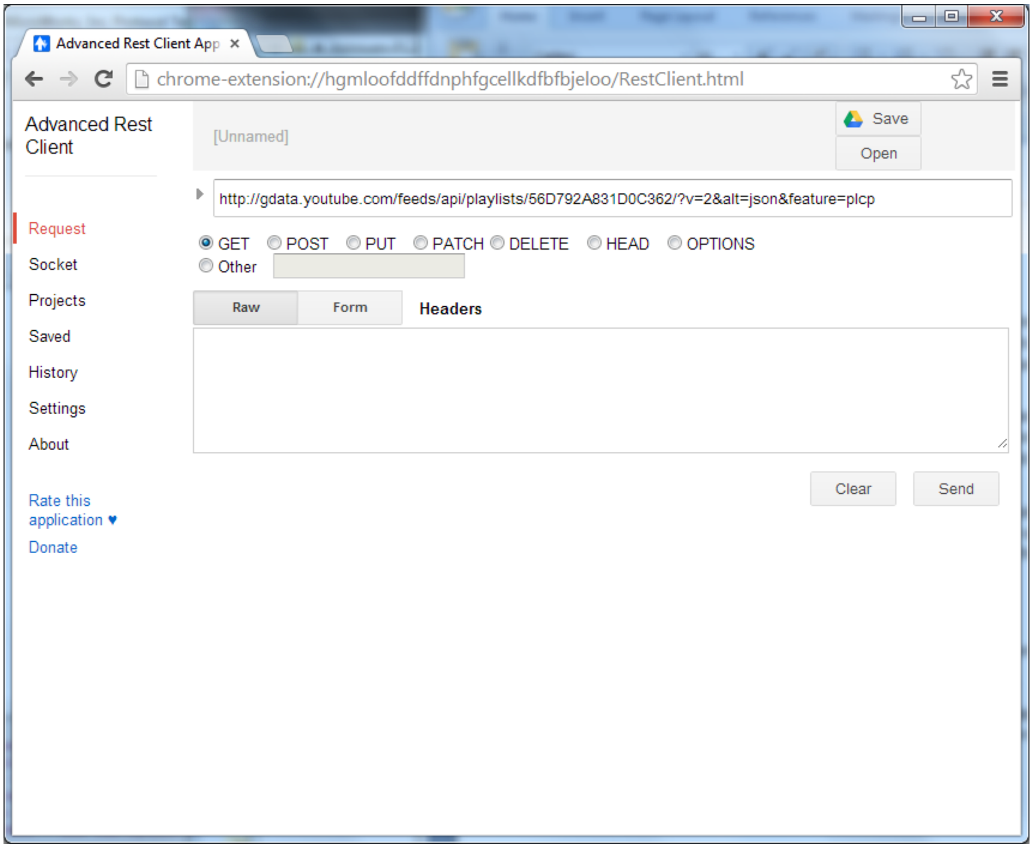

Figure 6. Advanced REST Client Interface

3.3 REST Client Quick Tutorial

The main components that are needed to initiate a REST command are:

1. The host's URL address, including the REST resource path. For the On-Ramp Wireless DNP3 Concentrator, the host address is the same as the On-Ramp Total View (OTV) web interface address.
2. The REST command. The On-Ramp Wireless DNP3 Concentrator supports the commands GET, POST and DELETE.
3. The REST request body. This represents the data to be exchanged between from the server to the client.
4. The REST response body. This represents the data returned from the server to the client.

The "Content-Type" field should normally be set to text/plain when dealing with "csv" type payloads. The content type field setting of text/plain handles XML formats as well.

Before any operational commands can be exchanged, the REST user must login and obtain a REST session token. Note that before an OTV user can even log into OTV using the REST interface, that OTV user must have an OTV assigned role of "Service" (see Section 3.1). General details of On-Ramp Wireless' REST interface can be found in the *OTV REST API Guide* (*010-0038-00).*

Figure 7 illustrates the typical REST interaction in five steps:

1. Specify the appropriate REST URL.
2. Specify the REST command (e.g., POST, GET, or DELETE).
3. Paste a REST body. The body usually consists of comma separated values, except for the case of a login, where an xml format is used.
4. Specify the Content Type. The Content Type is usually "text/csv" except for the case of a login operation, where it should be "application/xml."
5. Press the "Send" command.

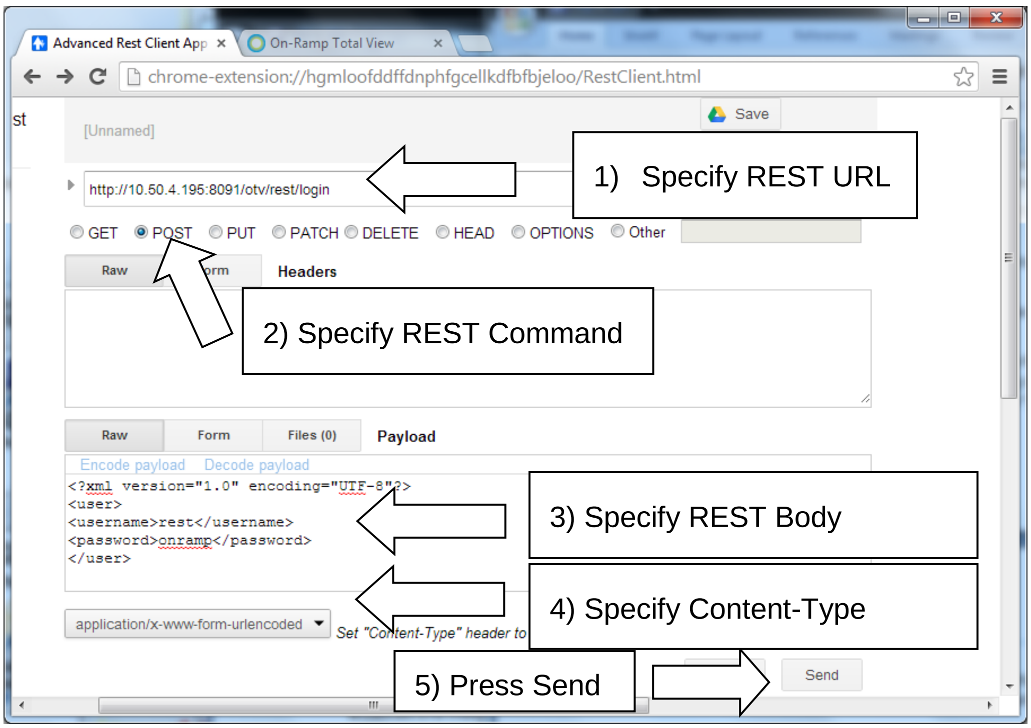

Figure 7. Steps to Log Into the OTV REST Interface

The REST command is posted by clicking the "Send" button. The subsequent response is returned in the REST Client's response shown in Figure 8. In that figure, a token value of `83d93bd1-9e35-416c-9b72-d307457e6318` is returned in the "Raw" response field. This signifies a successful REST login. The token value is used for subsequent REST commands until it expires.

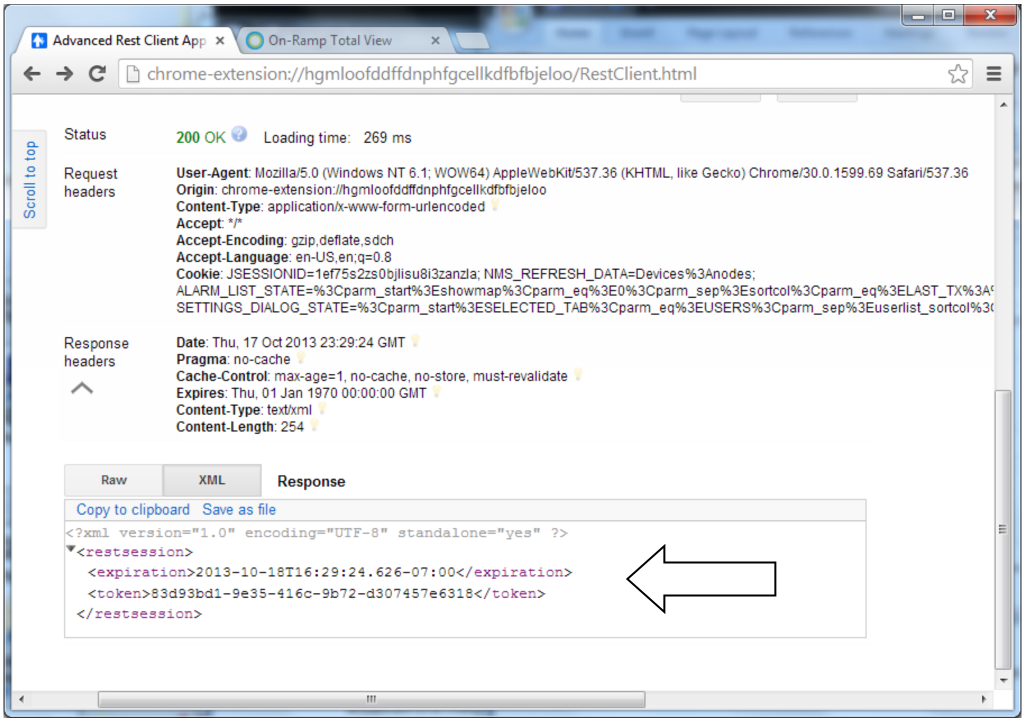

Figure 8. REST Response to a Login

A large portion of this document relies on REST examples given in the following format

Example: REST user log in (example description)

- URL (a representative example)

http://10.50.4.195:8091/otv/rest/login

NOTE: The value "10.50.4.195:8091" should be replaced with the OTV URL of the actual appliance in use. A port number is usually not required.

NOTE: Depending on IT network specifications, secure http may be required. Modify the URL as "https" if required.

- Action (GET, POST, or DELETE)

POST

- Request Body (a representative is given; in this case an xml format is used).

```
<?xml version="1.0" encoding="UTF-8"?>
<user>
    <username>username</username>
    <password>password</password>
</user>
```

NOTE: The "username" and "password" should be replaced with a valid OTV account credential. This account should have an OTV role of "Service" defined in the user account.

- Response Body (a representative example if applicable)

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<restsession>
    <expiration>2013-10-18T16:29:24.626-07:00</expiration>
    <token>83d93bd1-9e35-416c-9b72-d307457e6318</token>
</restsession>
```

3.4 Summary of REST URL variations

In general, a REST URL is in a form similar to the following:

`http://<OTV_IP_ADDR>:<OTV_PORT><REST_PATH>/<TOKEN><?QUERY_PARAMS>`

where:

`OTV_IP_ADDR`	The IP Address of the On-Ramp Wireless Total View.
`OTV_PORT`	The TCP port address used by the On-Ramp Wireless Total View.
`REST_PATH`	The rest resource path. The paths commonly used include: /otv/rest/dnp3/concentrator (GET, POST, or DELETE operations) /otv/rest/dnp3/concentrator/points (GET operation only) /otv/rest/dnp3/outstation (GET,POST, or DELETE operations) /otv/rest/dnp3/outstation/points (GET operation only) /otv/rest/dnp3/points (GET, POST or DELETE operations)
`TOKEN`	Upon initial REST OTV login, a token is assigned. This token is in a format similar to the one shown in the log-in example of 83d93bd1-9e35-416c-9b72-d307457e6318.
`QUERY_PARAMS`	Optional query parameters. Use this to filter the REST responses. If query parameters are not specified in a GET, POST, or DELETE method, the REST response body shows all applicable entities after each GET, POST or DELETE operation. The optional query parameters are: `port` Only return entities associated with the concentrators having this port assignment. `linkaddress` Only return entities associated with the concentrators having this link address. `nodeid` Only return entities associated with this outstation's MAC address (i.e., node ID). `remoteaddress` Only return entities associated with an outstation remote DNP3 link address of specified value.

A few comments are in order regarding general usage of the REST interface.

1. Every REST command without a query parameter returns all appropriate entities in the REST response message.

2. Optional query parameters only operate on the REST response messages (i.e., acts as a filter on the returned HTTP query results).
3. Optional query parameters themselves have no functional DNP3 concentrator configuration effects.

Example URL #1: In this example, all the points over all concentrators are returned (i.e., query parameters are not specified).

```
http://10.50.4.195:8091/otv/rest/dnp3/points/51a5ba18-4c8c-4a71-a0e9-
1c4070c6e5b9
```

Example URL #2: In this example, only the points associated with the concentrator whose port address is 20000 and DNP3 link address is 1 are returned (i.e., query parameters are utilized to filter the results).

```
http://10.50.4.195:8091/otv/rest/dnp3/points/51a5ba18-4c8c-4a71-a0e9-
1c4070c6e5b9?port=20000&linkaddress=1
```

4 Creating DNP3 Concentrator Entities

In the On-Ramp Wireless DNP3 adapter, three DNP3 entities can be defined: a concentrator, an outstation, and a point.

NOTE: When posting REST bodies, a header must always be included as shown in all of the posting examples.

4.1 Creating a DNP3 Concentrator

There exists several ways of creating a DNP3 concentrator:

1. Explicit creation of a concentrator.
2. Implicit concentrator creation with the creation of an outstation associated with a non-existent concentrator.
3. Implicit concentrator creation with the creation of a DNP3 point associated with a non-existent concentrator.

4.1.1 Explicitly Creating a Concentrator

With this method, a csv body should contain the following:

```
entity,port,linkaddress,tag
```

where:

`entity`	The entity to be created is the "concentrator"
`port`	The TCP port address of the concentrator
`link address`	The DNP3 link address of the concentrator
`tag`	An arbitrary name assigned to the concentrator

In this example, three concentrator instances are created on the HES DNP3 adapter.

- URL

```
http://10.50.4.195:8091/otv/rest/dnp3/concentrator/83d93bd1-9e35-416c-9b72-d307457e6318
```

- Action

POST

- Request Body

```
entity,port,linkaddress,tag
concentrator,20000,1,My First Concentrator
concentrator,20000,2,My Second Concentrator
concentrator,20000,3,My Third Concentrator
```

- Response Body
  When successful, the response body shows all concentrators that exist. Please verify that the concentrators have been created in the response body.

```
entity,port,linkaddress,tag
concentrator,20000,1,My First Concentrator
concentrator,20000,2,My Second Concentrator
concentrator,20000,3,My Third Concentrator
```

4.1.2 Implicitly Creating a Concentrator by Explicitly Creating an Outstation

With this method, explicitly creating an outstation and including a concentrator association with a non-existent concentrator causes the creation of that intended concentrator. An example of creating a DNP3 outstation with a concentrator association is covered in Section 4.2.

NOTE: Outstation entities can be automatically created. If an outstation device has already joined the Total Reach Network, then it is likely that that device's outstation entity has been automatically created. Automatically created outstations are never automatically associated with a concentrator

4.1.3 Implicitly Creating a Concentrator by Manually Mapping a DNP3 Point

With this method, creating a remote DNP3 point and associating it to a non-existent concentrator causes the creation of that concentrator. Additionally if an outstation entity did not exist, an outstation entity is automatically created. An example of mapping a DNP3 point to a concentrator is covered in Section 4.3.

4.2 Creating/Associating a DNP3 Outstation

The format of the REST body should be as follows:

```
entity,port,linkaddress,nodeid,remoteaddress,application,device,version
```

where:

`entity`	Represents the data type created (in this case "outstation")
`port`	The TCP port of the concentrator
`linkaddress`	The DNP3 link address of the concentrator
`nodeid`	The outstation device's Total Reach MAC address
`remoteaddress`	The DNP3 link address of the outstation (for non-native DNP3 devices such as the WSO-11, defaults to zero)
`application`	Unused in this POST operation
`device`	Unused in this POST operation
`version`	Unused in this POST operation

A few concepts about how the DNP3 concentrator handles outstation creation are given below.

1. Outstations are auto-created ***without*** any association to a concentrator if a DNP3 compatible device exists on the Total Reach Network and transmits any form of uplink payloads.
2. Outstations can be manually created. This can be the case if the DNP3 devices have not yet been deployed, but the DNP operator wishes to configure the devices on the DNP3 network.
3. Outstations must always be manually assigned to a DNP3 concentrator. Under no circumstances is a newly created outstation automatically assigned to a DNP3 concentrator.

In this example, two outstations are created and attached to two different concentrators. Referring to the example, a concentrator at TCP port 20000, DNP3 link address 0, is created (if non-existent) and is associated with node ID 0x118f5. Similarly, a concentrator at TCP port 20000, DNP3 link address 1, is created (if non-existent) and is associated with node ID 0x1050e.

- URL

```
http://10.50.4.195:8091/otv/rest/dnp3/concentrator/83d93bd1-9e35-416c-9b72-
d307457e6318
```

- Action

POST

- Request Body

```
entity,port,linkaddress,nodeid,remoteaddress,application,device,version
outstation,20000,0,0x0118f5,0,,,
outstation,20000,1,0x01050e,0,,,
```

- Response Body
  When successful, the response body shows all outstations that exist. Please verify that the outstations have been created in the response body.

```
entity,port,linkaddress,nodeid,remoteaddress,application,device,version
outstation,20000,1,0x0001050e,0,,,
outstation,20000,0,0x000118f5,0,,,
```

4.3 Mapping an Outstation DNP3 Point

This section is only applicable to the manual point mapping mode of the DNP3 concentrator.

The format of the REST body should be as follows

```
entity,group,port,linkaddress,localindex,remoteindex,nodeid,remoteaddress,tag
```

where:

`entity`	Represents the data type created (in this case “point”)
`group`	The point’s group assignment for the remote outstation. Group assignments are defined in the device’s DNP3 profile.
`port`	The TCP port of the concentrator
`linkaddress`	The DNP3 link address of the concentrator
`localindex`	The mapped point index corresponding to the “remoteindex.”

`remoteindex`	The DNP3 point index of the outstation.
`nodeid`	The outstation device's Total Reach MAC address
`remoteaddress`	The DNP3 link address of the outstation (if unused, defaults to zero)
`tag`	Description of the point
`application`	Unused in this POST operation
`device`	Unused in this POST operation
`version`	Unused in this POST operation

- URL

```
http://10.50.4.195:8091/otv/rest/dnp3/point/83d93bd1-9e35-416c-9b72-
d307457e6318
```

- Action

POST

- Request Body

```
entity,group,port,linkaddress,localindex,remoteindex,nodeid,remoteaddress,tag
point,1,20000,0,0,10,0x118f5,0, Armed Flag
point,1,20000,0,1,12,0x118f5,0, Low Battery Flag
point,1,20000,0,2,14,0x118f5,0, Mechanical Target Flag
point,1,20000,0,3,19,0x118f5,0, Fault Report
point,1,20000,0,4,18,0x118f5,0, Restoration Report

point,1,20000,1,0,10,0x1050e,0, Armed Flag
point,1,20000,1,1,12,0x1050e,0, Low Battery Flag
point,1,20000,1,2,14,0x1050e,0, Mechanical Target Flag
point,1,20000,1,3,19,0x1050e,0, Fault Report
point,1,20000,1,4,18,0x1050e,0, Restoration Report
```

NOTE: In the request body, the "tag" field in this POST operation is not consumed by the POST operation. The tag field is what is defined in the device's DNP3 profile file. As such, especially when creating a large list of point definitions, it may be helpful to use this field as a "comment" field for maintaining a master point list, but is otherwise unused if specified.

- Response Body
  When successful, the response body shows all DNP3 points that exist for all concentrators. Please verify that the outstations have been created in the response body.

```
entity,group,port,linkaddress,localindex,remoteindex,nodeid,remoteaddress,tag
point,1,20000,0,1,12,0x000118f5,0,
point,1,20000,0,2,14,0x000118f5,0,
point,1,20000,0,3,19,0x000118f5,0,
point,1,20000,0,4,18,0x000118f5,0,
point,1,20000,1,0,10,0x0001050e,0,
point,1,20000,1,1,12,0x0001050e,0,
point,1,20000,1,2,14,0x0001050e,0,
```

```
point,1,20000,1,3,19,0x0001050e,0,
point,1,20000,1,4,18,0x0001050e,0,
```

NOTE: When the next UL SDU for a particular device whose points have just been mapped is received, the “tag” fields are populated with descriptive text as defined in the DNP3 profile file of the device.

5 Querying DNP3 Concentrator Entities

There are many different variations of REST URLs that query DNP3 adapter entities. This section describes the most useful permutations.

5.1 Getting a List of Existing Concentrators

In this example, all instances of concentrators are queried. Assuming three concentrators exist, where each concentrator had the same IP Port but unique DNP3 link addresses, the output is shown below.

- URL

```
http://10.50.4.195:8091/otv/rest/dnp3/concentrator/83d93bd1-9e35-416c-9b72-
d307457e6318
```

- Action

GET

- Request Body

```
None
```

- Response Body

```
entity,port,linkaddress,tag
concentrator,20000,1,My First Concentrator
concentrator,20000,2,My Second Concentrator
concentrator,20000,3,My Third Concentrator
```

5.2 Getting a List of Existing Outstations

In this example, all instances of outstations in existence are queried. Assuming a single concentrator exists and this sole concentrator was associated with only four outstations, the output is shown below.

- URL

```
http://10.50.4.195:8091/otv/rest/dnp3/outstation/51a5ba18-4c8c-4a71-a0e9-
1c4070c6e5b9
```

- Action

GET

- Request Body

```
None
```

- Response Body

```
entity,port,linkaddress,nodeid,remoteaddress,application,device,version
outstation,20000,0,0x0001050e,0,2,2,1
outstation,20000,0,0x000118f5,0,2,2,1
outstation,20000,0,0x0000ffff,0,2,2,1
outstation,20000,0,0x000fffff,9,2,2,1
```

5.3 Getting a List of Concentrator Points

Whether auto point indexing or manual point indexing is enabled, obtaining a list of concentrator points entails the same method. In this example, there exists only one WSO-11 device in the entire network. Additionally, none of the points are omitted in the DNP3 profile file, and auto-point mapping is enabled. A global point query returns the entire set of points for a single WSO-11 device.

- URL

```
http://10.50.4.195:8091/otv/rest/dnp3/points/51a5ba18-4c8c-4a71-a0e9-
1c4070c6e5b9
```

- Action

```
GET
```

- Request Body

```
None
```

- Response Body

```
entity,group,port,linkaddress,localindex,remoteindex,nodeid,remoteaddress,tag
point,1,20000,0,0,10,0x000118f5,0,Armed
point,1,20000,0,1,19,0x000118f5,0,Fault Report
point,1,20000,0,2,21,0x000118f5,0,Other Report
point,1,20000,0,3,20,0x000118f5,0,LOC Report
point,1,20000,0,4,18,0x000118f5,0,Restoration Report
point,1,20000,0,5,17,0x000118f5,0,Periodic Report
point,1,20000,0,6,16,0x000118f5,0,Deployment Report
point,1,20000,0,7,15,0x000118f5,0,Event Alarm
point,1,20000,0,8,14,0x000118f5,0,Mechanical Target
point,1,20000,0,9,13,0x000118f5,0,Low Battery
point,1,20000,0,10,12,0x000118f5,0,Flash Error
point,1,20000,0,11,11,0x000118f5,0,RAM Error
point,10,20000,0,0,0,0x000118f5,0,
point,20,20000,0,0,5,0x000118f5,0,Cumulative LOC
point,20,20000,0,1,3,0x000118f5,0,Momentary Disturbance
point,20,20000,0,2,4,0x000118f5,0,Cumulative Faults
point,20,20000,0,3,1,0x000118f5,0,Momentary LOC
point,20,20000,0,4,2,0x000118f5,0,Momentary Load Pickup
point,20,20000,0,5,0,0x000118f5,0,Momentary Faults
point,30,20000,0,0,3,0x000118f5,0,Load
point,30,20000,0,1,2,0x000118f5,0,Current Magnitude
point,30,20000,0,2,1,0x000118f5,0,Current Threshold
point,30,20000,0,3,0,0x000118f5,0,Battery Voltage
point,41,20000,0,0,0,0x000118f5,0,Load Interval
```

NOTE 1: In manual point mapping mode, the “tag” fields are not populated in a point query unless valid device traffic is received after point creation.

NOTE 2: In auto point mapping mode, outstation points are not available until at least one UL SDU is received after the outstation-to-concentrator association is made.

6 Deleting DNP3 Concentrator Entities

The deletion operations for most entities can be thought of as an inverse operation of the corresponding create operation. The simplest method to delete concentrator entities would be to first do a REST query of the entity(entities) to be deleted, using query filtering parameters as required. Then one can turn around that same query response into a REST delete operation.

For example, suppose one would like to delete an unused point for all devices of the same type, from a possible set of several active concentrators, where each concentrator supported hundreds of devices. An example URL query for that device could be in the form of

http://10.50.4.195:8091/otv/rest/dnp3/points/51a5ba18-4c8c-4a71-a0e9-1c4070c6e5b9?port=20000

The response body can then be used as the content body for the subsequent DELETE content body of the REST command with a simple copy and paste operation within the browser's REST client. The following section discusses the various heuristics of deleting DNP3 concentrator entities.

Deletion Heuristics

- Hierarchical deletion of concentrators. Deleting a DNP3 concentrator entity destroys everything below it. For example if one deletes a concentrator, then all outstations associated with that concentrator become unassociated and deleted. Point entities that were mapped from the deleted outstations are also deleted.
- Hierarchical deletion of outstations. Deleting a DNP3 outstation removes any association to its concentrator. Point entities that were mapped from the deleted outstation are also deleted.

NOTE: Outstation entities are autonomously created if it does not exist when an UL SDU for that device has been received. This may have the apparent effect that a hierarchical deletion did not delete the outstations. It was in fact deleted, but in this case the UL SDU would have recreated it in the DNP3 database.

NOTE: Point entities are automatically created if the outstation exists, auto point mapping is enabled, and an UL SDU for that device has been received. This may have the apparent effect that individual points targeted for deletion have not been deleted. It was deleted, but in this case the UL SDU would have recreated it in the DNP3 database.

7 DNP3 Deployment Scenarios

7.1 Concentrator Configuration after DNP3 Devices Deployed

In this scenario, Total Reach enabled DNP3 devices have been installed and are communicating to the On-Ramp Wireless HES. DNP3 outstation entities are automatically created by the DNP3 HES adapter as the end point devices start sending out data to HES.

1. The DNP3 operator defines the outstation to concentrator mappings based on the existing outstation entities.
2. *Auto Point Mapping Mode - MANUAL*
   If the auto point mapping mode is set to false, define the manual point mapping as described in Section 4.3, using the decided outstation to concentrator mappings. This method creates the concentrator, outstation (if non-existent), and point entities as required.

   Or

   Auto Point Mapping Mode - AUTO
   If the auto point mapping mode is set to "auto," import the decided outstation to concentrator mappings as described in Section 4.2. This method creates the concentrator instances as required and also allows creation of DNP3 points that are enabled (i.e., not commented out in the device's HES DNP3 profile file).
3. *Auto Point Mapping Mode - MANUAL*
   If auto point mapping mode is set to false, query the DNP3 points for the concentrator as described in Section 5.3. Inspect the point mapping to ensure that it is as expected. At this point the DNP3 operator can map the concentrator DNP3 points to the DNP3 master application.

   Or

   Auto Point Mapping Mode - AUTO
   If auto point mapping mode is set to "auto," the DNP3 operator must wait until the DNP3 points are created. These points are dynamically created at the rate of the devices "Update Interval." Only when these DNP3 points are available (as observed from a concentrator point query as described in Section 5.3) can the DNP3 network operator begin mapping the concentrator DNP3 points to the DNP3 master application.

7.2 Concentrator Configuration Before DNP3 Devices Deployed.

In this scenario, Total Reach-enabled DNP3 devices have not been installed but the DNP3 network operators would like to have the network preconfigured prior to deployment. Outstations have not yet been created by the HES DNP3 adapter.

1. The DNP3 operator defines the outstation to concentrator mappings.

2. *Auto Point Mapping Mode - MANUAL*
   If the auto point mapping mode is set to false, define the manual point mapping as described in Section 4.3, using the decided outstation to concentrator mappings. This method creates the concentrator, outstation (if non-existent), and point entities as required.

   Or

   Auto Point Mapping Mode - AUTO
   If the auto point mapping mode is set to "auto," import the decided outstation to concentrator mappings as described in Section 4.2. This method creates the concentrator instances as required and also allows creation of DNP3 points that are enabled (i.e., not commented out in the device's HES DNP3 profile file).

3. *Auto Point Mapping Mode - MANUAL*
   If auto point mapping mode is set to false, query the DNP3 points for the concentrator as described in Section 5.3. Inspect that point mapping is as expected. At this point the DNP3 operator can map the concentrator DNP3 points to the DNP3 master application.

   Or

   Auto Point Mapping Mode - AUTO
   If auto point mapping mode is set to "auto," the DNP3 operator must wait until the DNP3 points are created. Creation of these points "trickle out" at the rate of device deployment as each device joins the OTR network for the first time. Only when these DNP3 points are available (as observed from a concentrator point query as described in Section 5.3) can the DNP3 network operator begin mapping the concentrator DNP3 points to the DNP3 master application.

7.3 Adding New Devices to an Existing Deployment

Deploying new Total Reach enabled DNP3 devices on a network that already contains DNP3 devices requires some care. Two sub-cases are define, the first for auto point mapping mode enabled, the second is for manual point mapping.

Case 1: Auto Point Mapping Mode

1. The DNP3 operator should define the outstation to concentrator association for these additional outstation devices to be deployed.
2. New outstation entities are automatically created by the DNP3 HES adapter as those deployed devices begin transmitting UL traffic.
3. Using the newly defined outstation to concentrator associations, the DNP3 operator updates the DNP3 concentrator configurations via the REST interface.
4. The newly deployed field devices must have been given a chance to transmit an UL SDU. When this occurs, the new auto-mapped DNP3 points are available at the concentrator.

NOTE: A disadvantage of auto point mapping method is the time interval required to receive an UL SDU. For example if WSO-11 devices have been deployed with a 24 hour UI, then it is possible that the DNP3 operator will have to wait a full 24 hours to see all automatically created points after being added to an existing Total Reach Network deployment.

5. Only after all DNP3 points have been created shall the DNP3 operator begin mapping the concentrator DNP3 points to the DNP3 master application. This should be verified by a REST query of the DNP3 points for the newly added devices.

    NOTE: It is recommended to wait until the batch of new devices have been deployed and sufficient time has elapsed to ensure the deployed devices have sent at least one UL SDU after deployment.

Case 2: Manual Point Mapping Mode

1. The DNP3 operator should define the outstation to concentrator association for these additional outstation devices to be deployed.
2. Define the DNP3 point mappings as described in Section 4.3, using the previously determined outstation-to-concentrator mappings. The method described in Section 4.3 automatically creates the outstation entities and any additional concentrators, if required.
3. The DNP3 operator should confirm the concentrator point mapping is as expected via a REST query.
4. After successful verification of DNP3 point creations, the DNP3 operator can begin mapping the concentrator DNP3 points to the DNP3 master application

    NOTE: Unlike the auto-point mapping mode, the DNP3 points are created instantaneously for the purposes of mapping to the DNP3 master. However, for each device, valid data is not available until at least one UL SDU is sent by the DNP3-enabled Total Reach device.

7.4 DNP3 Concentrator Bypass Mode

In some applications, a concentrator model is not desired. The On-Ramp Total Reach DNP3 concentrator can support such a mode by allowing a single concentrator instance for each Total Reach enabled DNP3 outstation. The DNP3 concentrator instance can be thought of as a proxy for the actual DNP3 outstation device. All of the rules for configuring a concentrator instance remain valid. Two sub-cases are defined. The first for auto point mapping mode enabled, the second is for manual point mapping. A significant difference between the two methods is that auto-point mapping does not guarantee the original ordering of an outstation's DNP3 point mapping profile.

Case 1: Auto Point Mapping Mode

1. The DNP3 operator defines the outstation to concentrator association in a one-to-one manner (e.g., each outstation is assigned its own concentrator). The desired DNP3 link address of each outstation is defined at this point.

2. Create the outstation to concentrator mapping using the REST interface as described in 4.2. Each concentrator's DNP3 link address represents a single outstation.
3. The DNP3 outstation devices must have been given a chance to transmit an UL SDU. When this occurs, the newly auto-mapped DNP3 points are available at the concentrator.
4. Query the DNP3 points to validate the points via a REST GET command.
5. After point validation, the DNP3 operator can map the DNP3 outstation points at the DNP3 master accordingly.

Case 2: Manual Point Mapping Mode

1. The DNP3 operator defines the outstation to concentrator association in a one to one manner (e.g., each outstation is assigned its own concentrator). The desired DNP3 link address of each outstation is defined at this point.
2. Create a point mapping file using the desired outstation to concentrator association decided upon as described in Section 4.3. During creation of this point mapping file, the DNP3 operator can choose the desired point mapping sequence (e.g., can choose the mapping order to match the devices DNP3 profile).
3. Post the DNP3 point mapping plus outstation to concentrator associations using the REST interface.
4. Query the DNP3 points to validate the points via a REST GET command.
5. Map each outstation to the DNP3 master as required.

7.5 DNP3 Network Maintenance

There may be times where the DNP3 concentrator HES adapter needs to be restarted. One example is the when the outstation to DNP3 concentrator associations need to be re-jiggered. Below is a recommended process to implement DNP3 maintenance for this scenario. Two sub-cases are defined. The first case is for auto point mapping mode, the second case is for manual point mapping.

Case 1: Auto Point Mapping Mode

1. Alert DNP3 Network Operators and OTV users of a planned maintenance window.
2. Perform a REST query of the current set of outstations as described in Section 5.2 . **Be sure to save off a copy of this REST query as a reference.**
3. Delete the current concentrator mapping as described in Section 0. Deleting at the concentrator level performs a hierarchical delete (e.g., all outstations and points associated with this concentrator are also deleted).
4. Stop the HES process. DNP3 communications are down during this service interval. This can be done by an OTV privileged user by logging onto the machine running the On-Ramp Wireless HES services and issuing the following command.

   ```
   sudo service orw-hes stop
   ```

5. Create an updated outstation to concentrator mapping file. The REST query from step #2 can be used as a starting template if desired.
6. Start the HES process. This can be done by an OTV privilege user by logging onto the machine running HES services and issuing the following command.
   `sudo service orw-hes start`
7. Post the updated outstation to concentrator association file using the REST interface.
8. Allow sufficient time for each DNP3 outstation device to report at least one UL SDU. Query the new DNP3 point mappings from the REST interface to validate the DNP3 point mappings.
9. Update the DNP3 master's point mappings as required.

Case 2: Manual Point Mapping Mode

1. Alert DNP3 Network Operators and OTV users of a planned maintenance window.
2. Perform a REST query of the current DNP3 point mappings as described in Section 5.3. This procedure also returns the current outstation to concentrator associations. **Be sure to save a copy of this REST query as a reference.**
3. Delete the current concentrator mapping as described in Section 0. Deleting at the concentrator level performs a hierarchical delete (e.g., all outstations and points associated with this concentrator are also deleted).
4. Stop the HES process. DNP3 communications are down during this service interval. This can be done by an OTV privilege user by logging onto the machine running HES services and issuing the following command.
   `sudo service orw-hes stop`
5. Create an updated point mapping file with implicit outstation to concentrator associations. The REST query from step #2 can be used as a starting template if desired.
6. Start the HES process. This can be done by an OTV privilege user by logging onto the machine running HES services and issuing the following command.
   `sudo service orw-hes start`
7. Post the updated DNP3 point mapping file with outstation to concentrator associations via the REST interface (as in Section 4.3). Validate the resultant point mapping from the REST message response.
8. Update the DNP3 master's point mappings as required.

7.6 Managing Multiple DNP3 Masters

Network topologies may exist at the back office where multiple DNP3 masters need access to the OTV DNP3 concentrator and its associated DNP3 outstation data. The only multiple DNP3 master model supported by the On-Ramp Wireless DNP3 adapter is where a unique DNP3 master is associated with a unique DNP3 virtual concentrator instance. Any number of these pairs of DNP3 masters to DNP3 concentrators can be configured but multiple DNP3 masters attempting to communicate with a common DNP3 concentrator instance is prohibited.

Two scenarios are supported as follows:

1. Physical DNP3 masters reside on different IP addresses (e.g., different computers).
2. Multiple DNP3 masters "sessions" exist on the same IP address (commonly in the same DNP3 master software package).

Scenario 1: DNP3 Masters Reside on Different IP Addresses

To configure a unique DNP3 master to unique DNP3 concentrator instance pair, the following rules must be observed:

1. Each DNP3 master must have a unique IP address.
2. Each DNP3 master must have an identical DNP3 master link address value.
3. In the hes_config.properties file, set "adapter.dnp3.master.linkaddress.uselast = false".
4. In the hes_config.properties file, set the "adapter.dnp3.master.linkaddress.expected" to the value specified from item #2.
5. Each virtual concentrator instance must be assigned unique port numbers. This may impact network firewall rules and require opening of ports for DNP3 traffic.
6. The virtual concentrators may or may not have different DNP3 link addresses. The port number is what will uniquely identify the concentrator instance in a multiple DNP3 master configuration.

Scenario 2: DNP3 Masters Reside on the Same IP Address

If multiple DNP3 master sessions are required, the following rules must be observed:

1. Unsolicited Reporting is not supported in this configuration and must be disabled at the On-Ramp Wireless HES configuration and it is recommended that it be disabled at the DNP3 master.
2. Each DNP3 master session must have a unique DNP3 link address.
3. In the hes_config.properties file, set "adapter.dnp3.master.linkaddress.uselast = true".
4. Each virtual concentrator instance must have a unique DNP3 link address.
5. Each virtual concentrator instance may be assigned unique port numbers but it is not recommended. This may impact network firewall rules and require opening of ports for DNP3 traffic.

Appendix A Troubleshooting

This appendix summarizes the possible pitfalls and known issues of the DNP3 Concentrator Adapter bundled in OTV version 1.1.12.2.

A.1 Network-Related

- A TCP/IP session between a DNP3 master and the HES DNP3 adapter fails if no concentrators have been defined. This is because at least one DNP3 link address has yet to be allocated within the HES DNP3 adapter.
- If a TCP/IP session already exists between a DNP3 master and at least one OTV DNP3 concentrator, the HES DNP3 concentrator adapter allows DNP3 link connections to “non-existent” DNP3 link addresses on that TCP/IP session (e.g., DNP3 concentrators that do not exist at DNP3 link address 17). However, any polling operations initiated by the DNP3 master to a non-existent concentrator, returns a DNP3 application layer message channel timeout of that polling operation.
- A single instance of a DNP3 concentrator does not support connections to multiple DNP3 masters. Unique DNP3 master-to-DNP3 concentrator pairing (strict one-to-one association) is allowed, provided the DNP3 masters share the same TCP/IP address (e.g., only the master’s DNP3 link address is unique). See Section 7.6 for more details.
- If the TCP/IP link is disrupted between the DNP3 master and the DNP3 HES adapter, there is a chance that upon restoration of the TCP/IP link, the subsequent and required integrity poll will fail. This is due to a known issue (#6535). A workaround is to restart the On-Ramp Wireless HES.

A.2 Operational Behavior

- The On-Ramp Wireless HES polls for newly created concentrators every 60 seconds. Therefore a latency of up to 60 seconds may exist before a DNP3 master can communicate with a newly defined concentrator.
- Outstation entities automatically get created as long as a recent UL SDU has been sent (e.g., a DNP3 outstation concentrator entity does not have to be explicitly created if an active device exists). It should be noted that these automatically created outstations will never be automatically mapped to a concentrator.
- Cases where the On-Ramp Wireless HES process must be restarted due to DNP3 operations from the end user:
  - Any On-Ramp Wireless DNP3 adapter changes on the On-Ramp Wireless appliance (e.g., modifying any field in the file: /opt/onramp_apps/hes/instance_x/hes_config.properties file)
  - Any changes in the DNP3 device profile file such as a point’s class assignment (e.g., /opt/onramp_apps/hes/instance_x/dnp3-profiles/wso11.dnp3.mapping.properties)

- Limited error checking on the DNP3 device profile file. If any error exists in the profile file after user modification, these errors may go unnoticed and/or unpredictable DNP3 protocol behavior occurs. One example is if a device's DNP3 point is inadvertently assigned an invalid (out of bounds) class assignment, that point will never be reported to the DNP3 master.
- Analog Output Block (AOB) is limited to data type short and long (e.g., integer data types). "float" and "double" are currently not supported. There is a bug in OTV 1.1.12.2 where these unsupported data types, when used, crash the HES (issue #7894).
- A DNP3 point can only be assigned to one unique event class type in the DNP3 profile file (e.g., cannot be assigned as both a class 2 and class 3 point event).
- DNP3 point "Class 3" assignment may appear broken. This is due to the fact that the values assigned in the HES configuration file are binary coded decimals. Use the mapping described in Appendix B.
- If DNP3 auto-point generation is enabled, one can still manually add points. This action may unintentionally overwrite existing points for other devices if not carefully tracked (e.g., usage/user induced error). It is suggested that point mapping modes not be mixed.
- In manual point mapping mode, points that are not commented out of the device's HES DNP3 properties file may still show up as points at the DNP3 master. This may happen if the manual mapping is not contiguous at the concentrator (i.e., not tightly packed). In this case, the DNP3 concentrator randomly chooses points to fill in the otherwise unused DNP3 points as seen by the DNP3 master. These points do not contain any valid information and should be ignored.
- Renaming the "tag" name in the DNP3 device profile will not take effect unless all existing DNP3 points for that device are deleted and the DNP3 points are recreated (in manual point mapping mode) or the DNP3 point mapping algorithm is allowed to run (in auto point mapping mode). In either case, a HES restart is required.
- Auto point mapping is enabled, but DNP3 points are not being automatically recreated.
    - Ensure the conditions outlined in Section 2.3.1 are met.
    - Ensure the hes_config.properties variable adapter.dnp3.generation.points is set to "auto," not "true." Any keyword other than "auto" means auto point mapping is disabled.

A.3 REST Interface Usage

- Unexpected concentrator configuration results. In one example, a batch of concentrators is added but DNP3 link addresses are not properly assigned. In another example, a batch of concentrators is deleted but when queried, these concentrators still exist. Most of these errors are attributed to user input errors.
    - Carefully verify the REST command did not fail. Depending on the REST client used, the error codes may be hard to see.
    - Verify the syntax of the *.csv content body. An error in syntax may or may not go undetected.

  - Verify the REST “Content-Type” setting is correct. Some formats may accept the *.csv content body without error; however the DNP3 concentrator may fail to parse. The content type must be set to “text/csv.”

- A REST command response returns the following error:

  `Invalid token`

  This can happen if the current token has expired or the OTV/HES system has been upgraded. Log in again to obtain a valid token. The default token expiration time is 24 hours.

Appendix B HES DNP3 Profile Files

This appendix documents the various DNP3 device profiles supported by the On-Ramp Wireless Total Reach Head End System (HES). Configurability details (e.g., what can and cannot be modified) are given on a per-device basis in the appropriate appendix subsection.

The various HES DNP3 profile files can be found on the HES server located in the directory similar to the following:

`/opt/onramp_apps/hes/instance_x/dnp3-profiles`

where “x” represents the HES numerical instance.

In the event of a discrepancy between this document and the actual HES device profile file, the HES device profile file should be considered as the authoritative reference.

The bullet points below apply to all supported HES DNP3 device profiles.

- Reassignment of classes. Event class assignments are binary coded (e.g., a class assignment of 1 is eventClass=1, a class assignment of 2 is eventClass=2, **but a class assignment of 3 is eventClass=4**). All allowable class assignment values are shown in the following table.

Table 2. HES DNP3 Device Profile Class Assignments

Desired DNP3 Event Class	“eventClass=” in HES dnp3-profiles file
Unassigned	Leave blank
Class 0	0
Class 1	1
Class 2	2
Class 3	4

- Commenting out DNP3 points (only used by auto point mapping mode) prevents those points from being seen by the DNP3 master. Comments are specified by prefixing a line with the ‘#’ character.

The following subsections discuss the DNP3 profiles specific to the device indicated.

B.1 SEL WSO-11, Gen 2

The WSO-11 Gen 2 (“v2”) DNP3 profile file is provided below.

```
#WSO-11->DNP3 data point mapping file

application.id=2
application.name=WSO-11
application.device.id=2
application.device.version=2

#DNP3 Device Attributes
group.0.variation.242.index.0=[tag=Firmware Version]
```

```
group.0.variation.245.index.0=[tag=Location]
group.0.variation.246.index.0=[tag=Node Id]
group.0.variation.250.index.0=[tag=Device Type]
group.0.variation.252.index.0=[tag=Manufacturer]

#DNP3 Data Points
#Group and Index pair are unique for all data points, i.e. can only have one data point
with index 0 for BINARY INPUT
#syntax= group.<number>.index.<number>=[tag=?,variation=?,eventClass=?,eventVariation=?]

#BINARY INPUTS (GROUP 1) (EVENT GROUP 2)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.1.index.10=[tag=Armed,variation=1,eventClass=1,eventVariation=2]
group.1.index.11=[tag=RAM Error,variation=1,eventClass=1,eventVariation=2]
group.1.index.12=[tag=Flash Error,variation=1,eventClass=1,eventVariation=2]
group.1.index.13=[tag=Low Battery,variation=1,eventClass=1,eventVariation=2]
group.1.index.14=[tag=Mechanical Target,variation=1,eventClass=1,eventVariation=2]
group.1.index.15=[tag=Event Alarm,variation=1,eventClass=1,eventVariation=2]
group.1.index.16=[tag=Deployment Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.17=[tag=Periodic Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.18=[tag=Restoration Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.19=[tag=Fault Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.20=[tag=LOC Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.21=[tag=Other Report,variation=1,eventClass=1,eventVariation=2]

#BINARY OUTPUTS (GROUP 10) (EVENT GROUP 11)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.10.index.0=[tag=Load Reporting Type,variation=1,eventClass=0,eventVariation=2]

#COUNTERS (GROUP 20) (EVENT GROUP 22)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 5 <- 32-bit; 6 <-
16-bit
group.20.index.0=[tag=Momentary Faults,variation=6,eventClass=1,eventVariation=6]
group.20.index.1=[tag=Momentary LOC,variation=6,eventClass=1,eventVariation=6]
group.20.index.2=[tag=Momentary Load Pickup,variation=6,eventClass=1,eventVariation=6]
group.20.index.3=[tag=Momentary Disturbance,variation=6,eventClass=1,eventVariation=6]
group.20.index.4=[tag=Cumulative Faults,variation=6,eventClass=0,eventVariation=6]
group.20.index.5=[tag=Cumulative LOC,variation=6,eventClass=0,eventVariation=6]

#ANALOG INPUTS (GROUP 30) (EVENT GROUP 32)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 3 <- 32-bit; 4 <-
16-bit; 5 <- float with flag; 6 <- double with flag
group.30.index.0=[tag=Battery Voltage,variation=4,eventClass=0,eventVariation=4]
group.30.index.1=[tag=Current Threshold,variation=4,eventClass=0,eventVariation=4]
group.30.index.2=[tag=Current Magnitude,variation=4,eventClass=1,eventVariation=4]
group.30.index.3=[tag=Load,variation=4,eventClass=1,eventVariation=4]

#ANALOG OUTPUTS (GROUP 41) (EVENT GROUP 42)
group.41.index.0=[tag=Load Interval,variation=2,eventClass=0,eventVariation=2]

#COMMANDS= WRITE, SELECT_OPERATE, DIRECT_OPERATE, IMMEDIATE_FREEZE, FREEZE_CLEAR,
COLD_RESTART, WARM_RESTART
```

```
#notation= gx represent, px denote point number of the pointindex array the group number
is referring
#syntax= COMMAND->(g1,p1),(g2,p2),(g3,p3)
```

B.2 SEL WSO-11, Gen 2b

The WSO-11 Gen 2b (“v2b”) DNP3 profile file is given below. The “v2b” adds to the “v2” WSO-11 DNP3 points for momentary event/alarm reporting. In a mixed network containing both “v2” and “v2b” devices, each version must have its own DNP3 profile file in the HES dnp3-profiles directory.

```
#WSO-11->DNP3 data point mapping file

application.id=2
application.name=WSO-11
application.device.id=2
#options are v1, v2, v2b (each version needs its own file)
application.device.version=v2
application.device.timeout=172800

#DNP3 Data Points
#Group and Index pair are unique for all data points, i.e. can only have one data point
with index 0 for BINARY INPUT
#syntax= group.<number>.index.<number>=[tag=?,variation=?,eventClass=?,eventVariation=?]

#BINARY INPUTS (GROUP 1) (EVENT GROUP 2)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.1.index.10=[tag=Armed,variation=1,eventClass=1,eventVariation=2]
group.1.index.11=[tag=RAM Error,variation=1,eventClass=1,eventVariation=2]
group.1.index.12=[tag=Flash Error,variation=1,eventClass=1,eventVariation=2]
group.1.index.13=[tag=Low Battery,variation=1,eventClass=1,eventVariation=2]
group.1.index.14=[tag=Mechanical Target,variation=1,eventClass=1,eventVariation=2]
group.1.index.15=[tag=Event Alarm,variation=1,eventClass=1,eventVariation=2]
group.1.index.16=[tag=Deployment Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.17=[tag=Periodic Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.18=[tag=Restoration Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.19=[tag=Fault Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.20=[tag=LOC Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.21=[tag=Other Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.22=[tag=Momentary Fault Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.23=[tag=Momentary LOC Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.24=[tag=Momentary Disturbance
Report,variation=1,eventClass=1,eventVariation=2]
group.1.index.25=[tag=Momentary Load Pickup
Report,variation=1,eventClass=1,eventVariation=2]

#BINARY OUTPUTS (GROUP 10) (EVENT GROUP 11)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.10.index.0=[tag=Load Reporting Type,variation=1,eventClass=0,eventVariation=2]

#COUNTERS (GROUP 20) (EVENT GROUP 22)
```

```
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 5 <- 32-bit; 6 <-
16-bit
group.20.index.0=[tag=Momentary Faults,variation=6,eventClass=1,eventVariation=6]
group.20.index.1=[tag=Momentary LOC,variation=6,eventClass=1,eventVariation=6]
group.20.index.2=[tag=Momentary Load Pickup,variation=6,eventClass=1,eventVariation=6]
group.20.index.3=[tag=Momentary Disturbance,variation=6,eventClass=1,eventVariation=6]
group.20.index.4=[tag=Cumulative Faults,variation=6,eventClass=0,eventVariation=6]
group.20.index.5=[tag=Cumulative LOC,variation=6,eventClass=0,eventVariation=6]

#ANALOG INPUTS (GROUP 30) (EVENT GROUP 32)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 3 <- 32-bit; 4 <-
16-bit; 5 <- float with flag; 6 <- double with flag
group.30.index.0=[tag=Battery Voltage,variation=4,eventClass=0,eventVariation=4]
group.30.index.1=[tag=Current Threshold,variation=4,eventClass=0,eventVariation=4]
group.30.index.2=[tag=Current Magnitude,variation=4,eventClass=1,eventVariation=4]
group.30.index.3=[tag=Load,variation=4,eventClass=1,eventVariation=4]

#ANALOG OUTPUTS (GROUP 41) (EVENT GROUP 42)
group.41.index.0=[tag=Load Interval,variation=2,eventClass=0,eventVariation=2]
```

B.3 DNP3 Bridge (On-Ramp Wireless uConnect)

When the On-Ramp Wireless uConnect platform is configured as a DNP3 bridge, it allows native DNP3 devices to wirelessly communicate to the back office DNP3 master over the On-Ramp Total Reach Network. The DNP3 Bridge networking topology is covered in Appendix B. The important network parameters that need to be set are summarized in Table 1.

Table 3. DNP3 Bridge Network Configuration

HES DNP Profile FileParameter	uconnect.ini File Parameter	DNP3 Outstation Parameter
application.id=31	Application ID of 31 (Fixed)	N/A
application.device.id=A	slaveId=A	N/A
application.device.version="a.b.c"	slaveVersion="a.b.c"	N/A
N/A	slave_sesssion_number=B	DNP3 Link Address=B
N/A	slave_ip_address=www.xxx.yyy.zzz	IP Address= www.xxx.yyy.zzz

NOTE: "A", "B", "www.xxx.yyy.zzz", and "a.b.c" represent variables to be defined.

The DNP3 Bridge has no prior knowledge of the DNP3 points of the DNP3 outstation. The DNP3 profile file is not readily known to the On-Ramp Wireless HES, and is dependent on the configuration of the DNP3 outstation.

The following steps provide a suggested process for completing an integration of a DNP3 Bridge.

1. On-Ramp Wireless works with the network operator (e.g., the utility company) to determine the set of DNP3 points of interest and class assignments.
2. On-Ramp Wireless assigns a DNP3 Bridge device ID for each unique DNP3 outstation data model (e.g., one device ID for all SEL-351S devices, another device ID for all ABB PCD devices, etc.).

3. The network operator gives the necessary IP address and DNP3 link address information for the DNP3 outstation.
4. On-Ramp Wireless creates a custom HES DNP3 profile file for the DNP3 outstation.

Example #1: SEL-351S DNP3 Outstation Connected to a DNP3 Bridge

A sample of a DNP3 profile file for a DNP3 outstation communicating to OTV via the DNP3 Bridge is shown below. The SEL-351S is the device used as an example and represents a subset of all possible data points available at the DNP3 outstation. When possible, it is strongly recommended that unnecessary DNP3 points be disabled at the DNP3 outstation in order to efficiently utilize the wireless bandwidth. The points of interest are then mapped to the HES DNP3 profile file unique to the DNP3 outstation.

```
#DNP3 Bridge Configuration for SEL-351S (TMW simulator)->DNP3 data point mapping file

#  uconnect app id is always 31
application.id=31
application.name=ORW_bridge_SEL_351s
application.device.id=3
application.device.version=0.0.0
application.device.timeout=21600

#DNP3 Device Attributes
#group.0.variation.242.index.0=[tag=Firmware Version]
#group.0.variation.245.index.0=[tag=Location]
#group.0.variation.246.index.0=[tag=Node Id]
#group.0.variation.250.index.0=[tag=Device Type]
#group.0.variation.252.index.0=[tag=Manufacturer]

#DNP3 Data Points
#Group and Index pair are unique for all data points, i.e. can only have one data point
with index 0 for BINARY INPUT
#syntax= group.<number>.index.<number>=[tag=?,variation=?,eventClass=?,eventVariation=?]

#BINARY INPUTS (GROUP 1) (EVENT GROUP 2)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.1.index.0=[tag=52a (dig in),variation=1,eventClass=1,eventVariation=3]
group.1.index.1=[tag=52b (dig in),variation=1,eventClass=1,eventVariation=3]
group.1.index.2=[tag=79LOA (dig in),variation=1,eventClass=1,eventVariation=3]
group.1.index.3=[tag=Ground Enabled (dig in),variation=1,eventClass=1,eventVariation=3]
group.1.index.4=[tag=Reclose Enabled (dig in),variation=1,eventClass=1,eventVariation=3]
group.1.index.5=[tag=Remote Enabled (dig in),variation=1,eventClass=1,eventVariation=3]

#BINARY OUTPUTS (GROUP 10) (EVENT GROUP 11)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.10.index.0=[tag=Trip (dig out),variation=2,eventClass=1,eventVariation=1]
group.10.index.1=[tag=Close (dig out),variation=2,eventClass=1,eventVariation=1]
group.10.index.2=[tag=Enable Ground (dig out),variation=2,eventClass=1,eventVariation=1]
group.10.index.3=[tag=Enable Reclose (dig out),variation=2,eventClass=1,eventVariation=1]
group.10.index.4=[tag=Enable Block (dig out),variation=2,eventClass=1,eventVariation=1]
```

```
#COUNTERS (GROUP 20) (EVENT GROUP 22)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 5 <- 32-bit; 6 <-
16-bit
group.20.index.0=[tag=Trip Counter,variation=5,eventClass=2,eventVariation=1]

#FROZEN COUNTERS (GROUP 21) (EVENT GROUP 23)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 5 <- 32-bit; 6 <-
16-bit
group.21.index.0=[tag=Trip Counter (Frozen),variation=5,eventClass=2,eventVariation=1]

#ANALOG INPUTS (GROUP 30) (EVENT GROUP 32)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 3 <- 32-bit; 4 <-
16-bit; 5 <- float with flag; 6 <- double with flag
group.30.index.0=[tag=IA,variation=3,eventClass=2,eventVariation=1]
group.30.index.1=[tag=IB,variation=3,eventClass=2,eventVariation=1]
group.30.index.2=[tag=IC,variation=3,eventClass=2,eventVariation=1]
group.30.index.3=[tag=IN,variation=3,eventClass=2,eventVariation=1]
group.30.index.4=[tag=VA,variation=3,eventClass=2,eventVariation=1]
group.30.index.5=[tag=VB,variation=3,eventClass=2,eventVariation=1]
group.30.index.6=[tag=VC,variation=3,eventClass=2,eventVariation=1]
```

Example #2: Generic RTU DNP3 Outstation Connected to DNP3 Bridge

A second example of a DNP3 profile file for a DNP3 outstation communicating to OTV via the DNP3 Bridge is shown below. This example illustrates how an Analog Output Block (AOB) is configured in addition to a Control Relay Output Block (CROB) for bi-directional communication.

```
#DNP3 Bridge Configuration for Generic RTU (TMW simulator)->DNP3 data point mapping file

#  uconnect app id is always 31
application.id=31
application.name=ORW_bridge_GenericRTU
application.device.id=10
application.device.version=0.0.0
application.device.timeout=21600

#DNP3 Device Attributes
#
# Note:  We don't do anything with these today.  We have capability to implement
#        on both end device and HES side if necessary.  Matt has special uConnect
#        command to retrieve them if called down from HES.  Roger hasn't done anything
#        with them yet.  Do we override and make ORW/Device merged fields?  Gets
complicated
#        if then we request OTA from HES/Scada in future.
#
#group.0.variation.242.index.0=[tag=Firmware Version]
#group.0.variation.245.index.0=[tag=Location]
#group.0.variation.246.index.0=[tag=Node Id]
#group.0.variation.250.index.0=[tag=Device Type]
#group.0.variation.252.index.0=[tag=Manufacturer]

#DNP3 Data Points
```

```
#Group and Index pair are unique for all data points, i.e. can only have one data point
with index 0 for BINARY INPUT
#syntax= group.<number>.index.<number>=[tag=?,variation=?,eventClass=?,eventVariation=?]

#BINARY INPUTS (GROUP 1) (EVENT GROUP 2)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.1.index.0=[tag=Binary Input 0,variation=1,eventClass=1,eventVariation=3]
group.1.index.1=[tag=Binary Input 1,variation=1,eventClass=1,eventVariation=3]
group.1.index.2=[tag=Binary Input 2,variation=1,eventClass=1,eventVariation=3]

#BINARY OUTPUTS (GROUP 10) (EVENT GROUP 11)
#supported variations= 1 <- 1-bit; 2 <- 1-bit with flag
group.10.index.0=[tag=Binary Output 0,variation=2,eventClass=1,eventVariation=1]
group.10.index.1=[tag=Binary Output 1,variation=2,eventClass=1,eventVariation=1]

#COUNTERS (GROUP 20) (EVENT GROUP 22)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 5 <- 32-bit; 6 <-
16-bit
group.20.index.0=[tag=Counter 0,variation=5,eventClass=2,eventVariation=1]
group.20.index.1=[tag=Counter 1,variation=5,eventClass=2,eventVariation=1]
group.20.index.2=[tag=Counter 2,variation=5,eventClass=2,eventVariation=1]

#FROZEN COUNTERS (GROUP 21) (EVENT GROUP 23)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 5 <- 32-bit; 6 <-
16-bit
group.21.index.0=[tag=Frozen Counter 0,variation=5,eventClass=2,eventVariation=1]
group.21.index.1=[tag=Frozen Counter 1,variation=5,eventClass=2,eventVariation=1]
group.21.index.2=[tag=Frozen Counter 2,variation=5,eventClass=2,eventVariation=1]

#ANALOG INPUTS (GROUP 30) (EVENT GROUP 32)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 3 <- 32-bit; 4 <-
16-bit; 5 <- float with flag; 6 <- double with flag
group.30.index.0=[tag=Analog Input 0,variation=3,eventClass=2,eventVariation=1]
group.30.index.1=[tag=Analog Input 1,variation=3,eventClass=2,eventVariation=1]
group.30.index.2=[tag=Analog Input 2,variation=3,eventClass=2,eventVariation=1]

#ANALOG OUTPUTS (GROUP 40) (EVENT GROUP 41)
#supported variations= 1 <- 32-bit with flag; 2 <- 16-bit with flag; 3 <- 32-bit; 4 <-
16-bit; 5 <- float with flag; 6 <- double with flag
group.41.index.0=[tag=Analog Output 0,variation=2,eventClass=2,eventVariation=2]
group.41.index.1=[tag=Analog Output 1,variation=2,eventClass=2,eventVariation=2]
```

Appendix C On-Ramp Wireless uConnect (DNP3 Bridge)

The On-Ramp Wireless uConnect is a versatile platform capable of running various applications. One application is the DNP3 Bridge, which provides a Total Reach Wireless connection to an otherwise non-wireless DNP3 outstation device.

Figure 9 shows a DNP3 network for a non-native DNP3 device such as a WSO-11. A non-native DNP3 device does not provide a DNP3 interface and must rely on the On-Ramp Wireless HES to map the application data into DNP3 points. This mapping is done at the On-Ramp Total Reach Appliance.

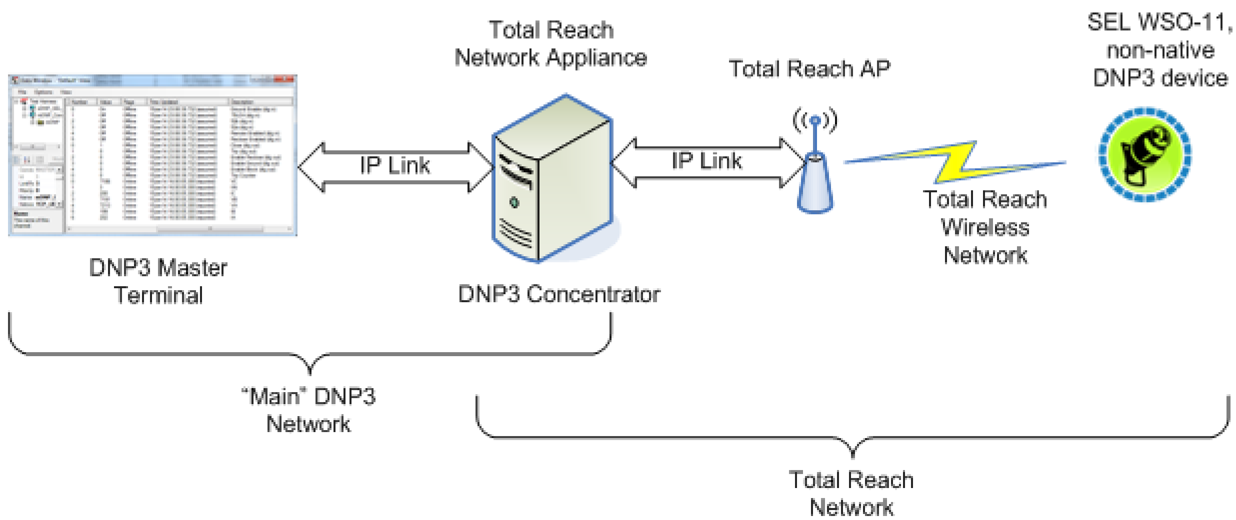

Figure 9. Non-Native DNP3 Outstation Network

When a native DNP3 outstation needs wireless communications, an On-Ramp Wireless uConnect module is used as part of the DNP3 Bridge solution. As shown in Figure 10, the uConnect module serves as a DNP3 master on the “remote side” DNP3 network. This remote DNP3 network terminates at the On-Ramp Wireless uConnect and the DNP3 data is encapsulated into the On-Ramp Total Reach Network wireless protocol. When the data reaches the On-Ramp Total Reach Appliance, its DNP3 adapter translates the data back to DNP3 points which are read by the back office DNP3 master.

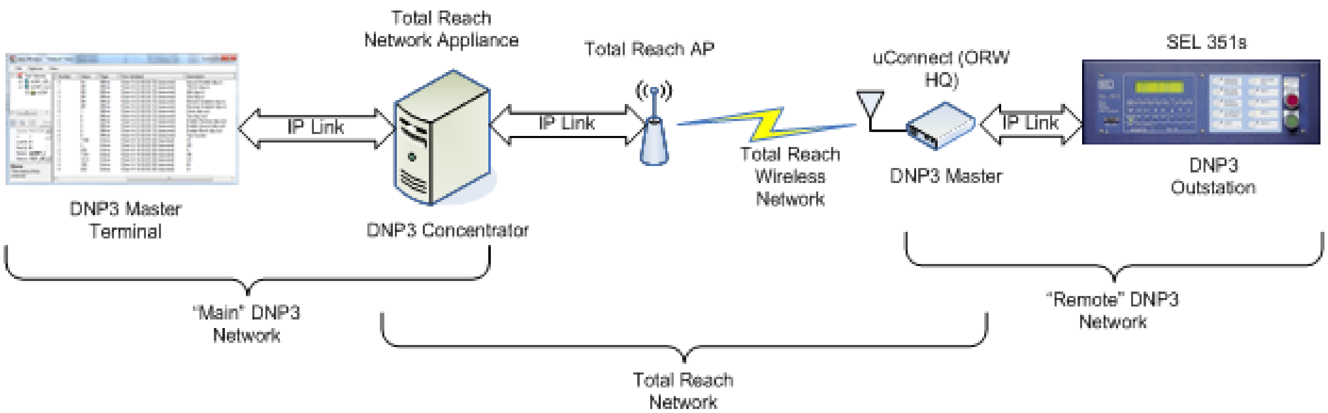

Figure 10. Native DNP3 Outstation Network

The main DNP3 network and the remote DNP3 network are independent DNP3 networks, each with separate polling rate configurations, DNP3 point mappings and class assignments, enablement of unsolicited reporting, etc. It is important to make meaningful configuration settings to be compatible with both the main DNP3 network and the remote DNP3 network. For example, one should probably not enable unsolicited reporting on the remote DNP3 network side if the main DNP3 network does not enable unsolicited reporting as well.

Another issue to recognize is the bandwidth constraints of the Total Reach Network. If polling rates at the remote network side are too high and there are too many dynamic DNP3 points at the DNP3 outstation, information may eventually be lost if the Total Reach Network bandwidth is exceeded.

It is strongly advised that the network operator work with the On-Ramp Wireless support team to confirm wireless DNP3 Bridge network compatibility with the expected data models.

C.1 Notes on Behavioral Expectations

While the DNP3 Bridge is meant to be "transparent," the overall behavior has subtle characteristic differences between a traditional wired DNP3network and a wireless DNP3 network such as the On-Ramp Wireless DNP3 Bridge solution. These are highlighted in the following bullet items.

- **Control Relay Output Block (CROB) response latencies.**
  Typically a CROB command may have been configured to do an immediate "feedback poll." Because of the latency of the system, the actual state set at the DNP3 outstation may not be reflected immediately at the DNP3 master view. This is due to the latency constraints of the On-Ramp Total Reach System.
- **Vector CROB commands not supported.**
  The DNP3 operator can only address one DNP3 point at a time.
- **Analog Output Block (AOB) is supported for data types of "short" and "long."**
  Currently floating point values are not supported.

- **AOB response latencies.**
  Similar characteristic as described for CROB response latencies.

C.2 DNP3 Bridge Security

The uConnect as a Total Reach endpoint is a secure device. However, because of its uniqueness as a Total Reach endpoint, there are some additional security considerations to keep in mind. This section summarizes the DNP3 Bridge security according to the three main areas:

1. Physical Security
2. Soft Security
3. Network Security.

C.2.1 Physical Security

Physical security is dependent on the physical enclosures provided by the Utility or Outstation manufacturer. Similar to the way the environmental enclosure protects the uConnect from the elements (uConnect is rated as IP58), the uConnect relies on the security features of the physical enclosure's security attributes (e.g., enclosure uses tamper-proof locks).

C.2.2 Soft Security

Soft security is any area where a "rogue" computer connection is of concern. For example, if the physical security of the device has been compromised, then the attacker may directly plug in a DNP3 slave device emulator into the uConnect RJ45 Ethernet connection.

RJ-45 Ethernet Port Tampering

- **Port 20,000 is the default DNP3 port.**
  To prevent unauthorized DNP3 outstations (or DNP3 emulators) to connect to the uConnect, it is highly recommended that SSL is enabled between the uConnect and the DNP3 outstation.

  NOTE: Currently SSL is not supported and is slated for a future revision of the DNP3 Bridge release.

- **Port 22 is the default SSH port.**
  Each network operator is provided with a unique password for uConnect SSH login.

  NOTE: There are no auto-lockouts for failed password attempts.

- **Port 4000 is the On-Ramp Wireless host (tools) interface.**
  This interface includes On-Ramp Wireless' provisioning client and node monitor software. It is possible to password-protect this interface but this option is disabled by default.

RS-485/RS-422 Connection Tampering

This port is only used during the manufacturing of the uConnect device. Any inputs on this port are ignored in normal operational mode.

RS-485/RS-422 Connection Tampering

This port is only used during the manufacturing of the uConnect device. Any inputs on this port are ignored in normal operational mode.

USB Port

The USB port emulates functions available on the RJ-45 Ethernet connection on port 4000. It is only used for the On-Ramp Wireless host (tools) interface. It is possible to password-protect this interface but this option is disabled by default.

C.2.3 Network Security

In terms of security, the uConnect is treated in the same fashion as most other On-Ramp Total Reach endpoint devices. From a network security perspective, there are two major security components to the On-Ramp Total Reach Network:

1. Over the Air (OTA) Security
2. Backhaul Security

Over-the-Air Security

Over-the-Air security is ensured with the following features of the On-Ramp Wireless Total Reach Network:

- Mutual Authentication
- Message Authentication
- Message Confidentiality (Encryption)
- Limited Anonymity
- Secure Firmware Upgrade

Backhaul Security

The backhaul is the physical network connection from the Access Points (AP) all the way to the Head End System (HES). The backhaul is IP-based and On-Ramp Wireless utilizes the industry standard Secure Socket Layer (SSL) for backhaul security.