AMI Overview

Advanced Metering Infrastructure (AMI)

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

RF Network Overview

© 2024 Eaton. All rights reserved.

Eaton RF Mesh Overview

© 2024 Eaton. All rights reserved.

Objectives

- Provide technical overview of RF mesh fundamentals
- Provide knowledge of RF Network deployment, formation and dynamic network behavior
- Provide overview of RF Applications
- Review Network Troubleshooting use cases

© 2024 Eaton. All rights reserved.

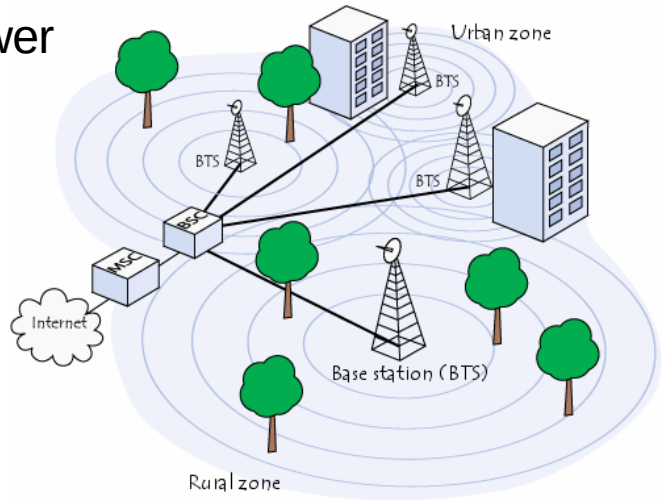
Introduction to Wireless Communications

Powering Business Worldwide

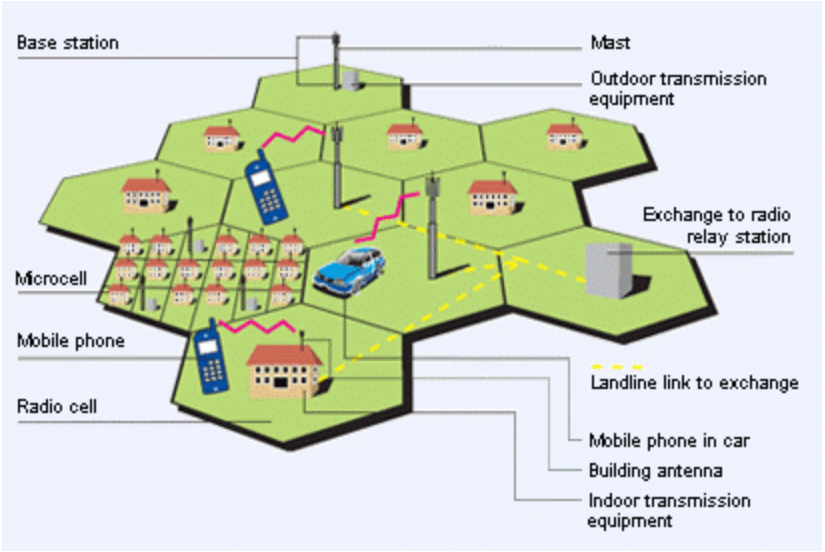
© 2024 Eaton. All rights reserved.

Network Types

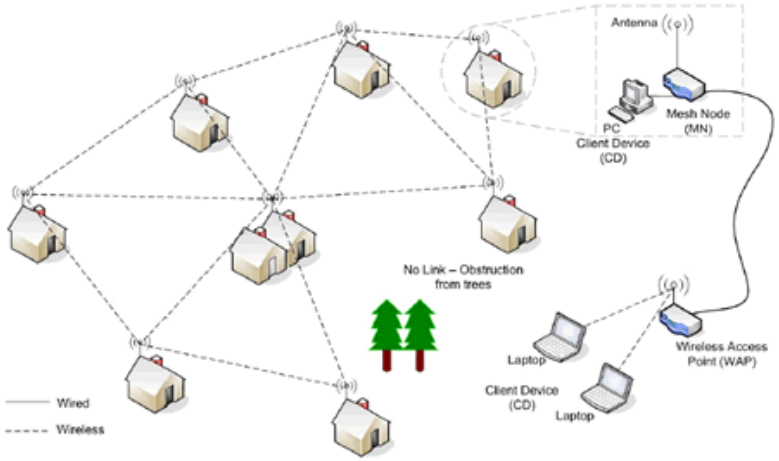
Tower



Cell



Mesh



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Eaton's RF Mesh

- Self-Organizing and Self-Healing
  - No configuring of the nodes at the utility or in the field
  - Nodes independently determine the most efficient method to get to the gateway
  - Nodes automatically identify alternate routes to the gateway when primary communications paths are interrupted
- Easily Expandable/Scalable
  - Easy to add additional gateway when required to expand network
- Secure and Interoperable
  - Mutual authentication and derived encryption keys for each data exchange between nodes
- OTA Firmware Updates
- Single Network
  - A full two-way network AND a single Software Platform for Electric, Water, Gas, DR and DA

© 2024 Eaton. All rights reserved.

Eaton's RF Network Specification

- Spectrum
  - ISM bands - 902-928 MHz frequency product (25 MHz available spectrum (50 channels))
  - Frequency Hopping Spread Spectrum (FHSS)
- Throughput
  - Up to 153 kbps data rate with Auto-Optimization
- Variable Power Optimization
  - 125mW to 1W
- Industry Leading Data Transport
  - Up to 96 metric points in the daily report
  - 15 User Defined Interval Data Channels (kWh, voltage, TOU, kVAR/kVARh, etc.)
  - Over 50 different alarms and events
- Security
  - Security built-in to all node-to-node communications. End-to-end security, with mutual authentication and derived encryption keys for each node data exchange.

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Communications Range

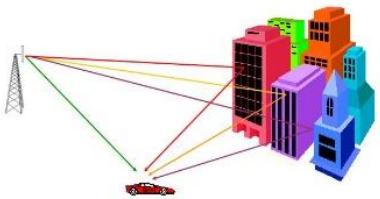
- Communication Range in an RF network is affected by the following factors:
  - Power
  - Receive Sensitivity (Data Rate)
  - Path Loss

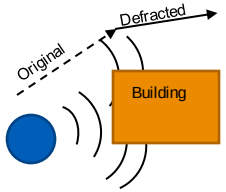
Powering Business Worldwide

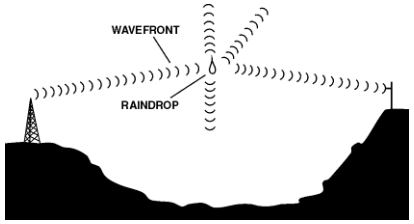
© 2024 Eaton. All rights reserved.

Communications Range - Path Loss

- Distance
  - Received power goes down by the square of the distance between nodes
- Obstacles
  - Topography (i.e. walls, trees, buildings, hills, mountains…)
- Reflections & Multi-Path
  - Reflected radio signals take different length paths and interfere
- Diffraction
  - Gives the effect that the signal can bend around corners
- Scattering
  - Due to small particles, air pollutants and moisture droplets along the path







Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Communications Range - Power

- Total Network Communications Range or Distance =

$$Node\ to\ Node\ Distance\ \times Number\ of\ Hops$$

- Node to node distance is affected by:
  - Transmit Power of Source Node
    - Transmit Power Limited by FCC Regulations
    - Transmit Power Limited by Source of Power (i.e. Battery)
    - Transmit Power Affected by Type of Antenna (Gateway, Relay)

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Communications Range - Data Rate

- Receive Sensitivity
  - Measure of how well the receiver performs
  - Defined as the power of the weakest signal the receiver can detect
  - Function of data rate
- Rate vs. Range
  - The lower the data rate, the longer the transmission range
  - The higher the data rate, the shorter the effective range of the transmission
- Rate vs. Throughput
  - Lower data rate = lower throughput
  - Higher data rate = higher throughput

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Eaton RF Mesh Network Fundamentals

© 2024 Eaton. All rights reserved.

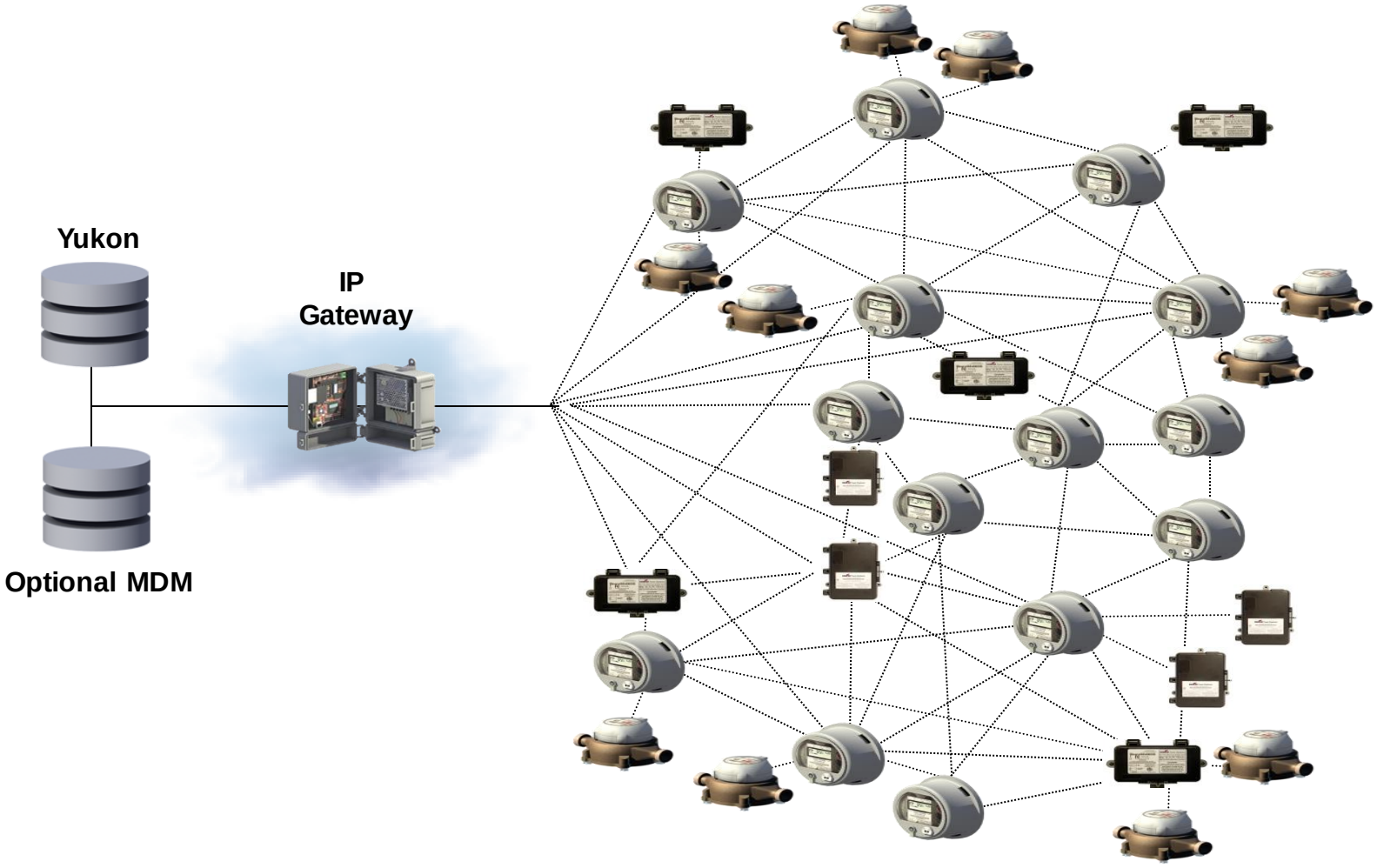
RF Mesh Components

- Our mesh solution is comprised of the following elements:
  - Yukon/Network Manager
  - Gateway
  - Electric Nodes
    - Single Phase Meters
    - Polyphase Meters
    - DR Switches
    - DA RTUs
  - Battery Nodes
    - Water
    - Gas (New)
  - IP Link Nodes (New)
    - WiFi
    - Cellular (Future)
  - Relays
  - Network Runner

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

RF Mesh Network Components



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

RFN Hardware

Gateway - Network Bridge, Collector, between RF wireless mesh and IP wide area network, backhaul support to Network Manager, Yukon

Powered Nodes - Support two-way unicast and broadcast messaging, Metrology, Events and alarms, …

Battery Nodes - Support multiple vendor water registers, Gas, OTA updates, …

Relays - Build out infrastructure to form robust mesh, extend RF communications into rural areas

IPLink WiFi Node - Meter functions, network bridge between RF wireless mesh and utility network

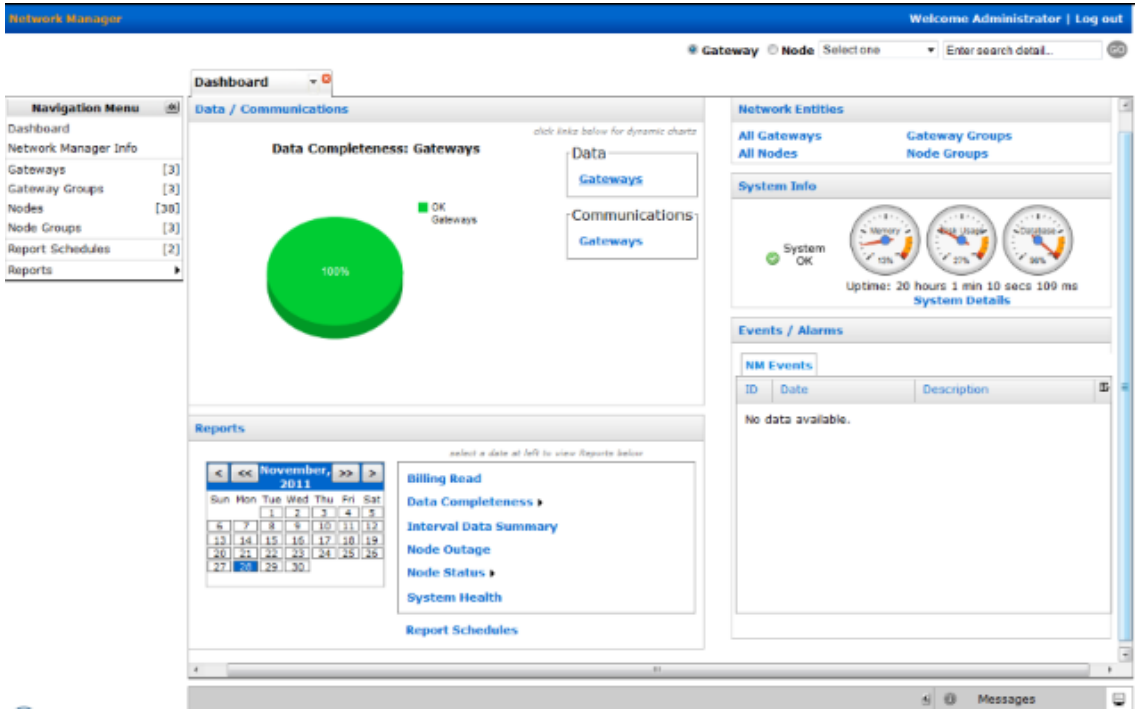
Network Runner - Provides configuration and diagnostic field support

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

RF Network Manager

- Acts as a middleware between Yukon and Gateway
- Manages the Gateways and performs network monitoring functions
  - Network Flow Control
  - Maintains a Database
- Provides diagnostics for the network and nodes



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Deployment

© 2024 Eaton. All rights reserved.

RF Network Deployment: Gateway Planning

- A propagation study is done as part of initial network design:
  1. Connectivity
  2. Network formation
  3. Capacity
- Gateway locations are proposed as a result of the study
- Final gateway locations are decided upon based on initial proposed location and the constraints imposed by back-haul locations

© 2024 Eaton. All rights reserved.

RF Network Deployment: Backhaul planning

Backhaul is critical to system performance

- Always available 2-way communication
  - IT infrastructure is setup correctly for access to:
    - NM and Yukon servers
    - NTP server that was configured at Gateways
- At least 128Kbps of backhaul capacity per gateway
- MTU size of 1500 bytes

Unreliable backhaul can affect:

- Data completeness of interval data
- Remote Connects and Disconnects
- On Demand Reads
- Demand Response events

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

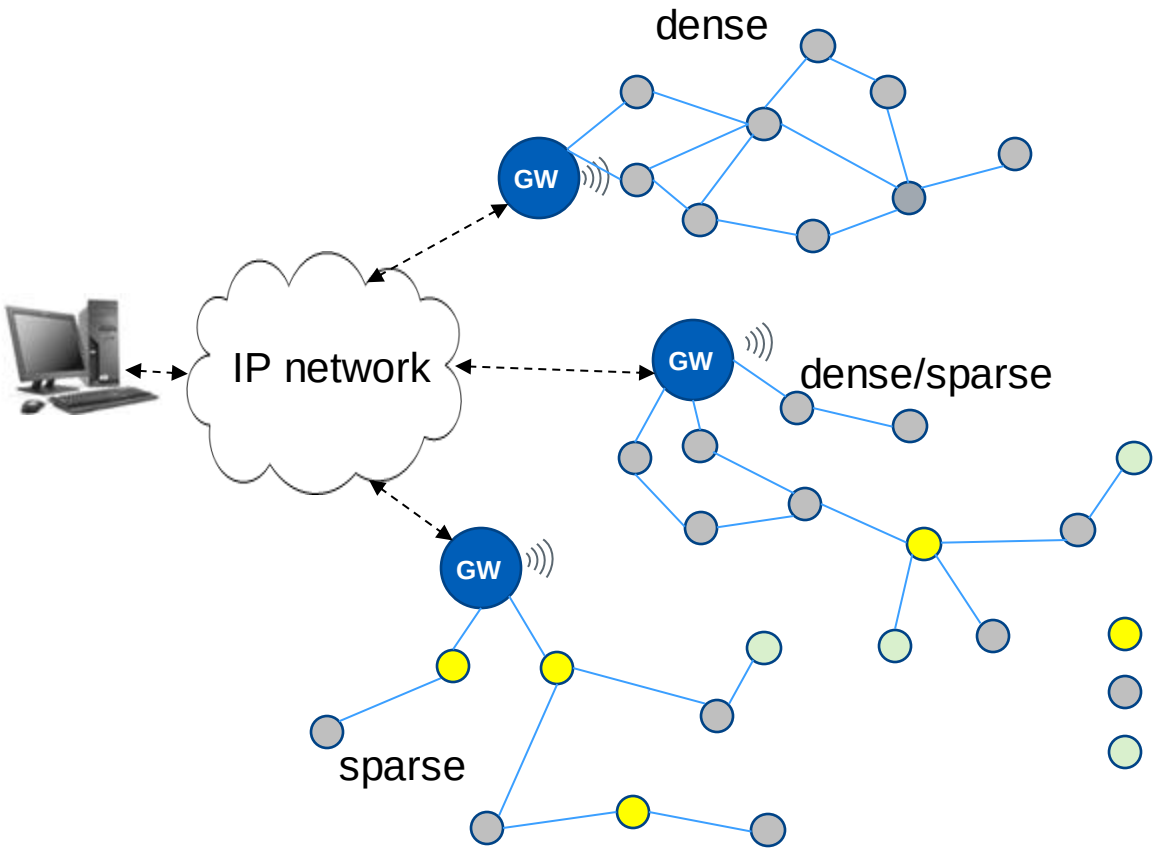
RF Network Deployment

- The order in which the elements that comprise the RF network are deployed is CRITICAL to how quickly the RF network forms
- Order of recommended installation and deployment
  - Yukon and RF Network Manager installation should be planned first
  - Install Gateways
    - Backhaul considerations (wired, wireless)
    - Configure the gateways and setup backhaul communications with RF Network Manager
  - Install recommended relays starting closest to the gateway
  - Install electric nodes outwards from gateway
  - Revisit network coverage after network is discovered and install additional relays or gateways as needed
  - Install battery nodes (water, etc.)

© 2024 Eaton. All rights reserved.

RF Network Deployment

- Install and setup Yukon/NM
- Install gateways and configure backhaul



- Install relays
- Install electric nodes outwards from gateway
- Add additional relays as needed
- Add Battery nodes

Relay
Electric node
Battery node

Powering Business Worldwide

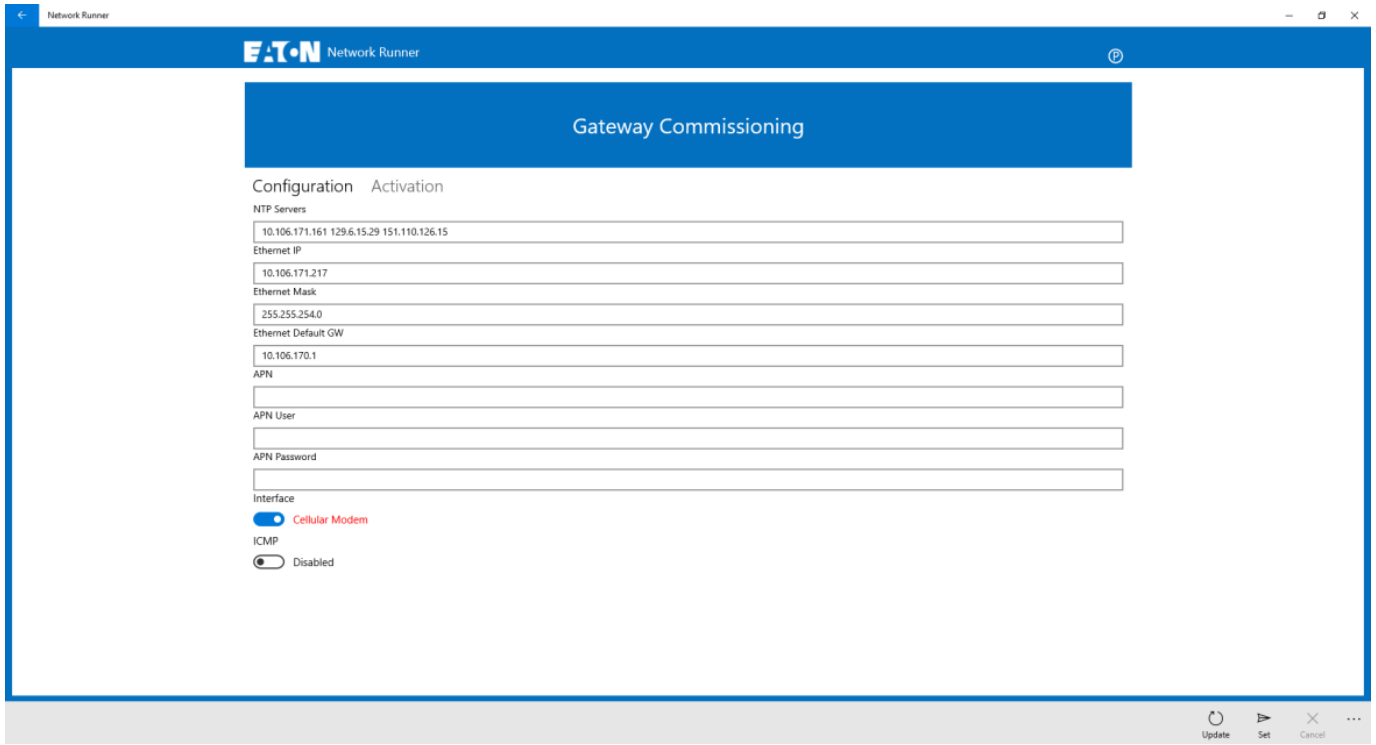
© 2024 Eaton. All rights reserved.

RFN Gateway Configuration

- Requires minimum configuration
  - Ethernet IP address, NTP Server IP address
  - GPS Coordinates
  - Gateway must be configured using the RF Field Tool via the Gateway Commissioning Workflow

© 2024 Eaton. All rights reserved.

RFN Gateway Configuration



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Node Configuration

- Electric nodes configured at production (Plug-n-play)
- New Water nodes configured at production
- WiFi devices require additional configuration
- All devices may be optionally configured with GPS coordinates
  - May also be imported into Yukon

Powering Business Worldwide

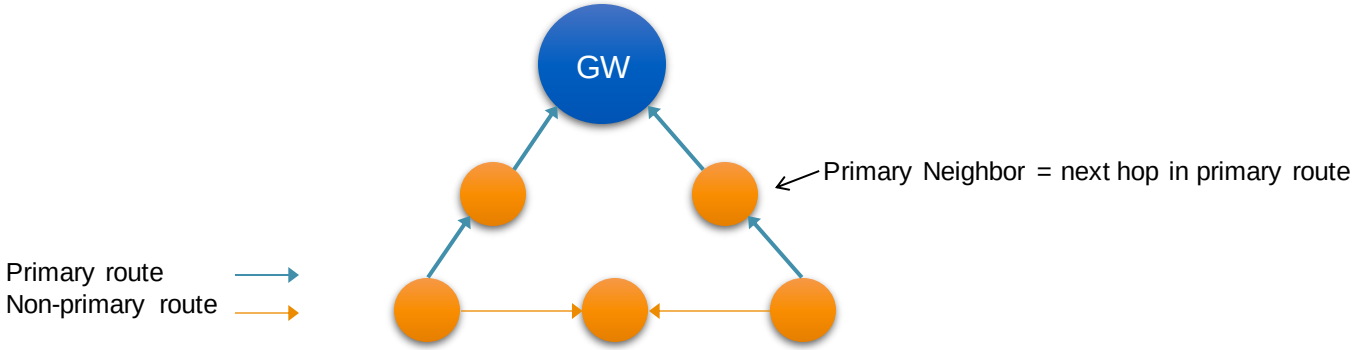
© 2024 Eaton. All rights reserved.

Eaton RF Network Operation

© 2024 Eaton. All rights reserved.

Network Concepts: Routes

- A Route defines the path from one node to another
- Four major components:
  - Destination – the GW to be reached
  - Next hop – the node where the data is forwarded to reach destination
  - Cost – Quantitative representation of the link quality through the route
  - Hop – Number of hops to the destination
- Node objective: Always find the route with lowest cost to Gateway
- The ‘primary route’ is the route to the gateway

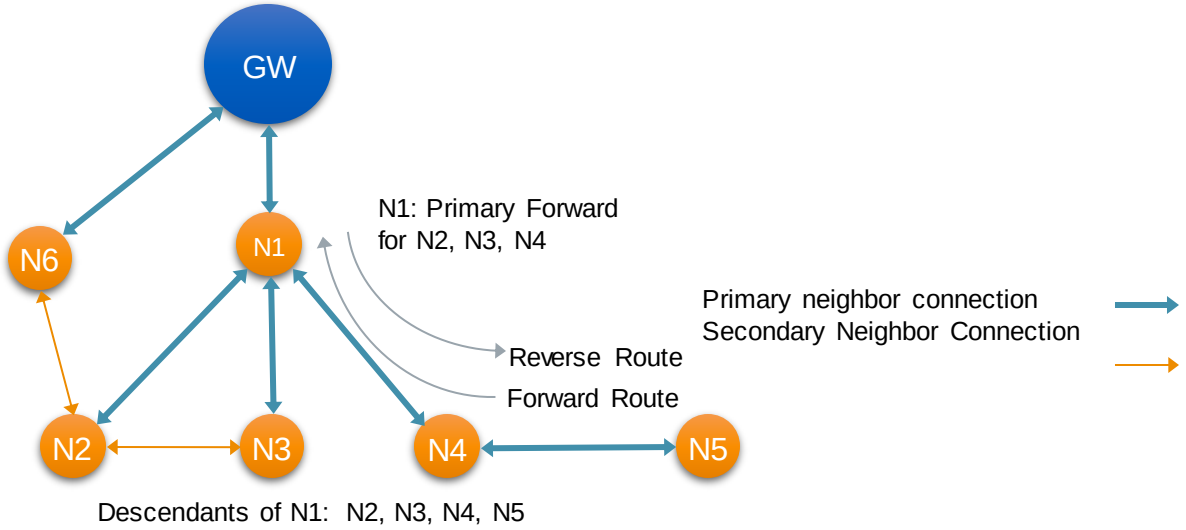


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Network Concepts: Neighbors and Route Types

- The next hop node in primary route to Gateway is ‘Primary Forward’ (PF)
- A group of nodes using a node as their primary forward are ‘descendants’ of that node
- The next hop node from GW down to a descendant is ‘Primary Reverse’ (PR)
- All neighbors used as next hop for primary routes are ‘Primary Neighbors’
- Neighbors not in primary route are ‘Secondary Neighbors’

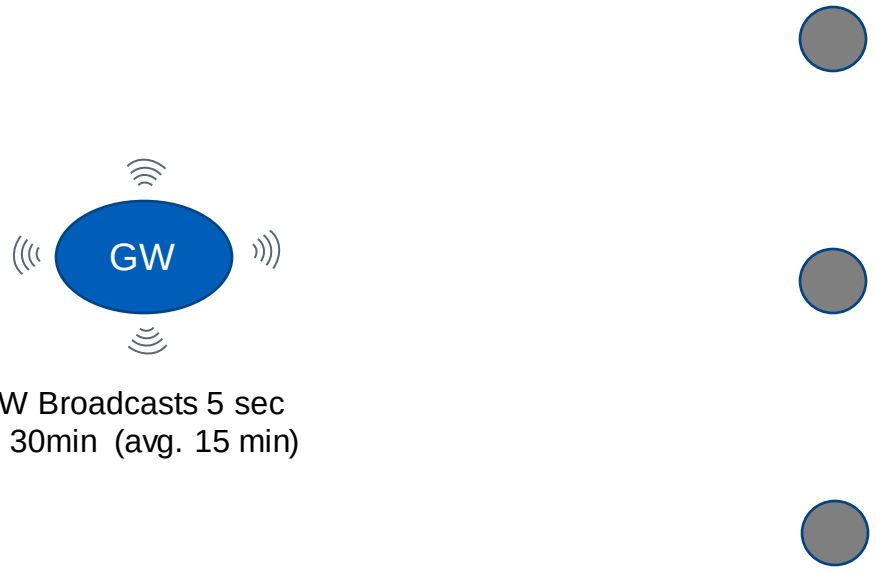


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Initial Network Formation: Electric Node

- Upon power up, the Gateway starts ‘visibility’ broadcast
- The new nodes, invisible to the rest of the network, wait for the broadcast containing gateway information.



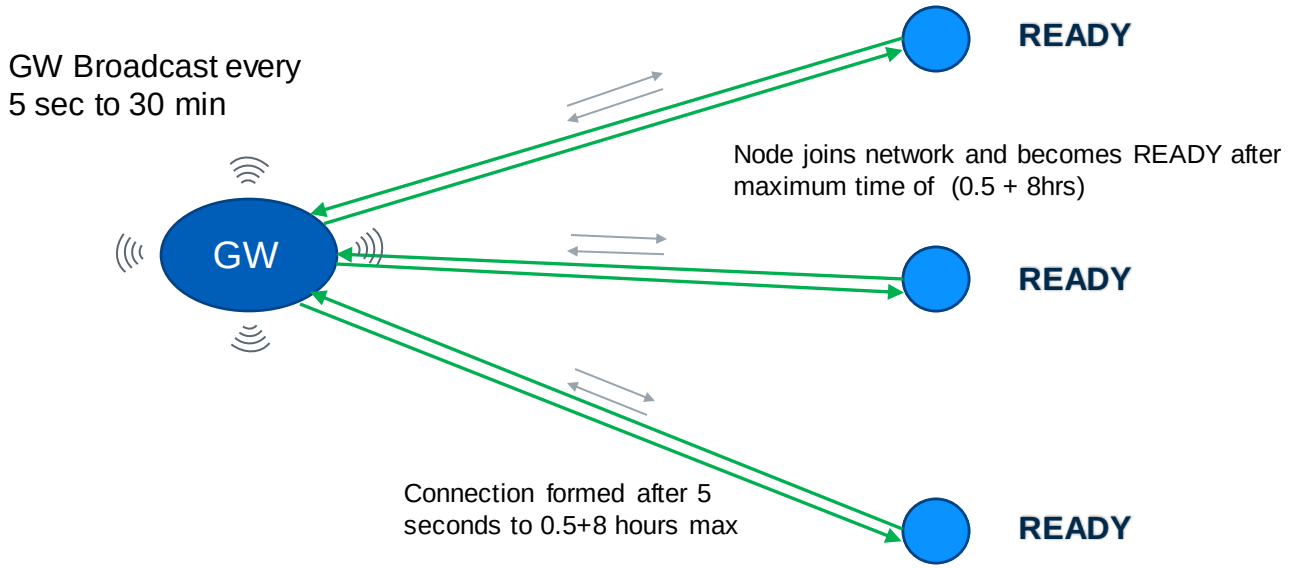
GW Broadcasts 5 sec
to 30min (avg. 15 min)

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Initial Network Formation: Electric Node

- A node that can hear the broadcast, schedules a connection to the gateway
- During the connection, the node and gateway exchange route information and the Gateway learns the node's information.
- The node becomes READY once the Network Manager receives node's identification information and its route to the Gateway.

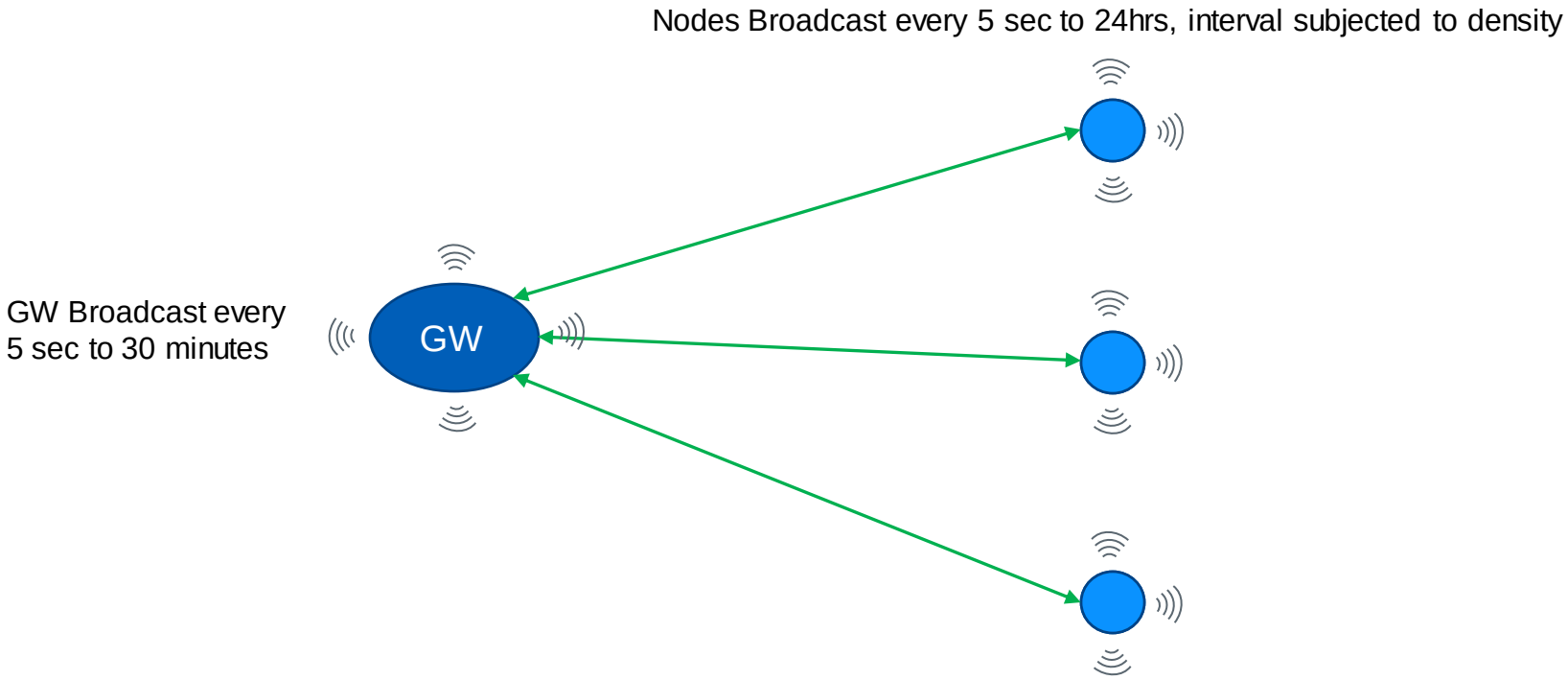


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Initial Network Formation: Electric Node

- The node is now a ‘one hop node’ and ‘In Network’
- It starts its own visibility broadcast

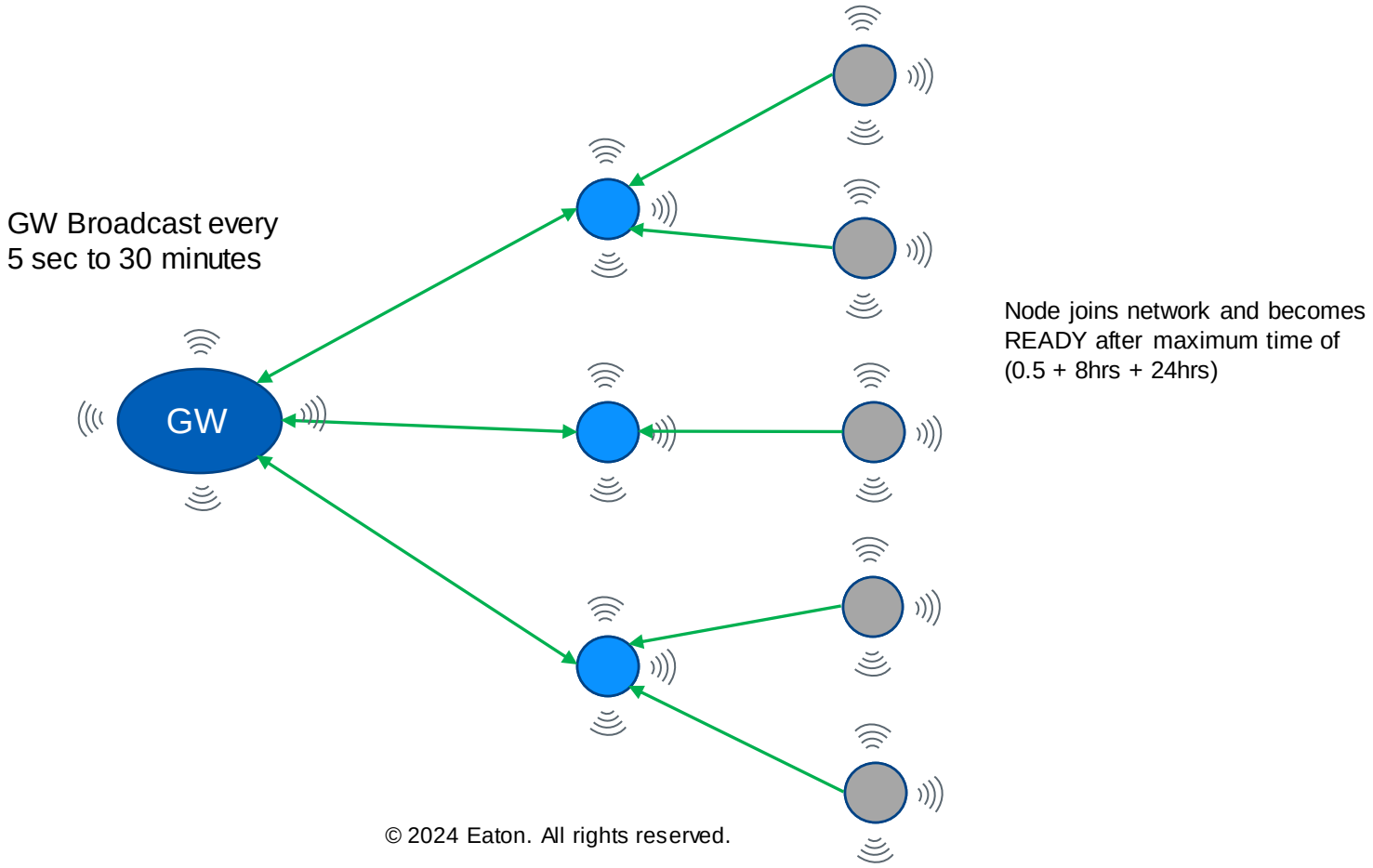


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Initial Network Formation: Electric Node

- The nodes that can hear ‘one-hoppers’ join next
- Second hop is formed

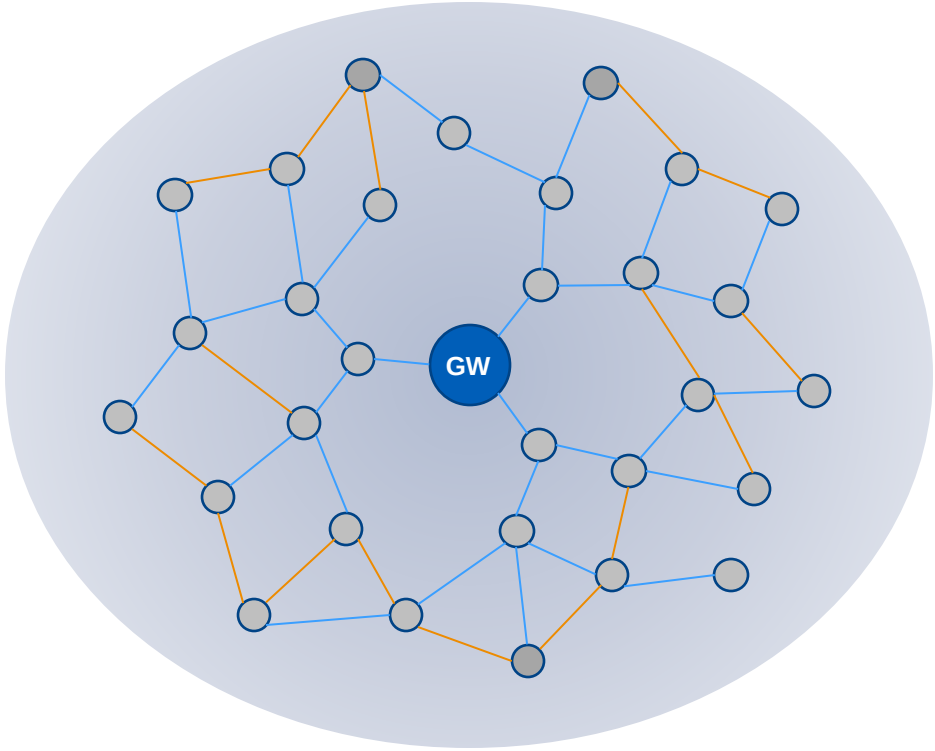


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Initial Network Formation: Electric Node

- The sequence of broadcast, connection, route discovery follows, more hops are added to the gateway
- Network thus forms outward from the gateway to the leaf nodes

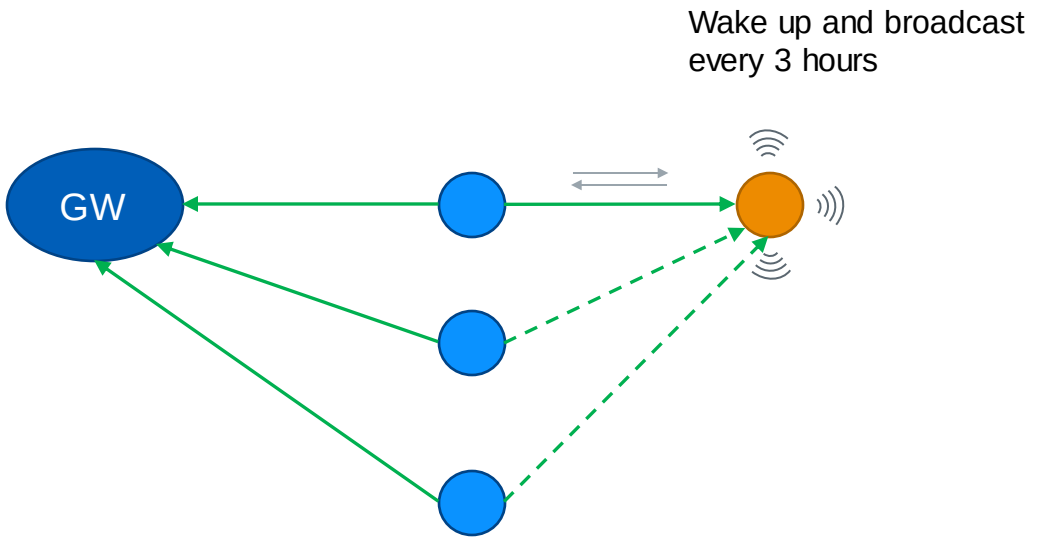


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Initial Network Formation: Battery Node

- Out of network Battery node broadcasts its presence
- Nearby electric nodes schedule connections
- The first electric node to make a connection negotiates rendezvous time with the battery node
- The battery node joins network and stops broadcasting



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Fast Network Join

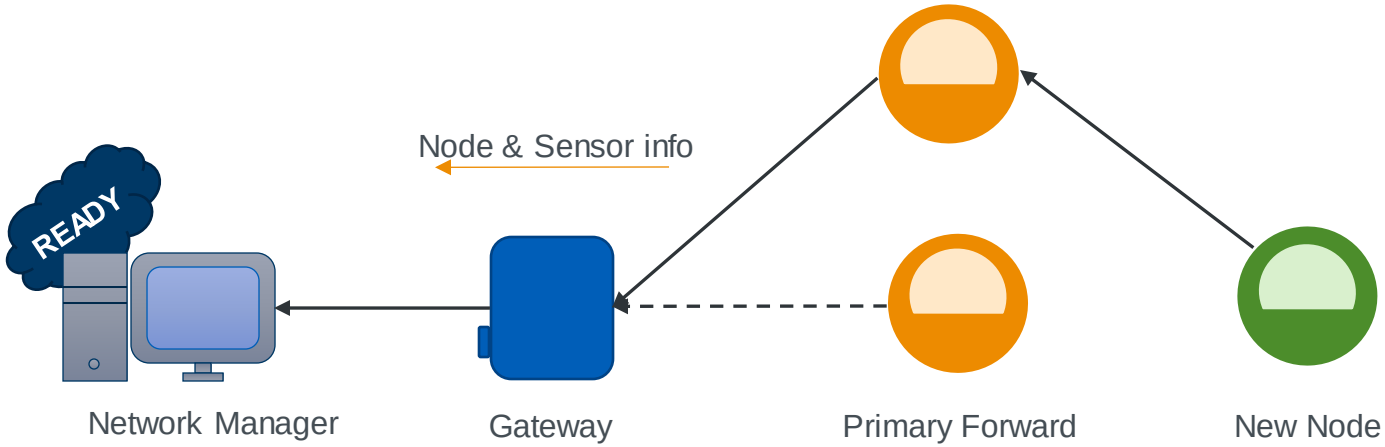
- RF Field Tool commands a newly installed RF device to join Network immediately
- The new device broadcasts its presence to the network at various power levels
- If an ‘in-network’ node hears the broadcast, it connects to the new device within a minute, does time sync and provides Gateway route information

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Fast Network Join

- Newly installed node identification and routing path is immediately sent to the Gateway and Network Manager
- Node becomes READY within 5 minutes after Field Tool command.
- Eventually the node may find a more optimal path through dynamic network evaluation.

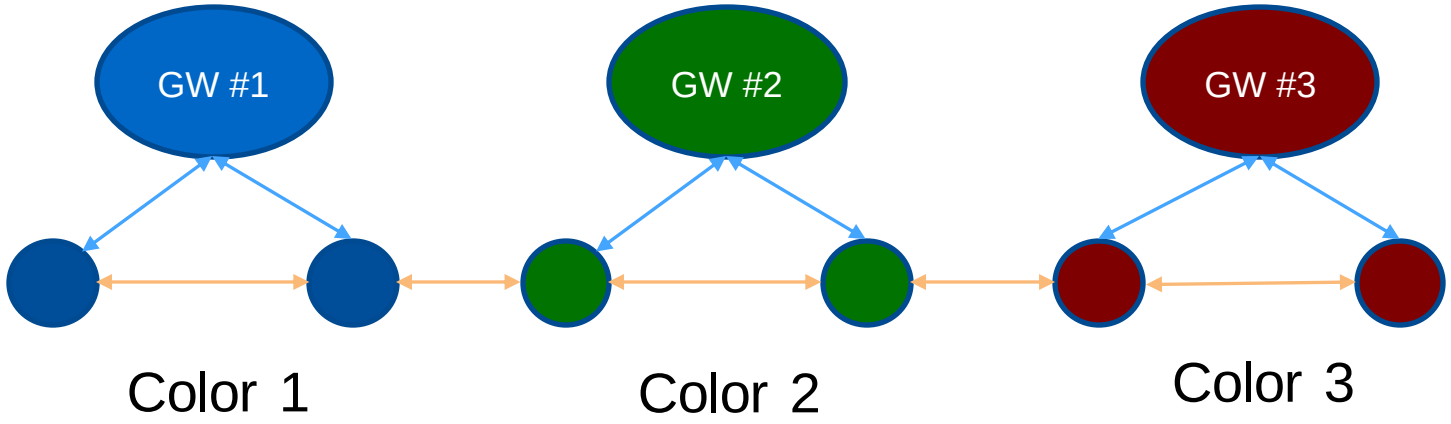


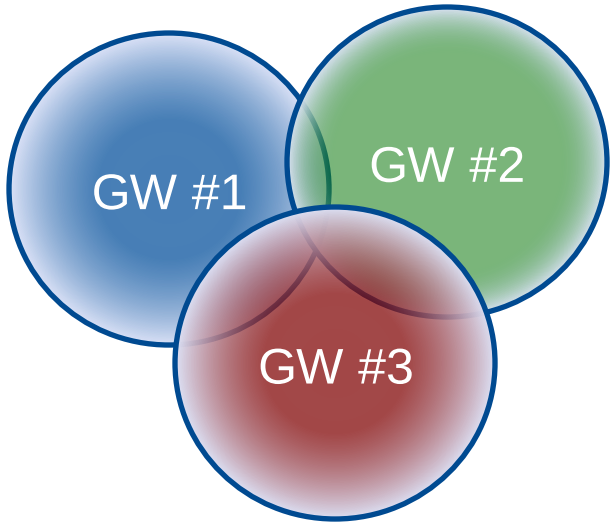
Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Network Segmentation

- A network is logically divided into Gateway segments
- Segmentation is represented by a unique identifier per deployed Gateway known as Color
- All nodes with the same Color form one network segment
- Segmentation distributes network load among gateways
- Overlapping segments provide network redundancy



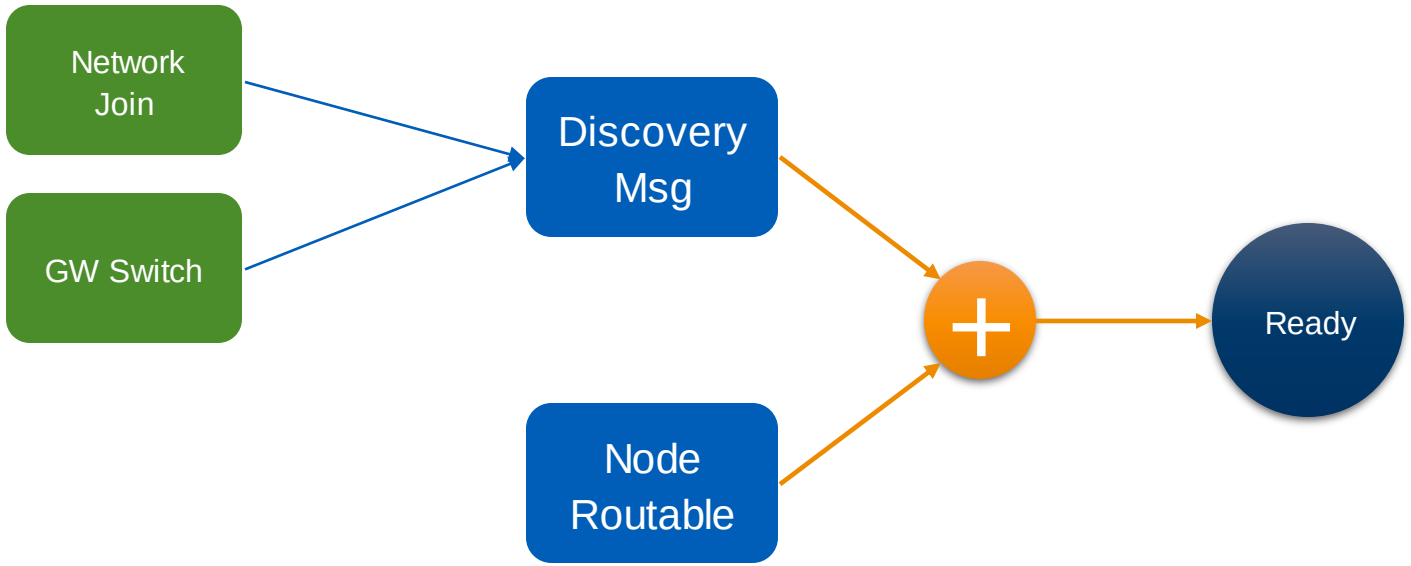


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Ready Status

- Node sends discovery message after joining a network
- A node is READY when the gateway receives both the discovery message and it has a route to the gateway
- Node also sends discovery message when it switches gateways



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Ready Status

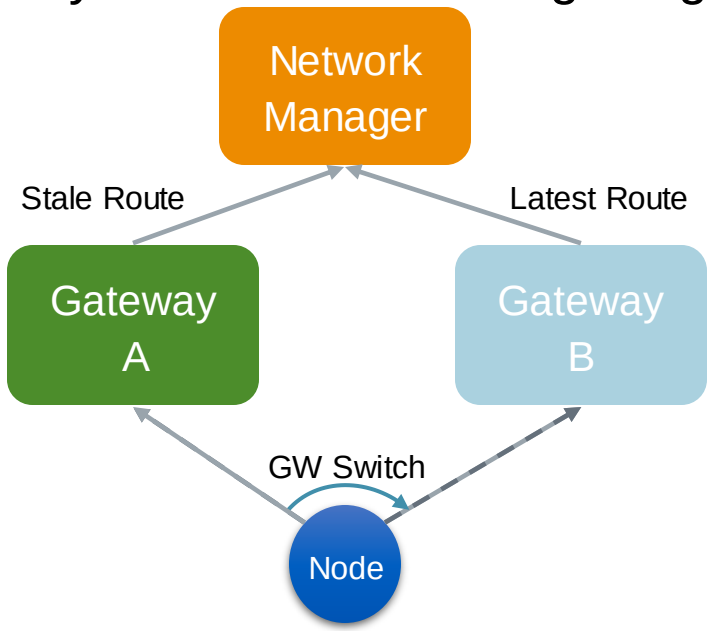
- Node is NOT-READY when
  - Gateway receives no route update from the node for 6 hours

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Ready Status: Switching Gateways

- A node is READY under a particular gateway.
- When a node switches gateway, it sends route information to the new gateway.
- Network Manager uses the latest route to update its READY status
- The node eventually times-out at the original gateway

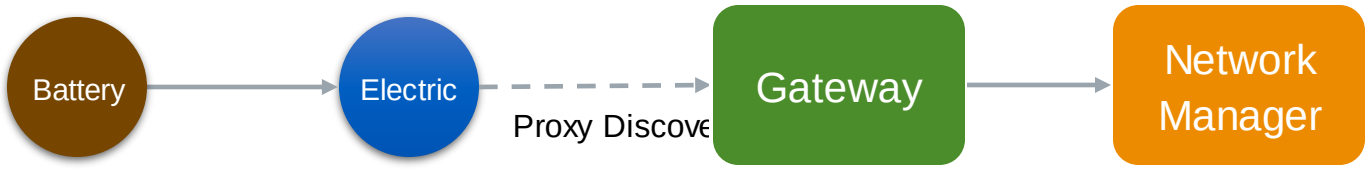


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Battery Node Operation

- The battery nodes sleep except during reporting time once a day.
- Battery nodes do not take part in network formation or routing
- Always associated with an electric peer for daily reporting at a predefined ‘rendezvous’ schedule.
- Electric node forwards battery node data to the gateway
- Electric node generates ‘proxy-discovery’ message for battery node



Powering Business Worldwide

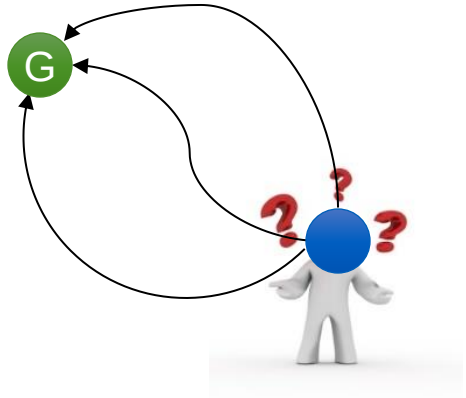
© 2024 Eaton. All rights reserved.

Network Steady State Operation

© 2024 Eaton. All rights reserved.

Network Optimization

- Once the network is formed it goes through an optimization process
  - Network is designed to find the ‘lowest cost’ path to the gateway
- The nodes continue to evaluate paths.
- The essence of mesh networking:
  - Option to choose the best path
  - Multiple path redundancy = resilience

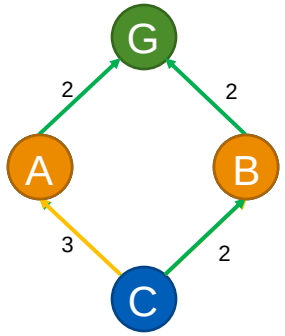


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Network Optimization (cont'd)

- A node starts with a 'primary neighbor', its next-hop to the gateway.
- Path cost to the gateway is based on link quality of the hops.
  - Nodes exchange routes and gateway path costs with each other
  - Nodes evaluate link cost when they connect to their neighbors
- When a node finds a better path, it switches its 'primary'



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Link Cost Evaluation

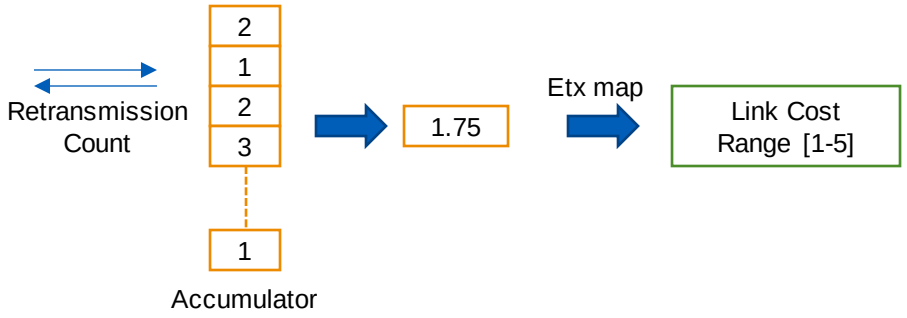
- Patented RF mesh link quality measurement technique
- Node to node link quality is measured by
  "Expected Transmission Count" or ETX
- Raw ETX = average retransmissions of a single frame
- Higher ETX => More retransmissions => worse link

Powering Business Worldwide

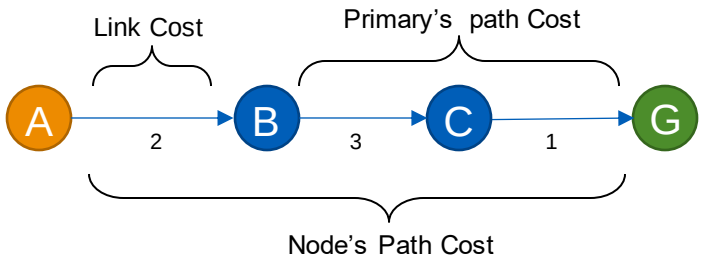
© 2024 Eaton. All rights reserved.

Link Cost Evaluation

- The raw ETX is mapped in to ETX bands 1-5, aka link cost.



- Node's path cost = Total cost to gateway =
  Normalized link cost to its primary + Primary's path cost.



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Multirate and Cost Normalization

- The link cost between node and its peer is normalized based on rate
- Lower rate = Lower Throughput = Higher Cost
- Supported rates = 1/8x, 1/4x, 1/2x, 1x, 2x
  [9.6, 19.2, 38.4, 76.8, 153.6 Kbps]
- Normalization factor = rate throughput ratio

Data Rate	Data Rate (Kbps)	Throughput ratio
1/8x	9.6	1
1/4x	19.2	2.5
1/2x	38.4	5
1x	76.8	10
2x	153.6	20

Rate	Bandwidth Factor	Cost Multiplier
9.6	1	5/1=5
19.2	2.5	5/2.5=2
38.4	5	5/5=1

Powering Business Worldwide

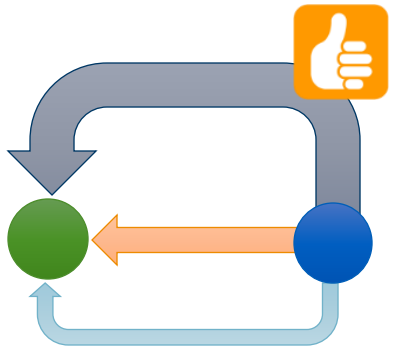
© 2024 Eaton. All rights reserved.

Rate Adaption

- Patented rate/power adaption algorithm
- The ‘common control rate’ is identical for the whole network
- The connection rate is adaptive
  - Higher link cost → Lower Rate
  - Lower link cost → Higher Rate

Lower rate when the link is bad
Raise rate when link is good

- The convergence is designed to maximize throughput.



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Rate Adaption

A typical sparse neighborhood configuration may look like

- MR-C := {R0 = 9.6}
- MR-E := {R0 = 9.6, R1 = 19.2, R2 = 38.4}

A dense network typically has a configuration that looks like

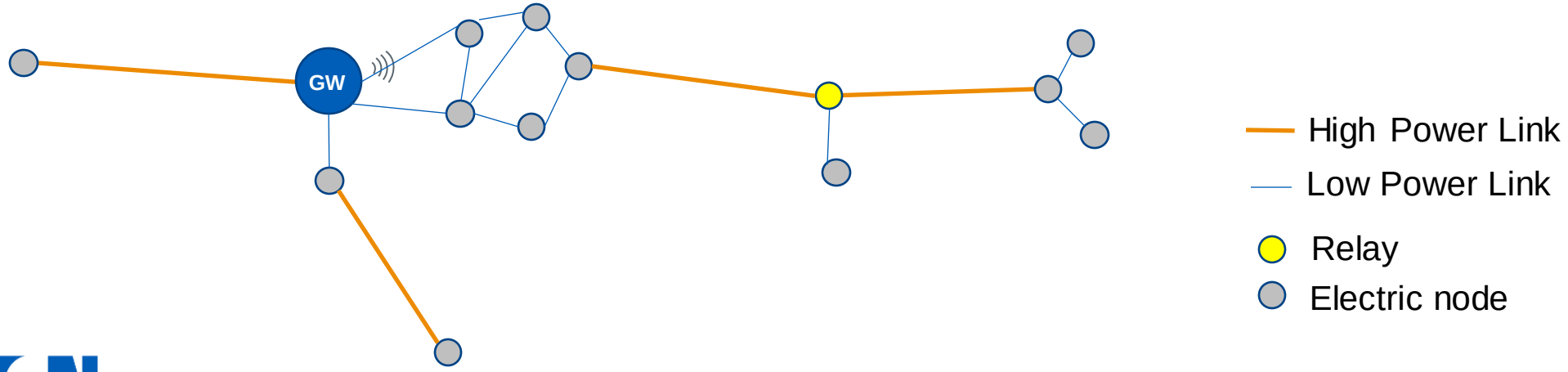
- MR-C := {R0 = 38.4}
- MR-E := {R0 = 38.4, R1 = 76.8, R2 = 153.6}

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Power Adaption

- Power level starts with neighbor density
  - ½ Watt for dense neighborhoods, 1 Watt for sparse.
- If a link can adapt to the highest rate, nodes will begin sampling lower power levels
- 4 power levels available (Release 9.5)
- Lower interference generally in dense areas while retaining the capacity to use higher power for longer distance when needed

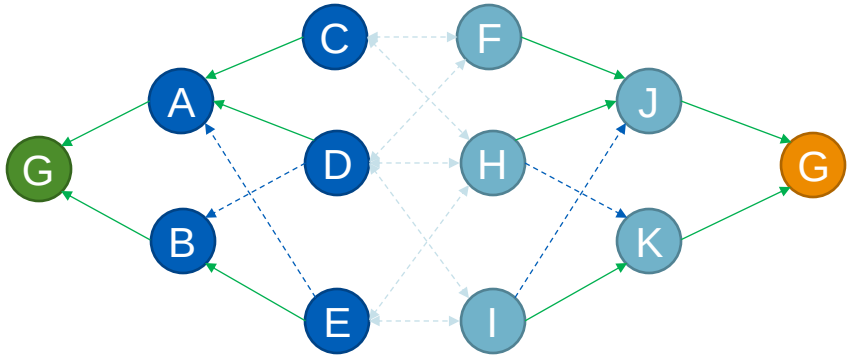


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Network Redundancy

- Node maintains an alternate primary with similar cost for traffic forwarding and load balancing.



- Node maintains two sets of suitable neighbors that offer paths to current gateway and an alternate gateway.

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Primary Path Failure Detection

- Node connects to its primary at least once every 2 hours.
- If connection fails, node retries (at least 25) for at least 30 minutes
- If all retry attempts fail, node declares a link failure.

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Primary Path Failure: What follows

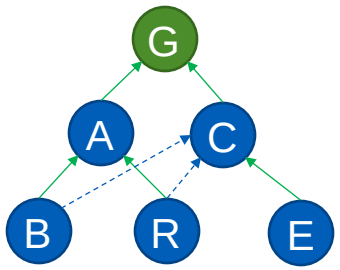
- A node switches its primary path if it:
  - Has an alternate path to the gateway…. AND
  - Detects primary path link failure…. OR
  - Receives a broadcast message from some other node informing about its primary failure

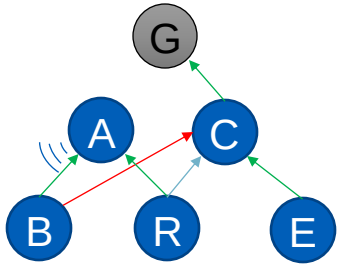
Powering Business Worldwide

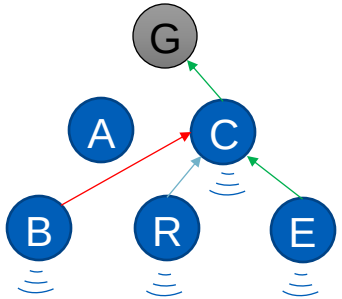
© 2024 Eaton. All rights reserved.

Primary Path Failure: What follows

- When node has no suitable primary or secondary to use, it broadcasts its own primary failure to alert its descendants
- The primary path failure is thus propagated hop by hop





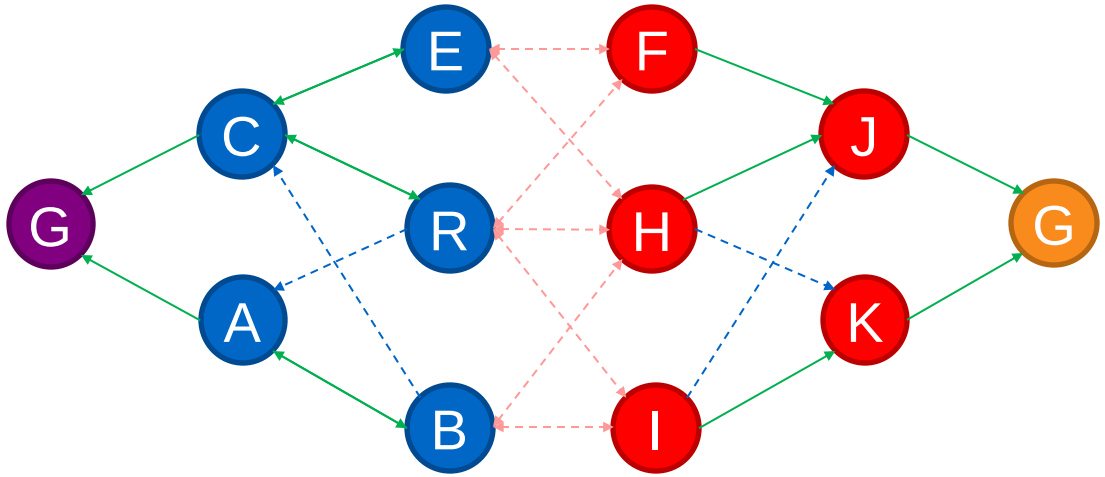


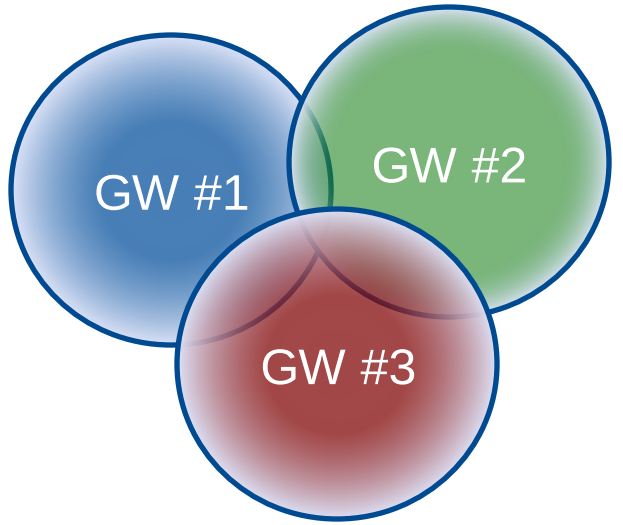
Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Gateway Failure: What follows

- Gateway failure information is propagated throughout the segment.
- The nodes in overlapping segments switch primaries first
- Other nodes follow hop by hop
- The whole segment gradually points to an alternate gateway within 24 hours.





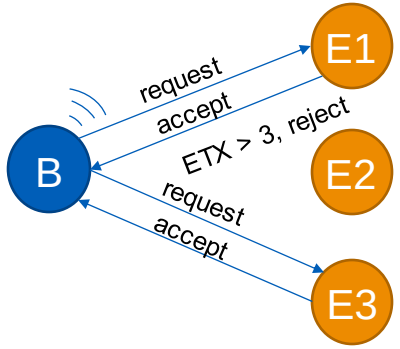
- Segment overlap is therefore essential

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Battery Association Convergence

- The battery association is renewed at every rendezvous.
- If link cost > threshold, the electric node rejects the association.
- Battery node starts broadcasting again looking for a partner
- Last partner does not respond, allowing new partners to connect
- Process continues until a good link-partner is found.

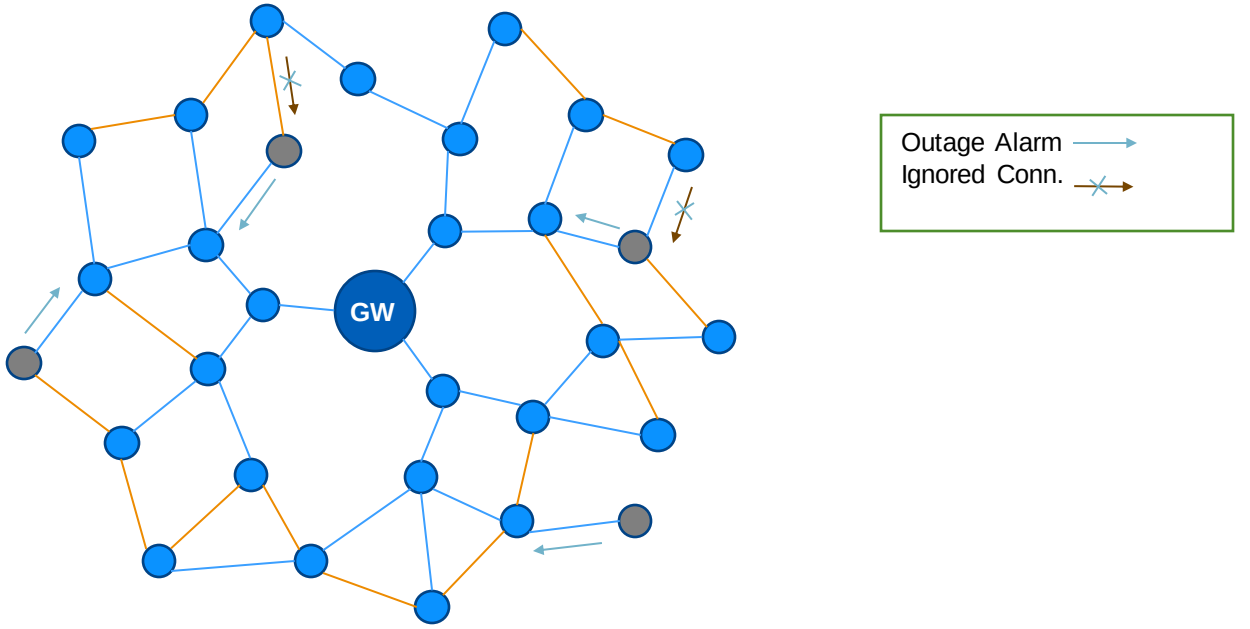


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Outage and Restore: Network Response

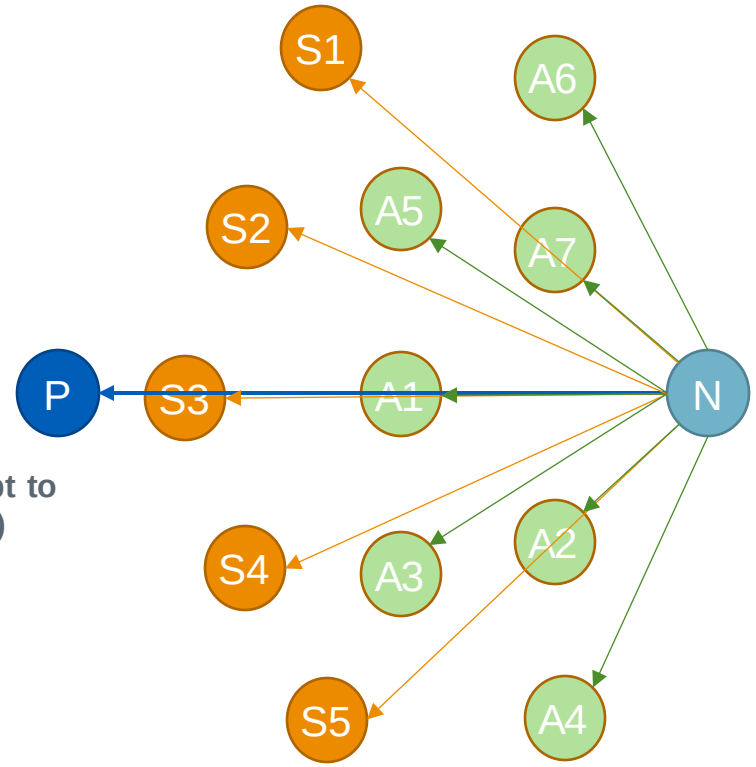
- A node in outage can run up to 4 min on backup power
- An outage node does not participate in any connections. Except when:
  - It needs to send an outage alarm
  - Incoming connection is carrying an outage alarm



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Outage Delivery



Delivery Attempt to Primary (5 tries)

Delivery Attempt to 5 best Secondaries

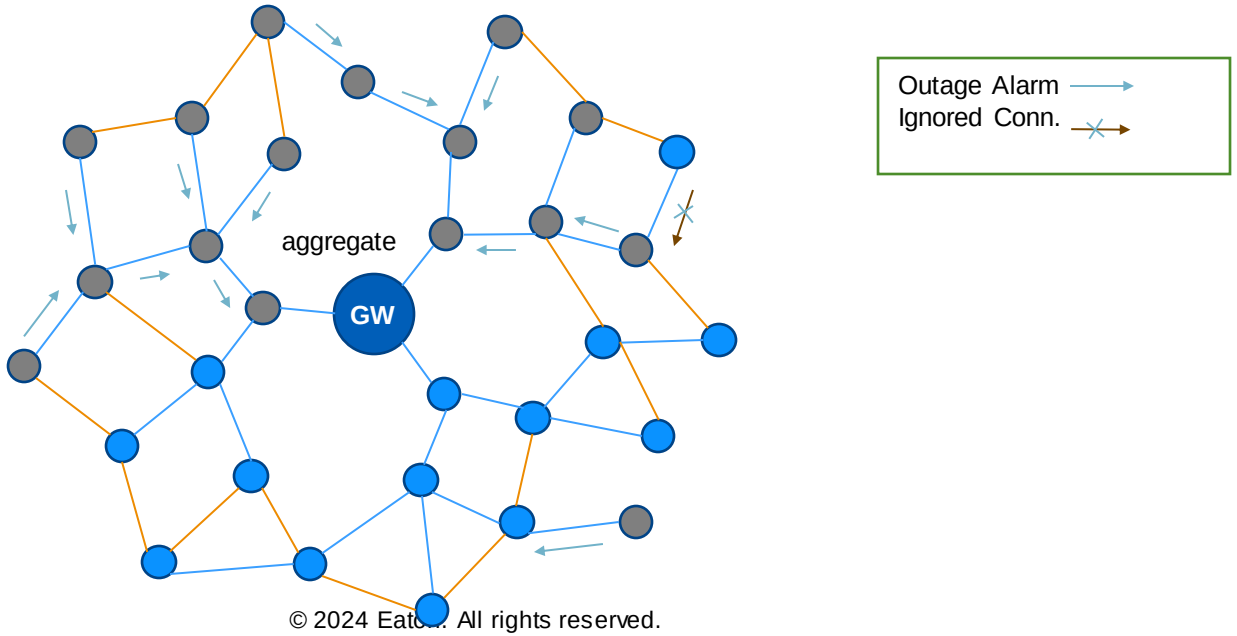
Delivery Using Anycast: Any neighbor with equal or less hops
Rank by: a. Path cost b. RSSI c. Charge Left

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Outage and Restore: Network Response

- Large scale outage event -> alarms not guaranteed to reach GW
- Outage alarm delivery improvements:
  - Aggregate outage alarms prior to sending its own
  - Connect only when outage alarm message is to be delivered
  - Employ connection back-off at the powered node, when it receives an outage message



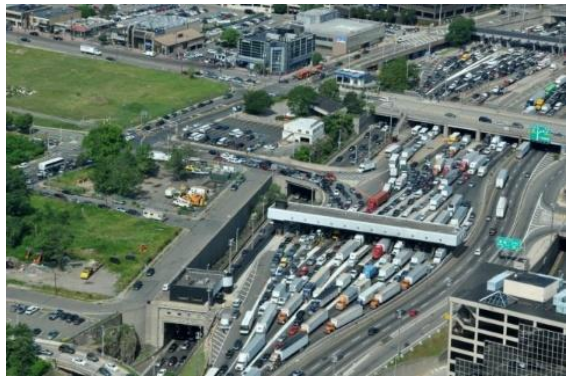
Powering Business Worldwide

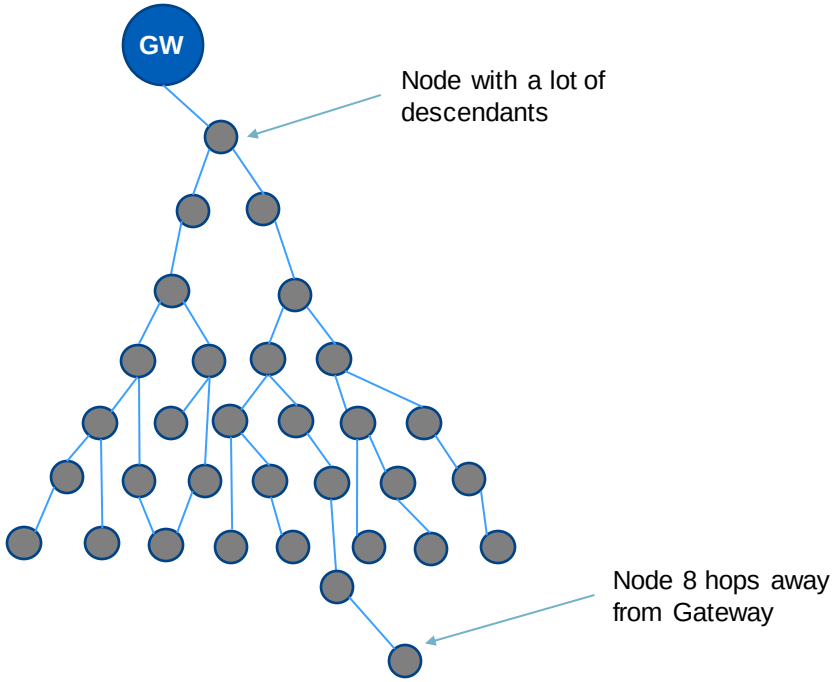
© 2024 Eaton. All rights reserved.

Outage and Restore: Network Response

Outage Response is constrained by Network Topology

- A single node or relay carrying a lot of descendants may reduce chance.
- A message has less probability of reaching gateway if it originates many hops away





Powering Business Worldwide

© 2024 Eaton. All rights reserved.

New/Recent Features (Release 9.3-9.7)

- WiFi IPLink Meter (9.3)
  - Acts as network bridge for the RF Network to utility backhaul using WiFi
  - Based on the C2SX meter
- Power Adaptation (9.5)
- Remote Meter Programming
  - Supports meter configuration for Elster A3 and LG S4
- Gas Meter (9.7)

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Applications

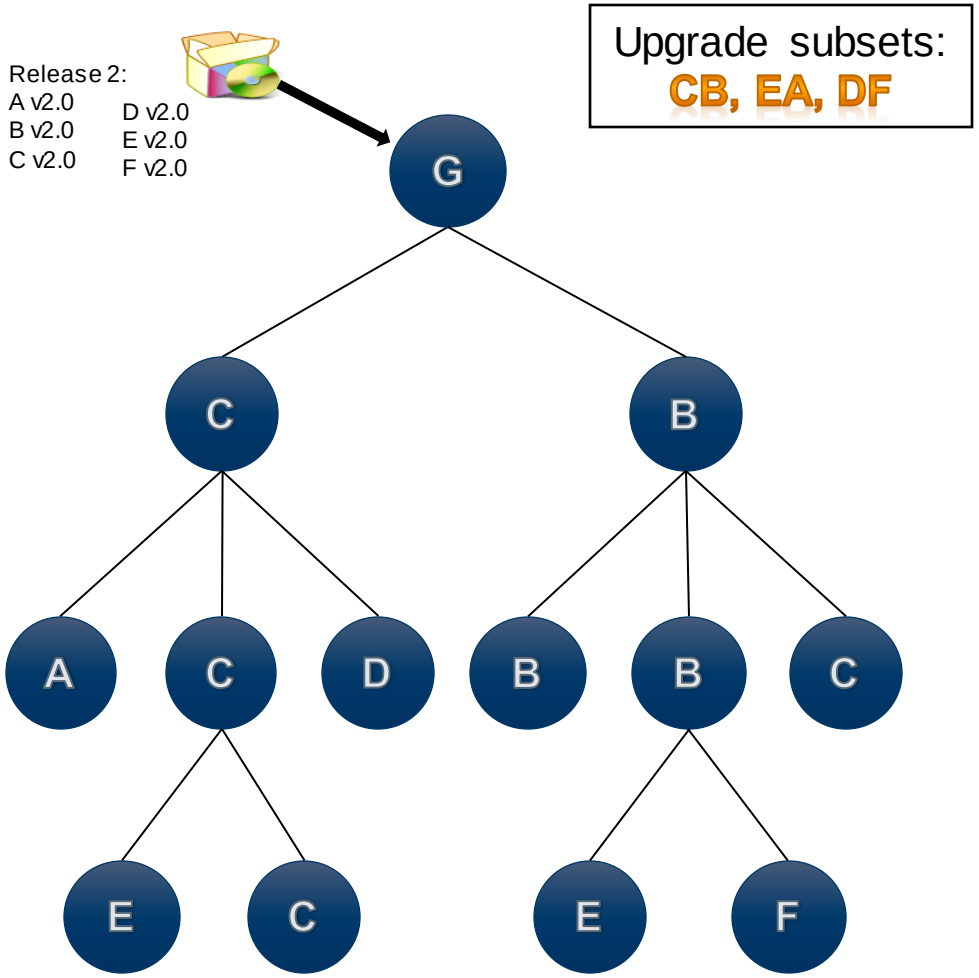
© 2024 Eaton. All rights reserved.

Firmware Upgrade

- RF system can deliver new features for all RF devices through firmware upgrades
- All RF upgrade images are created with a RSA signature and authenticated before being accepted by a node
- Firmware upgrade mechanism relies on neighbor topology to “spread” the new images down and across the network
- The upgrade mechanism is capable of upgrading any RF node unless it has poor link connectivity to the network
- New design facilitates traffic efficient upgrades resulting in minimizing effect to network traffic

© 2024 Eaton. All rights reserved.

Firmware Upgrade – Gateway

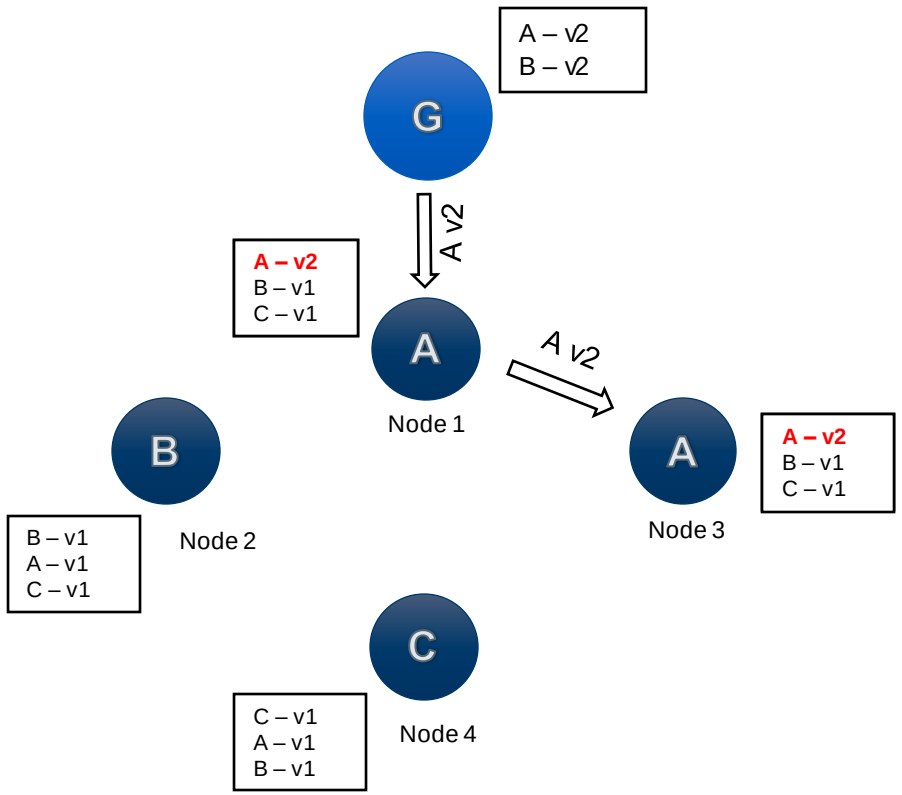


- Upgrades are initiated at the Gateway
- Controlled traffic event
- Gateway sends only a subset of all images into network at anytime
- A defined period of time is given for images to propagate into the network
- Nodes apply updates and send version information to Gateway
- Gateways stop sending images when 99% of nodes have been updated or the defined period of time has elapsed
- Nodes will continue to upgrade each other as needed

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Firmware Upgrade – Node Upgrade

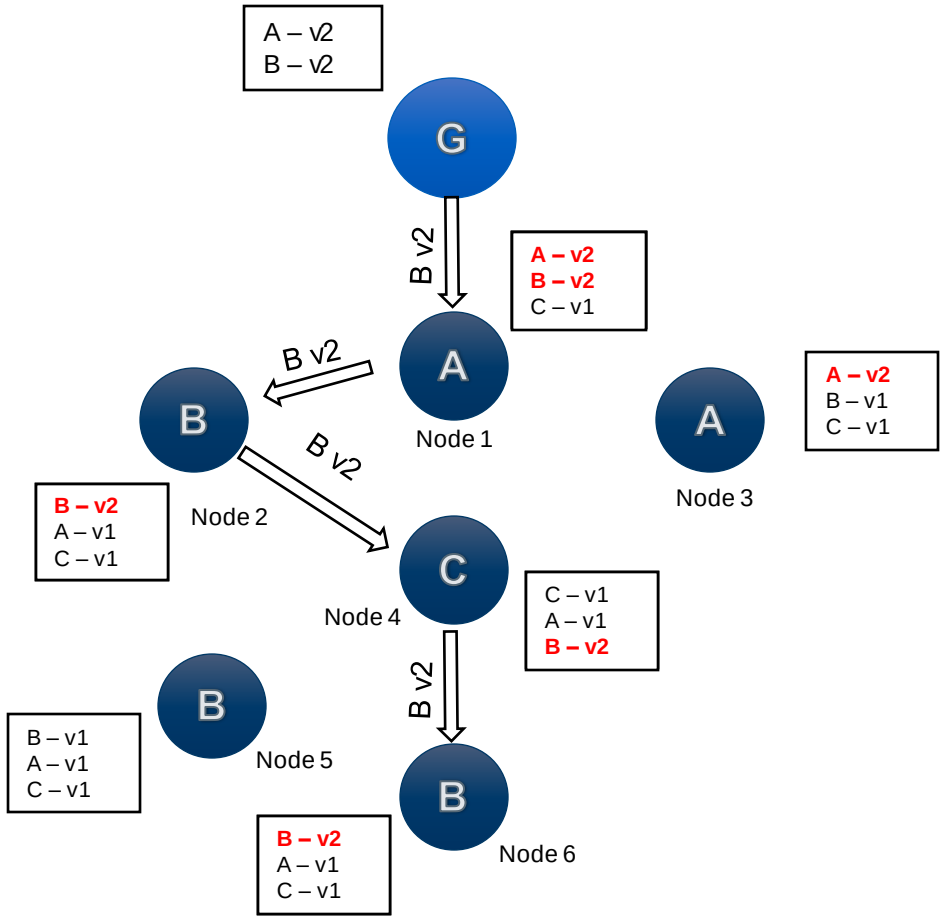


- A node receives new firmware from one of its neighbors
- Neighbors connect to each other periodically to send application traffic or to exchange control traffic
- Firmware exchanges are randomized to avoid heavy network traffic: 1/6 – Gateway, 1/3 - Nodes
- All Nodes store their own and images of 2 other types of nodes to facilitate faster spread through the network
- A node will send the newer version of any of its stored firmware to its neighbor

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Firmware Upgrade – Node Upgrade



- Nodes of different types can send an upgrade to each other from their stored images
- Nodes sent updated firmware version to the Gateway
- A node that gets newly installed will receive updated firmware if its available from one of its neighbors

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Outage Detection

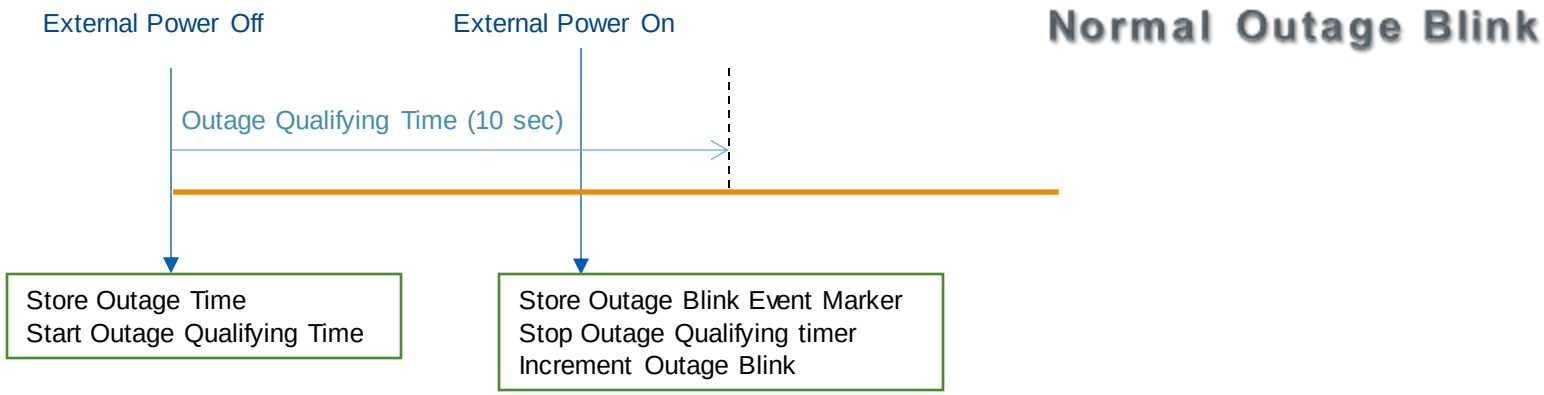
- RFN Outage and Blink Determination
  - Blink is defined as loss or restoration of power for less than 10 seconds (Release 9.0)
  - Outage is loss of power for 10 or more seconds
  - Restore is after power has been back on for 60 seconds or more

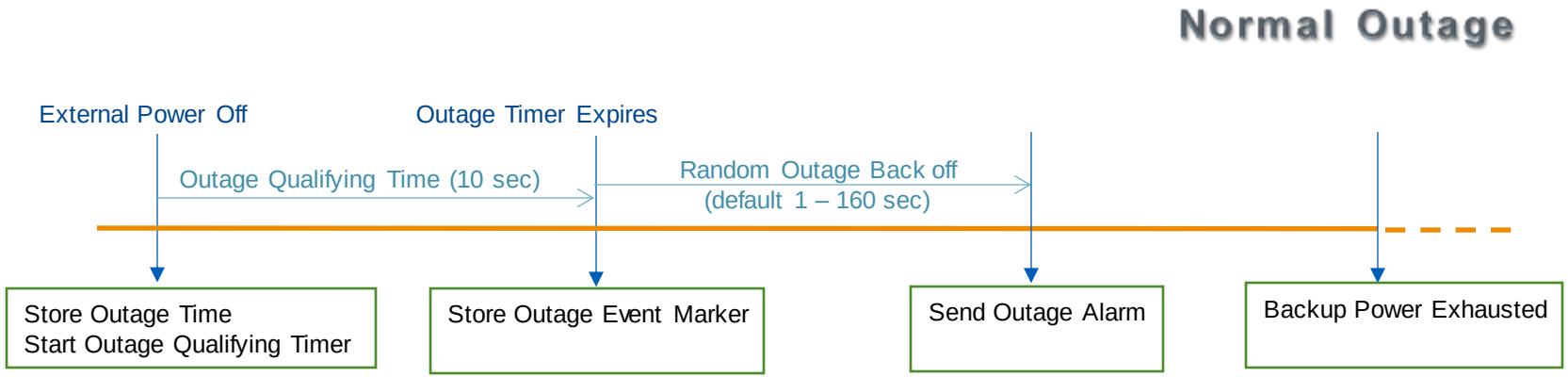
Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Outage Detection

Outage Detection and Reporting Steps





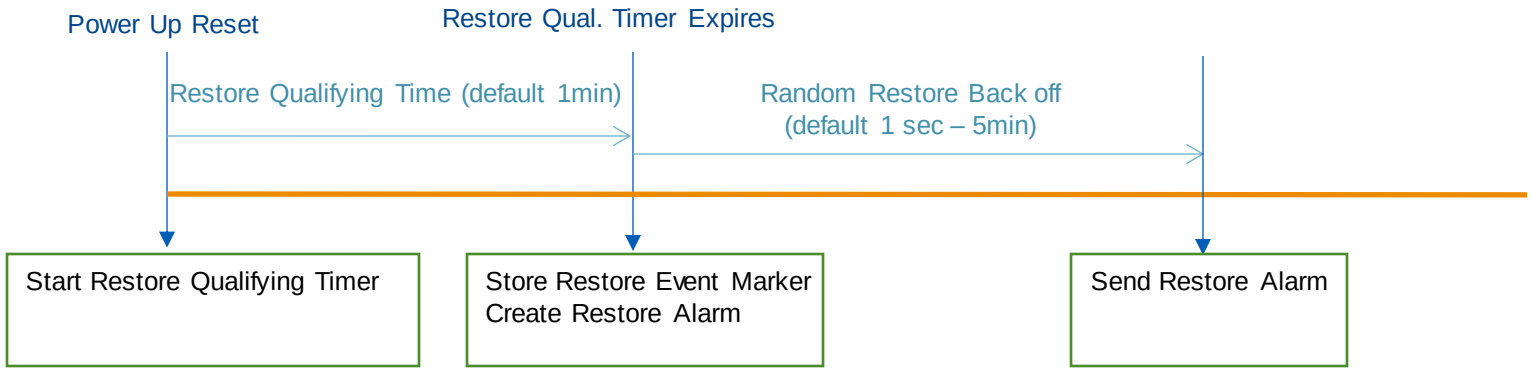
Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Outage Detection

Restoration Reporting Steps

Normal Restore



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

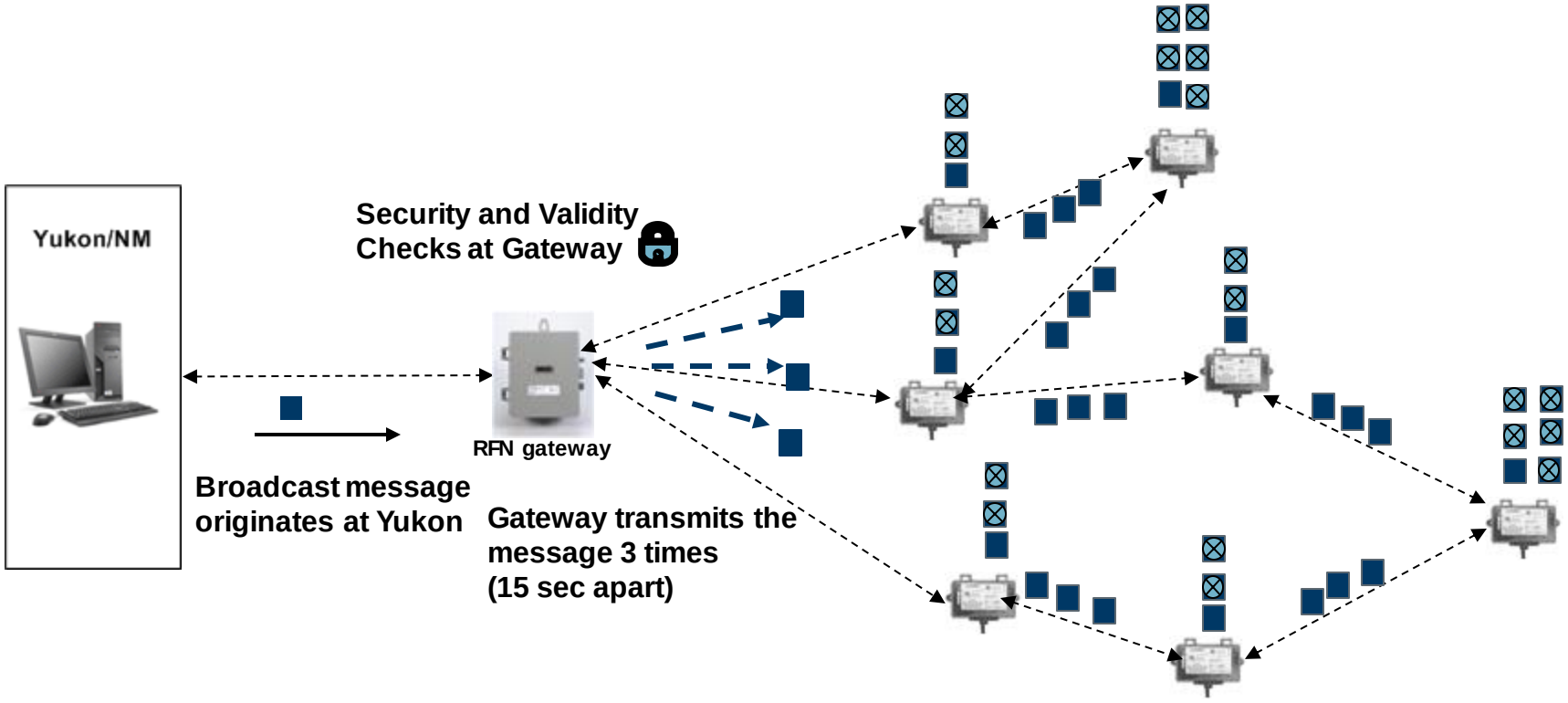
RFN Broadcast Summary

- RFN Broadcast is a controlled flooding mechanism where the message frames are repeatedly broadcast from node to node
- Uses the link layer and it works independent of the network routing connectivity
- Limits the number of broadcasts as well as the period of transmission in order to reduce the impact on any unicast messaging
- Supports authentication and data encryption as well as delay and replay protection
- Uses security keys independent of the unicast transmission
- Supports real-time and non-real time delivery

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Broadcast (Real-time message delivery)



- Original message
- Repeated message 1
- Repeated message 2
- Dropped Repeated message

All nodes within reach receive same messages but drop duplicates and expired messages.
Transmit 3 times.
Randomized 0-10 seconds

Message expires in 15 minutes (Validity time)

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

RFN Broadcast Summary

- Supports mainly Demand Response (DR) application. DR messages are broadcast as real-time/high-priority messages
- Originates at the Yukon DR Application
- NM implements flow control into the network
- RFN Gateways and Nodes implement message security, validity time and priority as the messages pass onwards into the RF mesh network

© 2024 Eaton. All rights reserved.

RFN Data Streaming

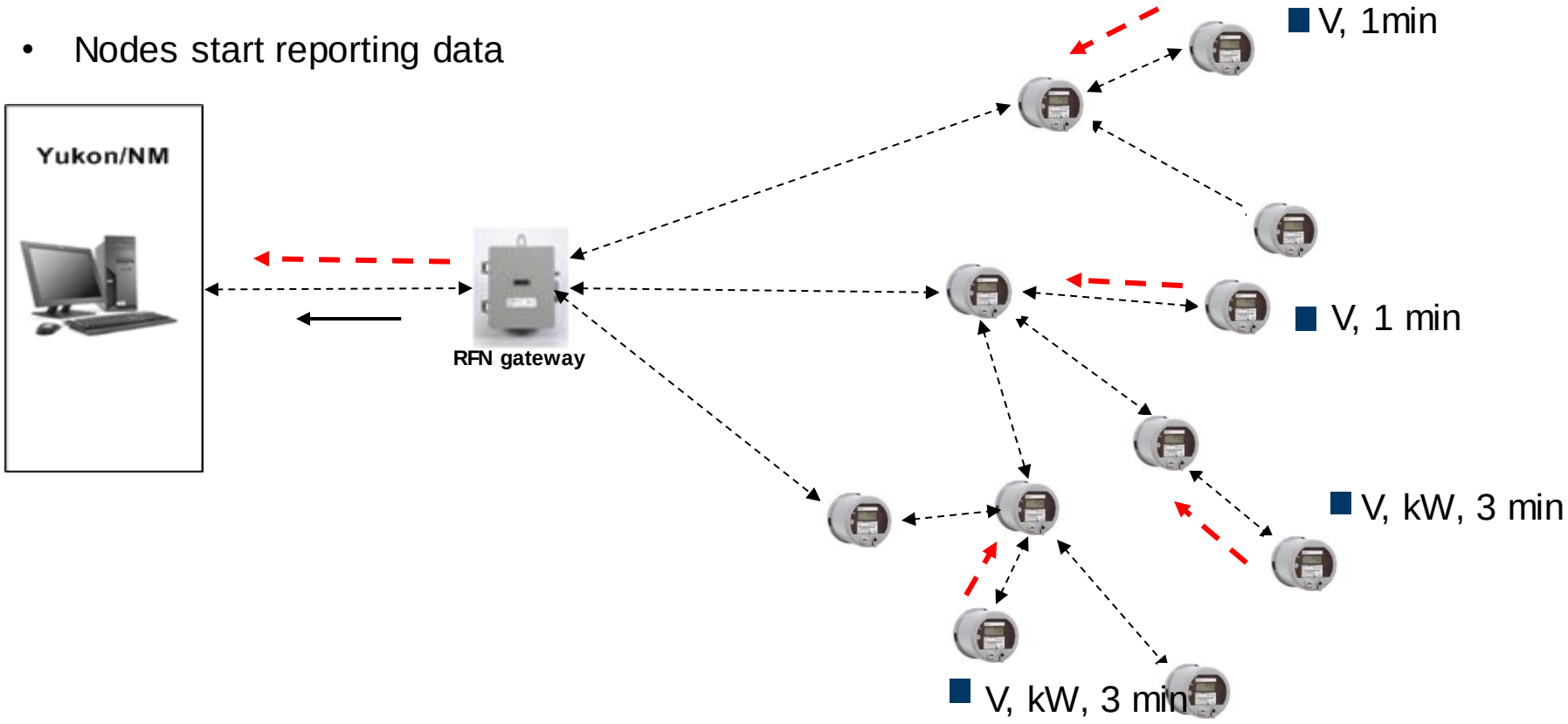
- Near-real time monitoring of selected meter data mainly aimed for voltages but supports other meter data points (KW, VA, VAR)
- Uses a new RFN connectionless transport layer messaging with low latency, shorter data payloads. Supports up to 8 data points per message. Not recorded nor gap filled.
- Security and validity checks at each node and the gateway
- 1, 3, 5, 15 and 30 minute configurable reporting intervals
- End-to-end configuration and management and data interface to the customer management system are provided by Yukon
- Capacity is managed by Yukon and allows data streaming on a subset of meters.

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

RFN Data Streaming

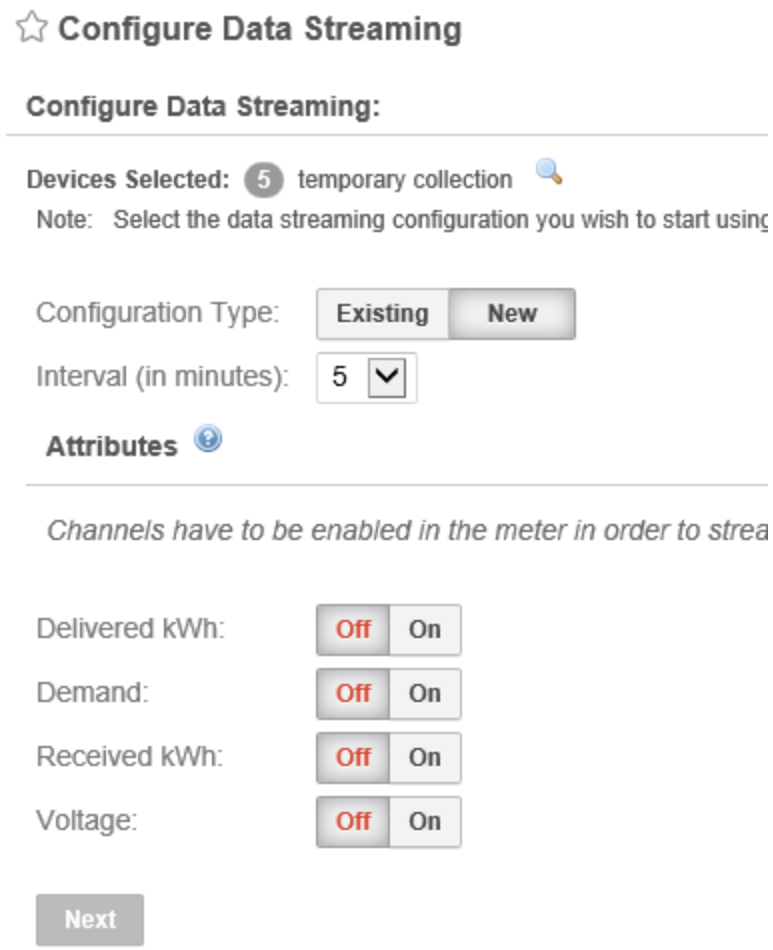
- Yukon enables and select channels for Data Streaming
- Nodes start reporting data



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

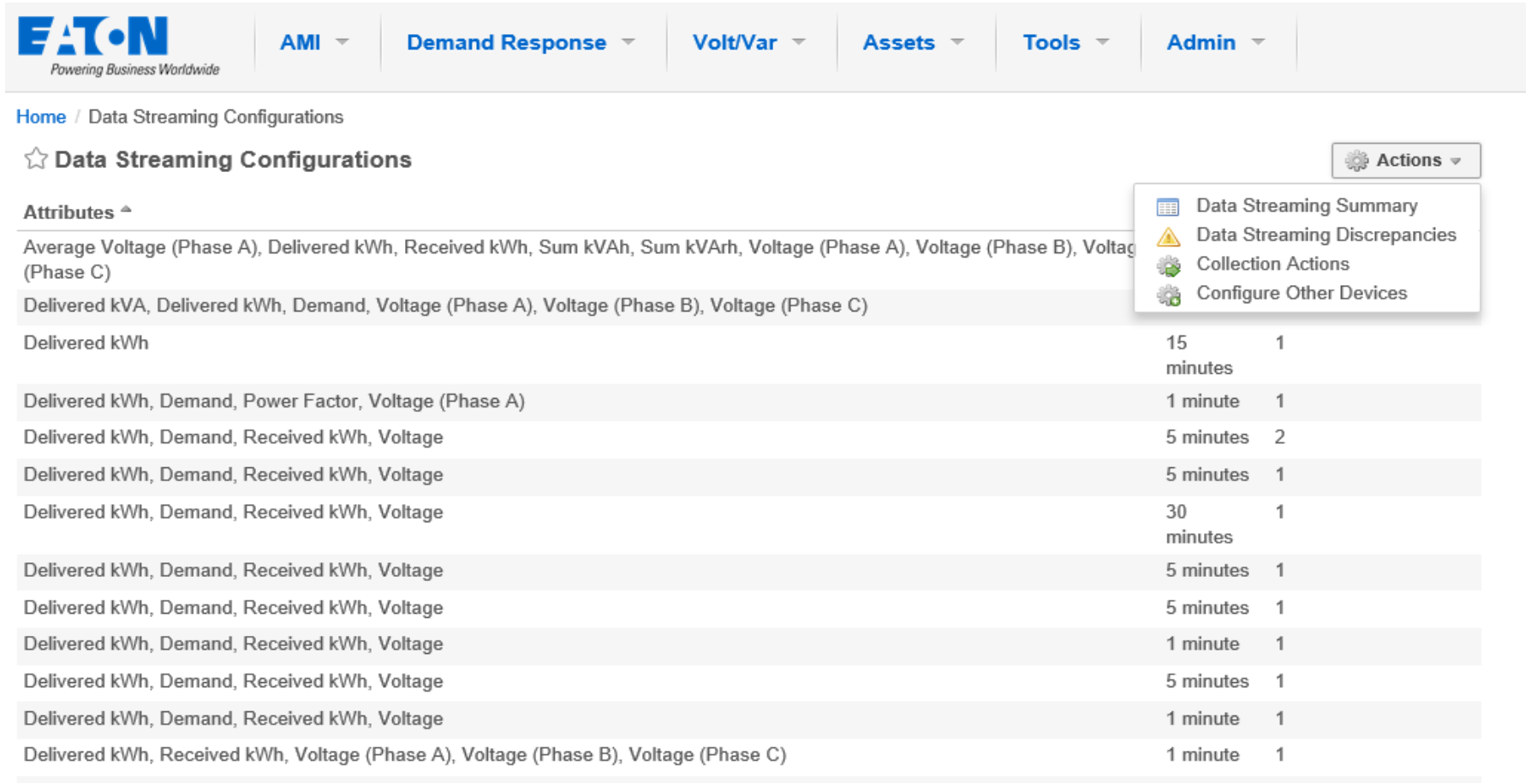
Data Streaming: Yukon Configuration



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Data Streaming: Yukon Configuration

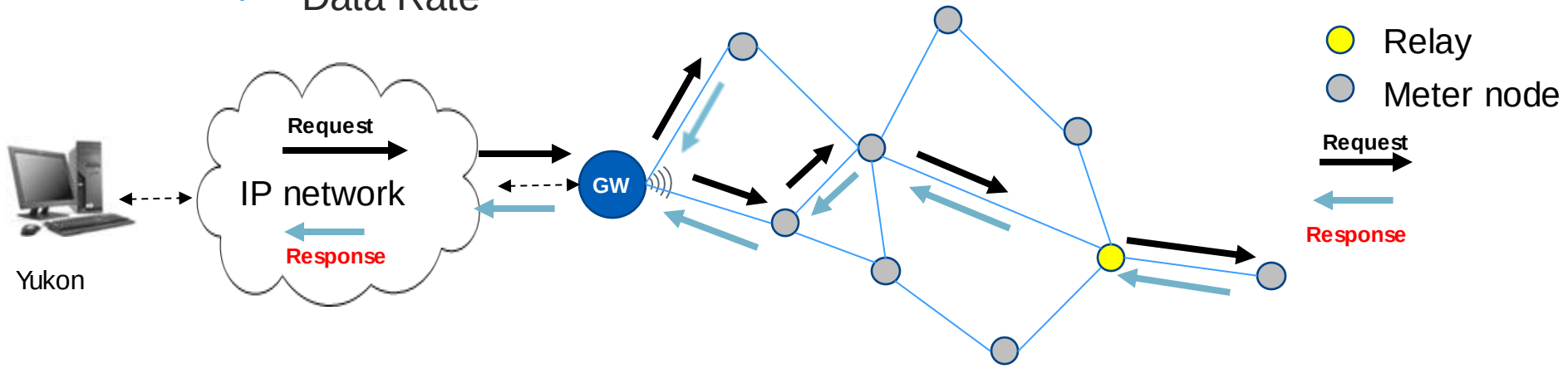


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

On-Demand Reads

- On-Demand reads (current meter reading) can be initiated from Yukon/NM to a node
- Average time is about 2-3 seconds per hop but it can be more depending on many factors
  - How busy the gateway and nodes are at the time of on-demand
  - Link quality
  - Data Rate



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Q & A

- Questions?

© 2024 Eaton. All rights reserved.

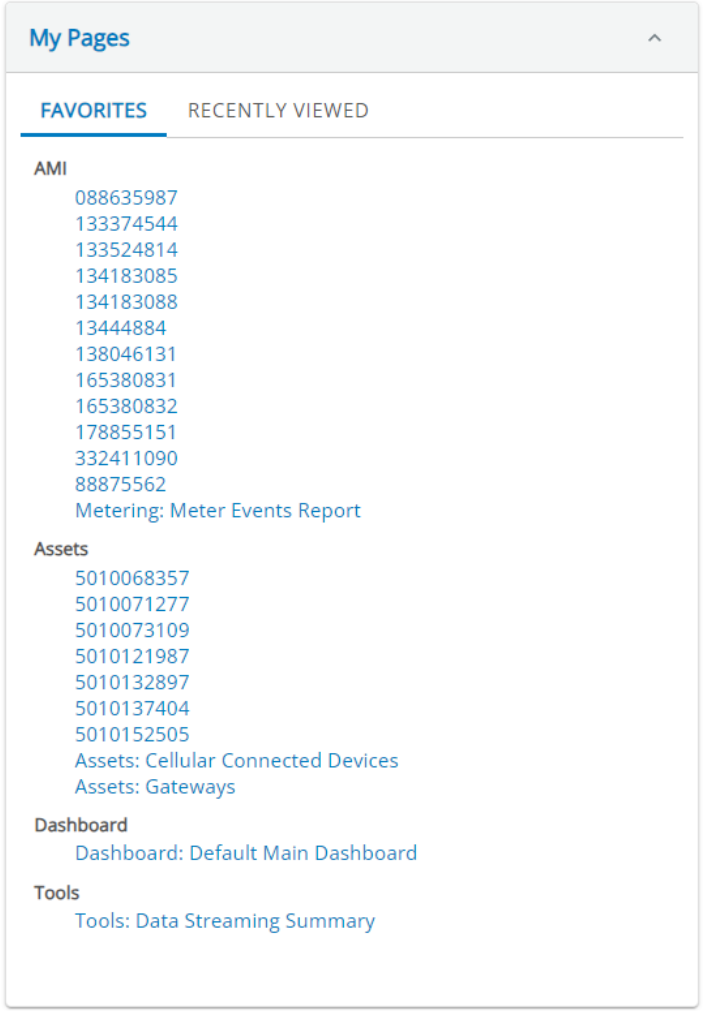
EAS Conference – Yukon 101

© 2024 Eaton. All rights reserved.

Dashboards

© 2024 Eaton. All rights reserved.

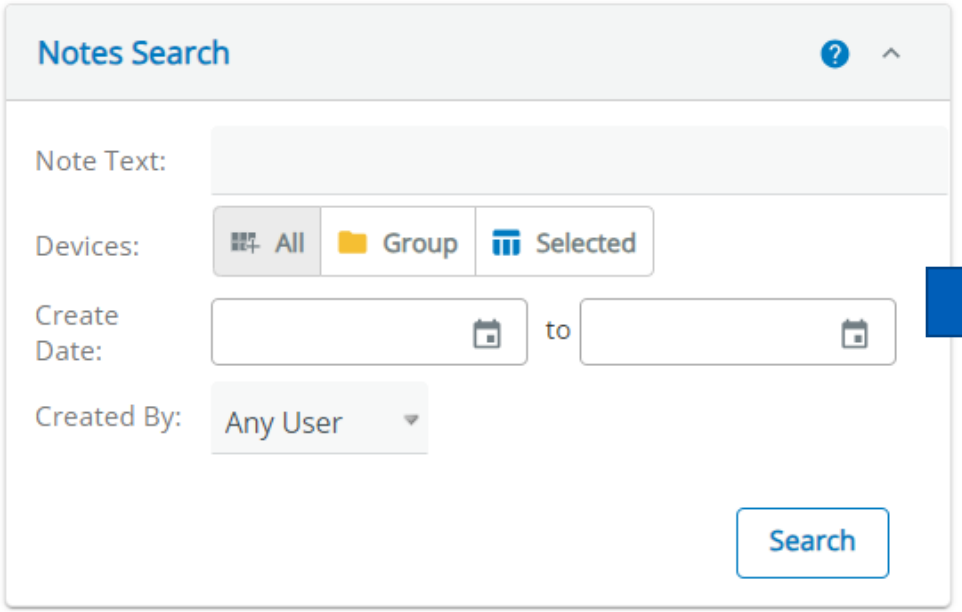
Dashboard – **My Pages**

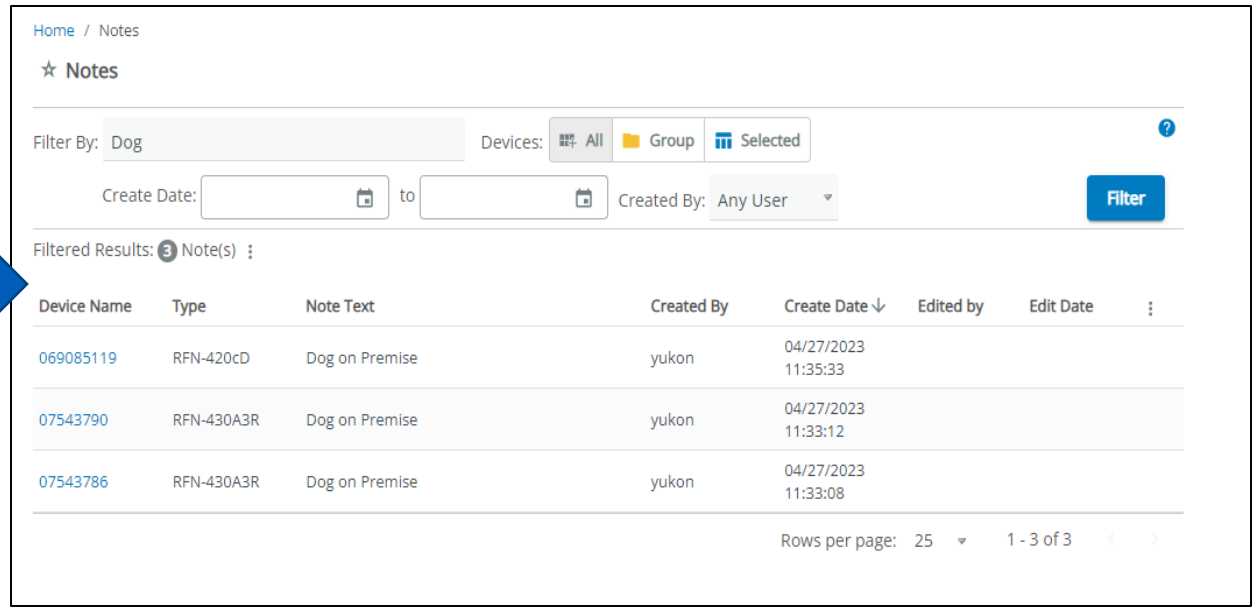


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Dashboard – **Note Search Widget**

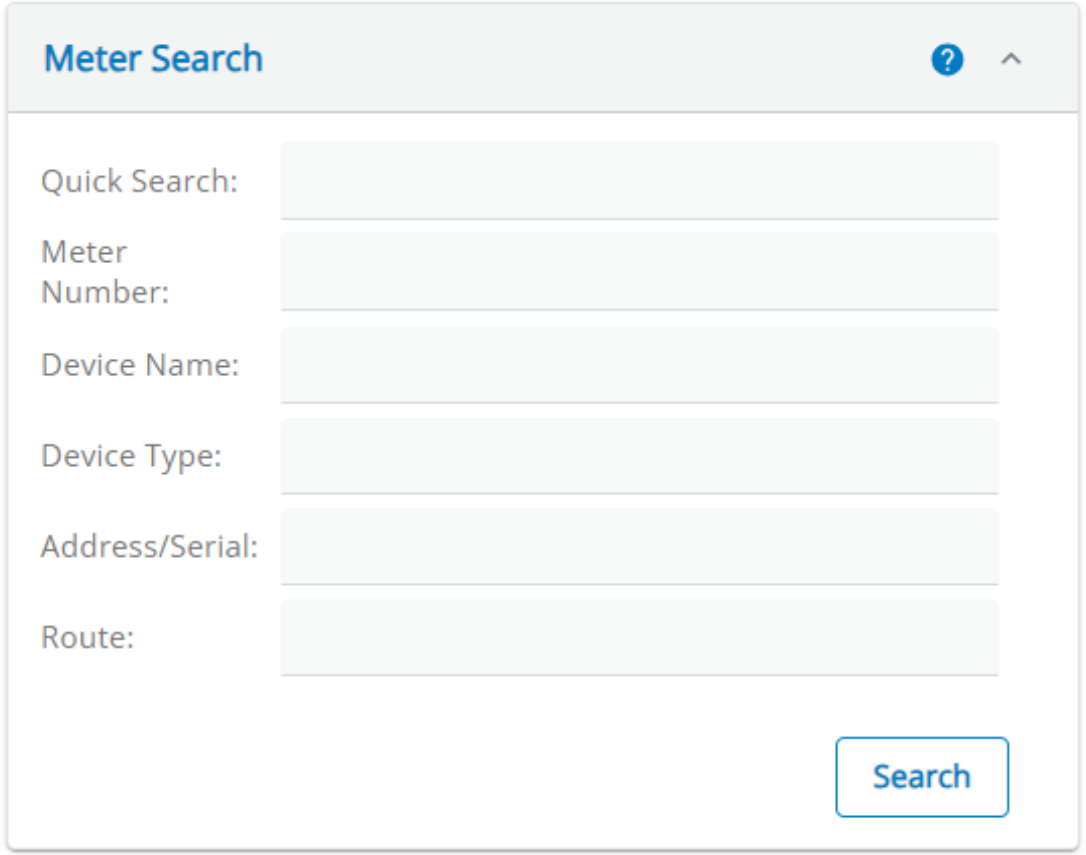




Powering Business Worldwide

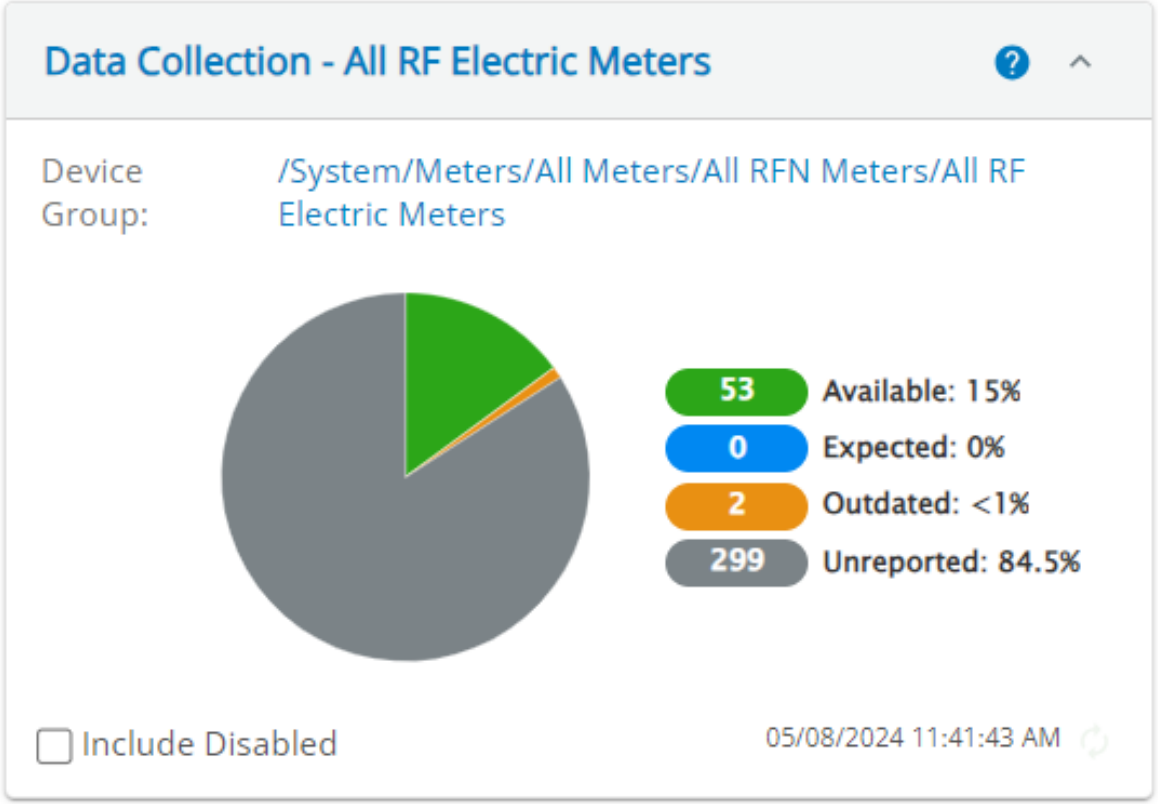
© 2024 Eaton. All rights reserved.

Dashboard – **Meter Search**



© 2024 Eaton. All rights reserved.

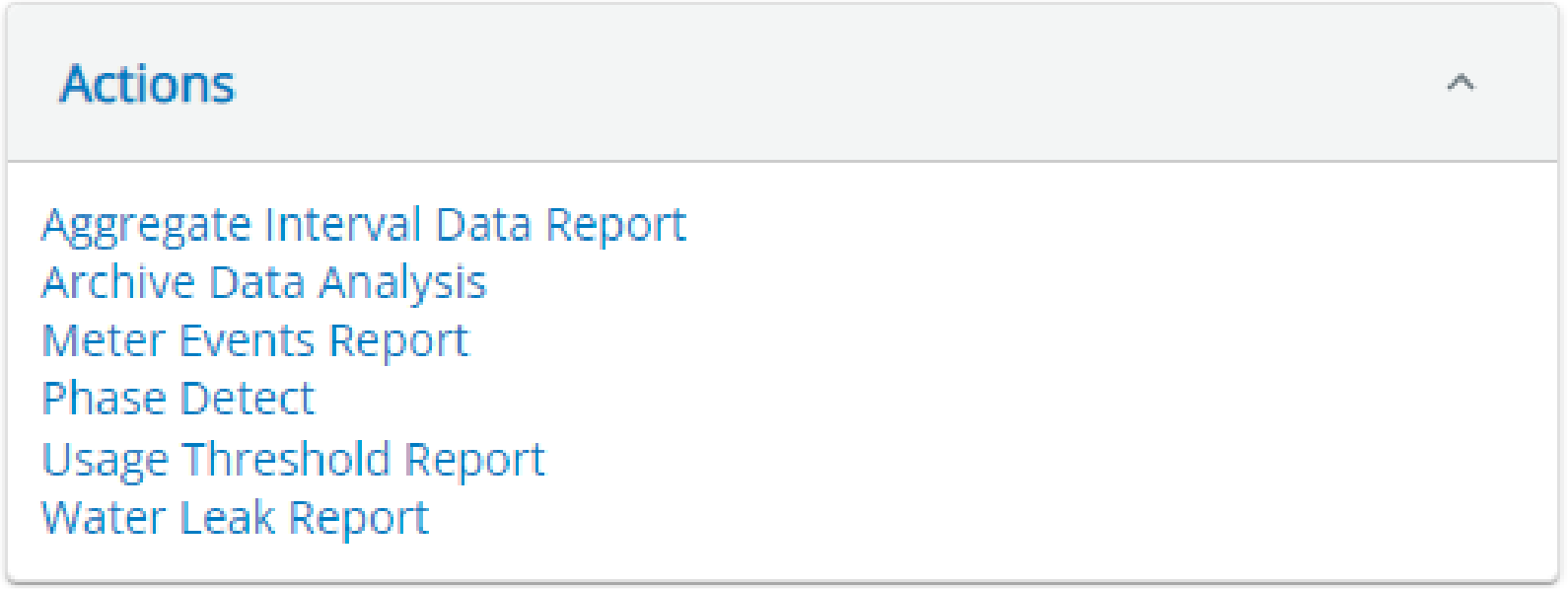
Dashboard – **Data Collection**



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

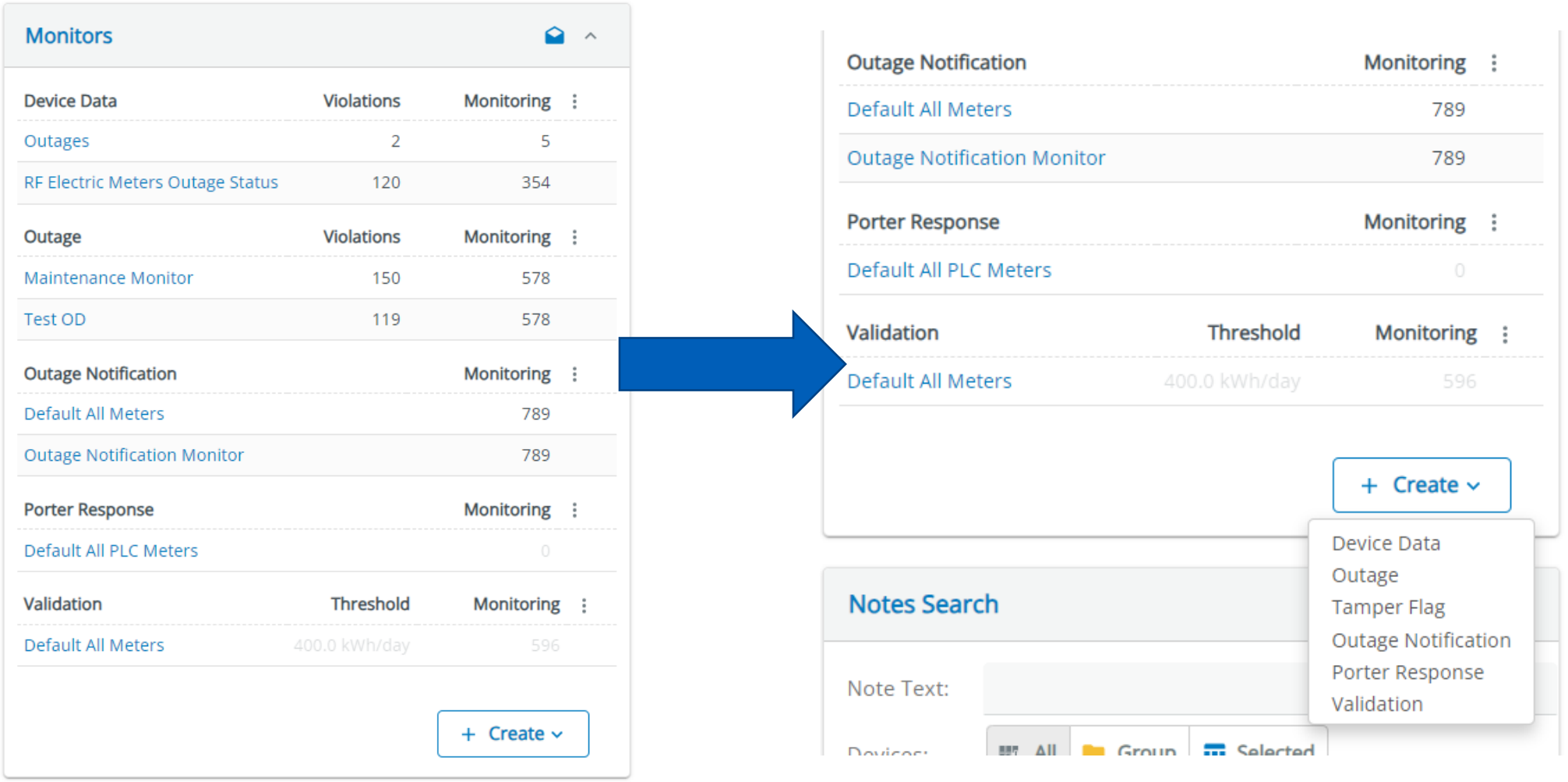
Dashboard – **Actions Widget**



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

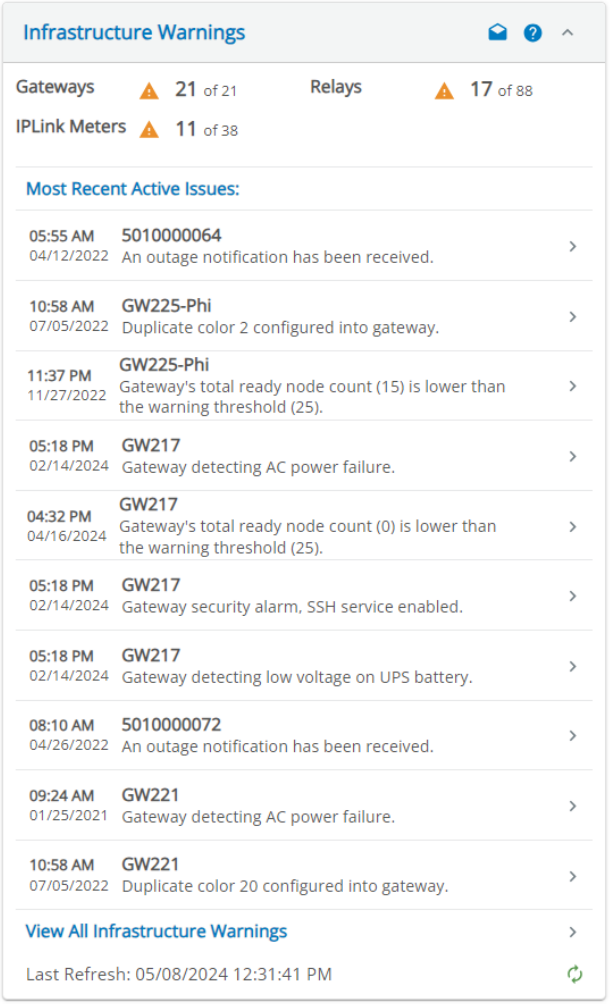
Dashboard – **Monitors**



© 2024 Eaton. All rights reserved.

Dashboard – **Infrastructure Warnings**

•The Infrastructure Warnings widget periodically evaluates devices associated with the communications network such as RF gateways, RF relays, IPLink meters, CCUs or repeaters. Results of the evaluations will produce informational or warning messages about specific conditions that may require investigation. A summary will display for each of the corresponding device types:



• - No current warnings exist for the device type.
• - Number of devices with warnings.

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meters

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

Home / AMI / Meters / 68498678

☆ 68498678

Actions

Meter Information

Device Name:	68498678
Meter Number:	68498678
Type:	RFN-410cL
Serial Number:	68498678
Manufacturer:	ITRN
Model:	C1SX
Status:	Enabled

Edit

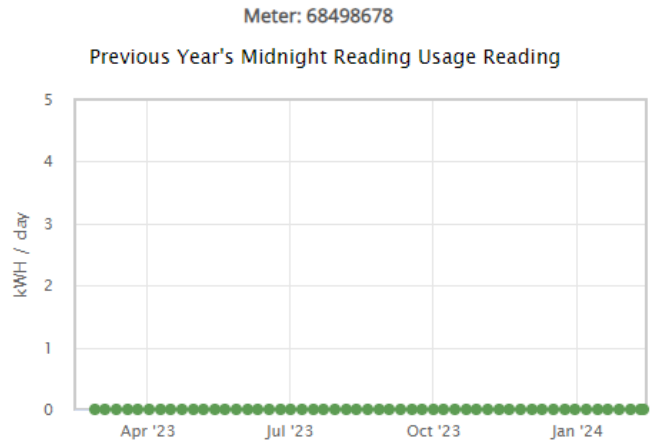
Meter Readings

Usage Reading:	23.019 kWH 02/12/2024 23:00:00
Previous:	23.019 kWH 02/12/2024 23:00:00
Total Consumption:	0.000
Peak Demand:	0.000 kW 02/12/2024 23:00:00
Demand:	0.000 kW 02/12/2024 23:00:00
Voltage:	238.3 Volts 02/12/2024 23:00:00

View All | Quick View

Read

Meter Trend



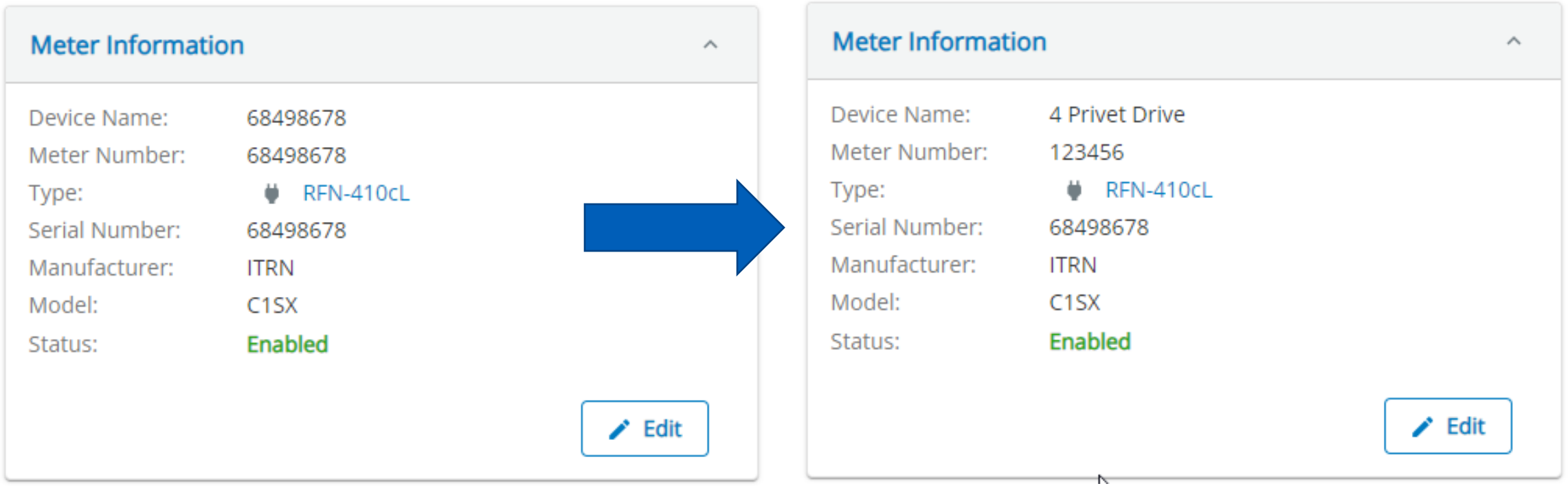
Graph Type:	Voltage Profile | Daily Usage | Demand | Delivered kWh per Interval
Time Period:	1D | 1W | 1M | 3M | 1Y | Custom
Chart Style:	Line | Bar
Archived Usage Data	HTML | CSV | PDF
Daily Usage Data	HTML | CSV | PDF

Meter Events

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

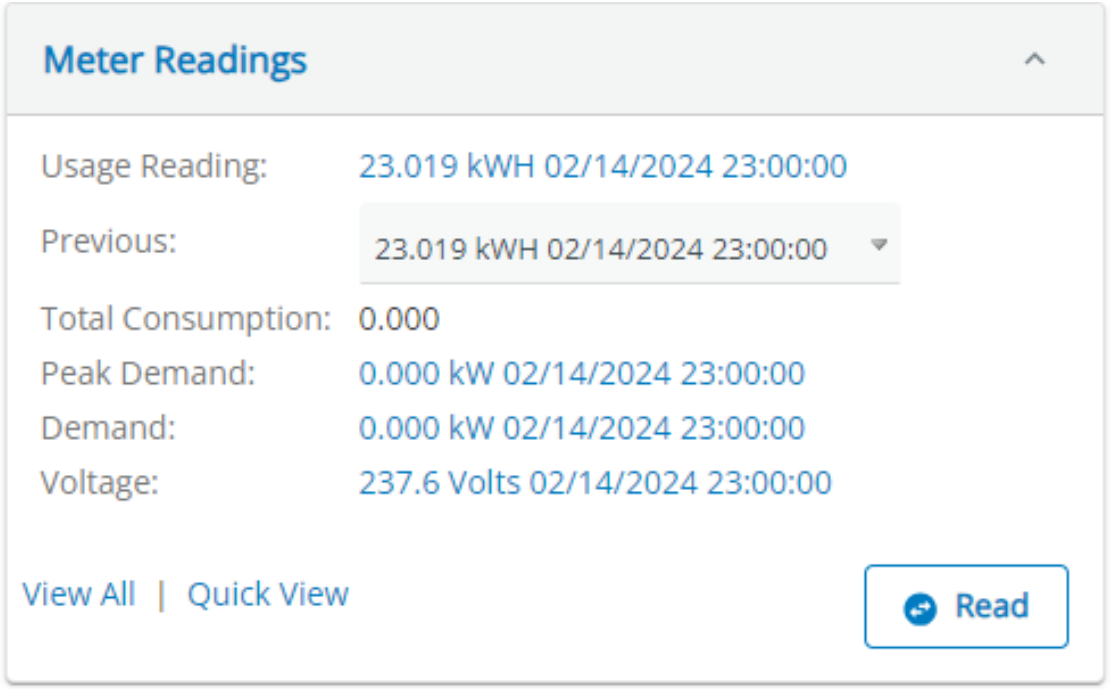


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- Contains current usage data and previous meter readings
  - View All: lists all existing data points for the selected device
- To view the current usage for a meter, press Read

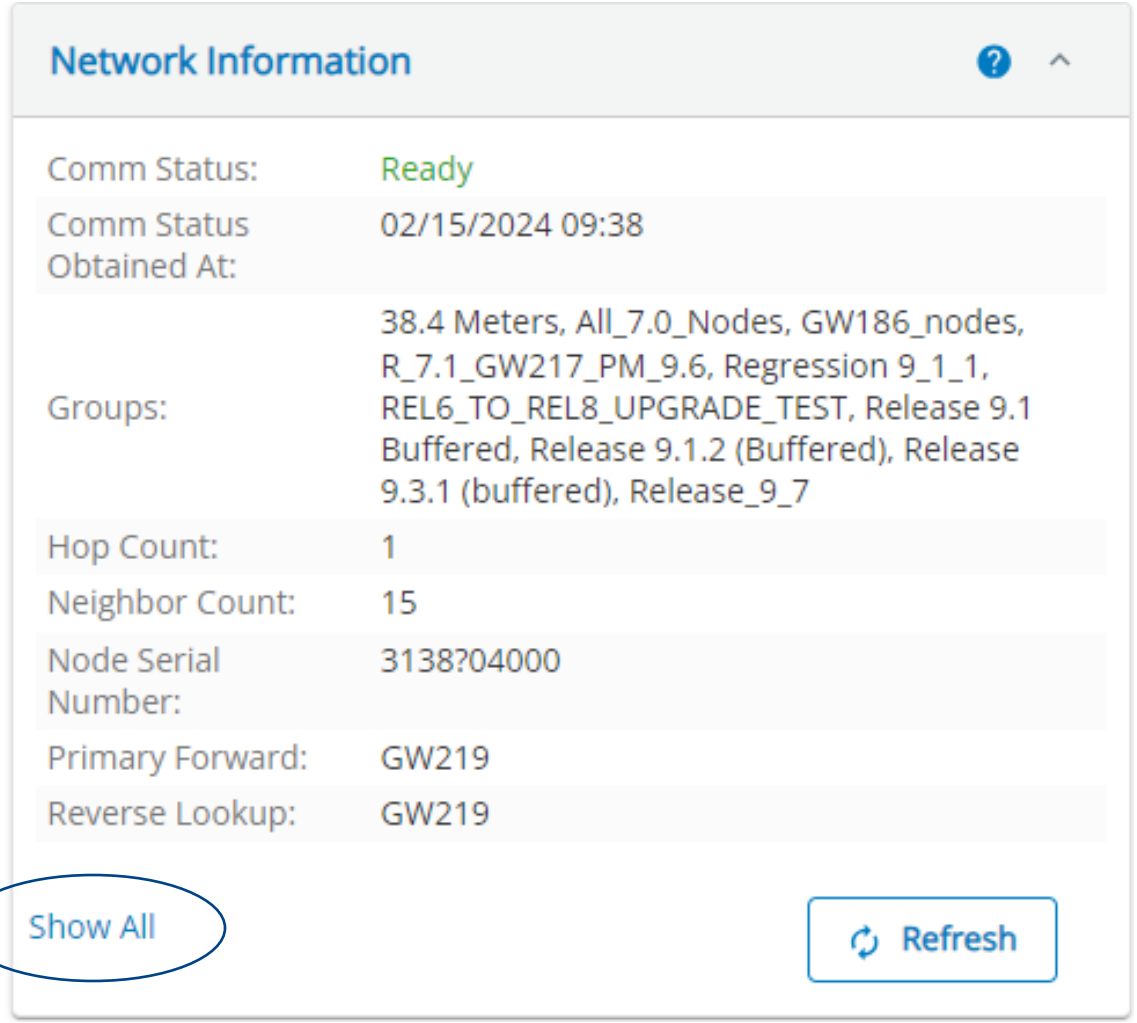


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

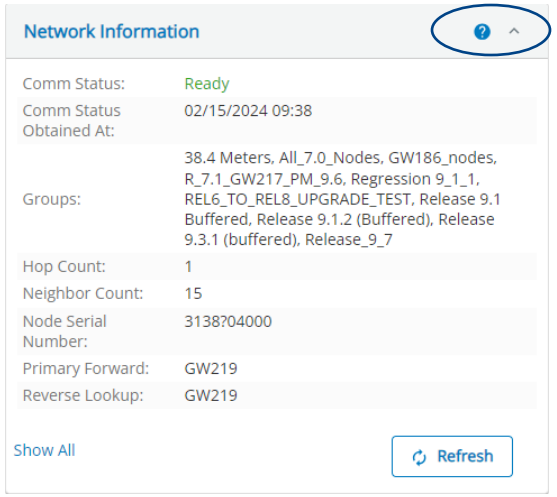
- Network Information for a meter
  - Comm Status: Ready, Not Ready, Unknown
  - Hop Count: number of hops away from the gateway
  - Neighbor Count: identified neighbors the node can communicate through

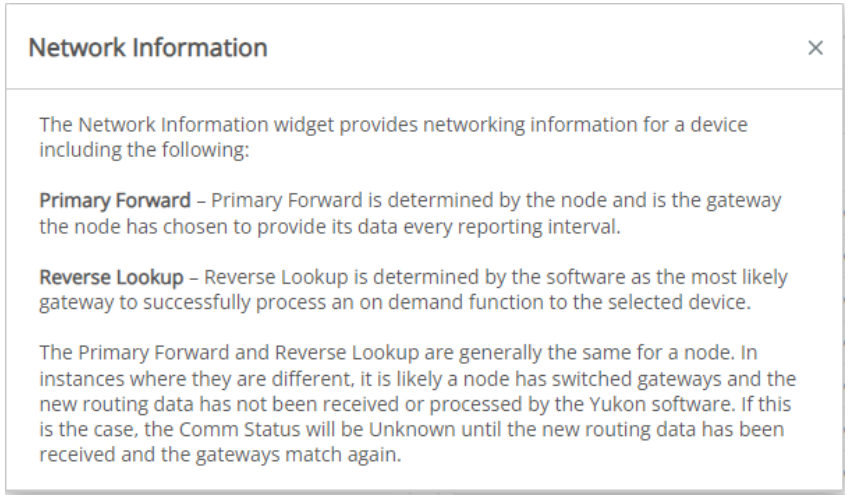


© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- Tip: question mark icons in Yukon will provide an explanation of the widget or page



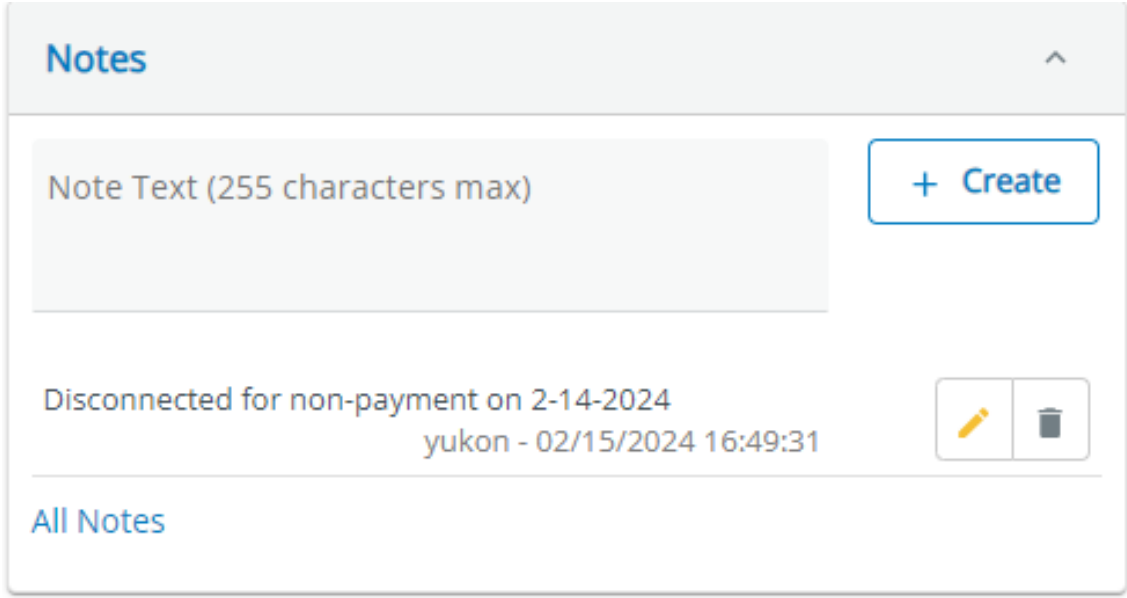


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- Create, view, and manage notes attached to the meter

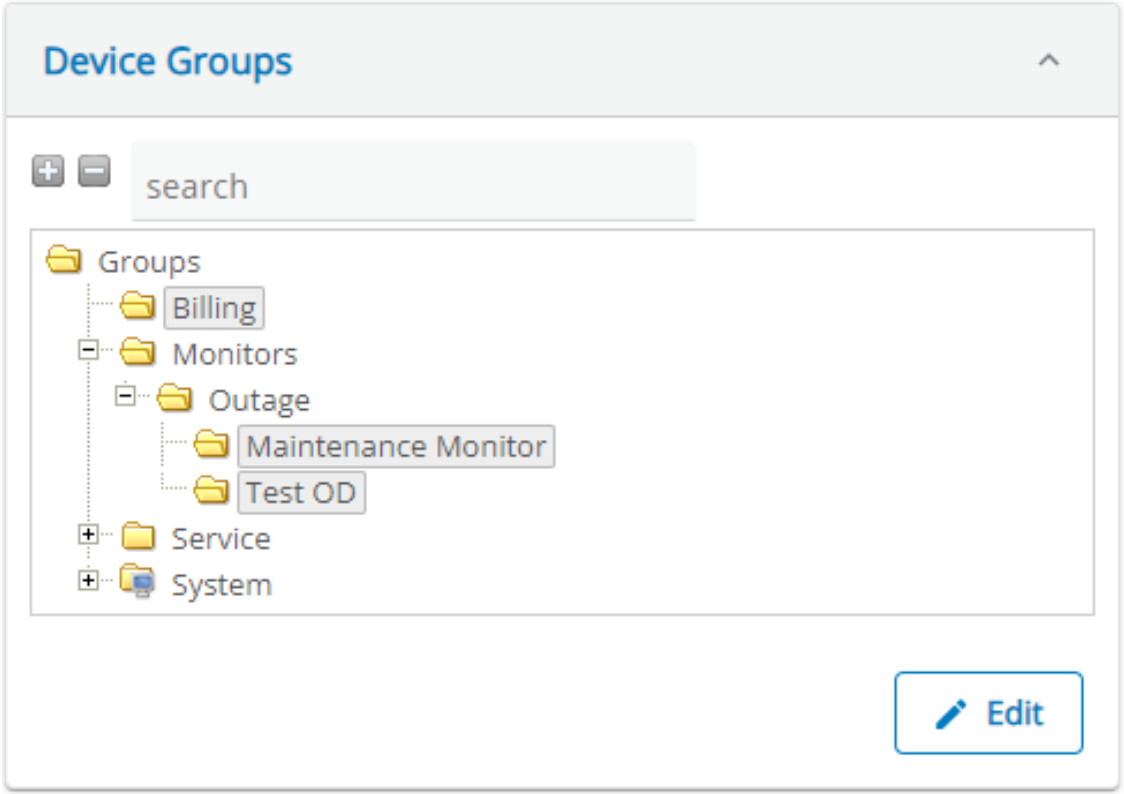


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- View and modify the Device Groups to which the meter belongs

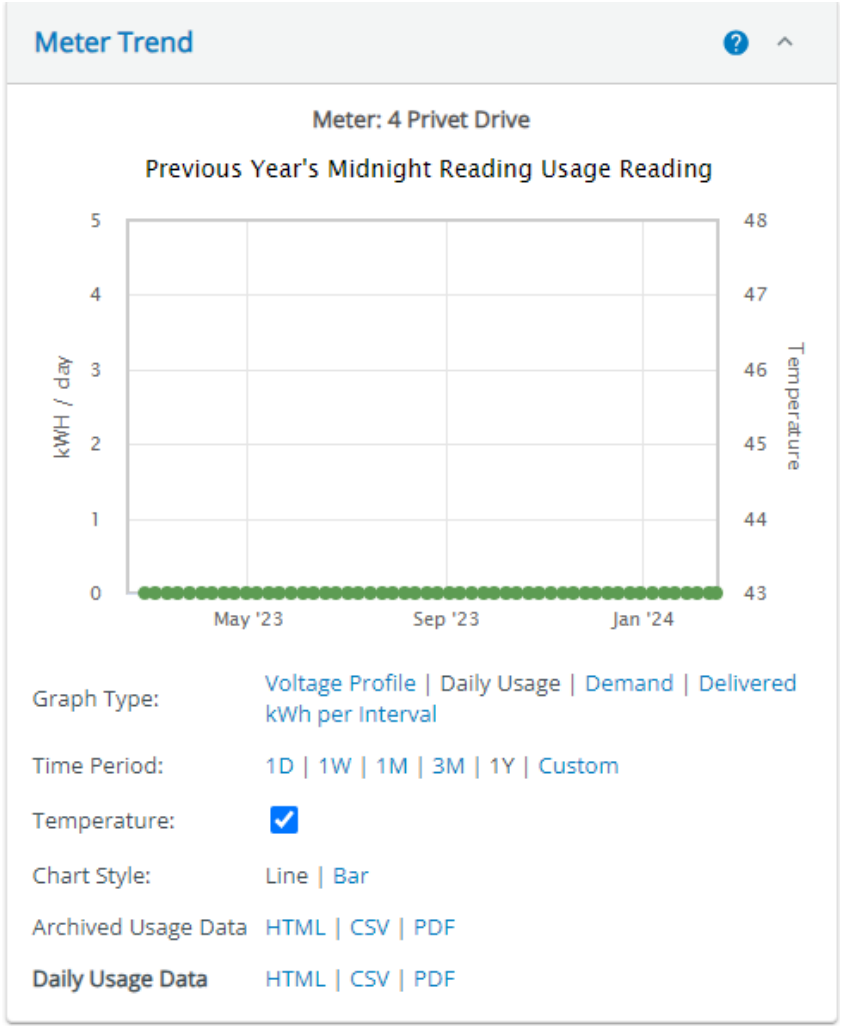


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- Interactive widget that provides a quick and easy way to view usage, demand, voltage, and load profile graphs
  - The list of available graphs is based on the meter type
  - Example: if meter does not support load profile, that option is not available

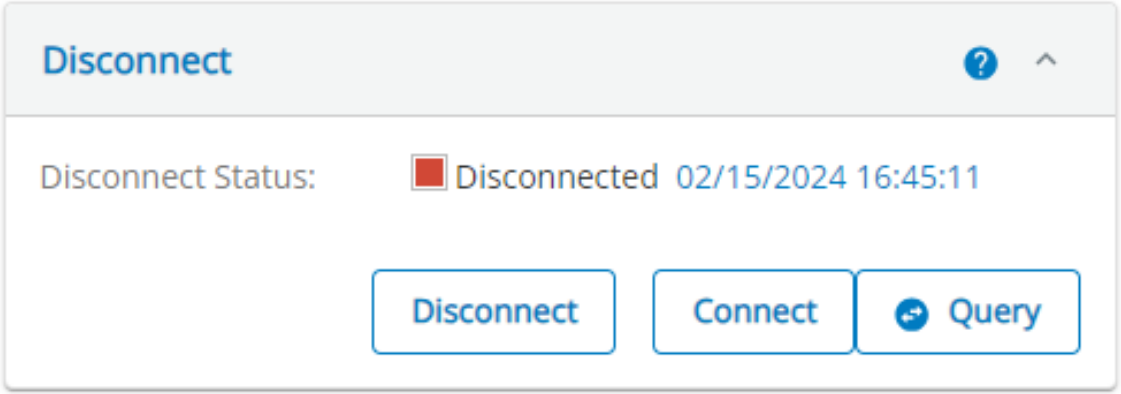


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

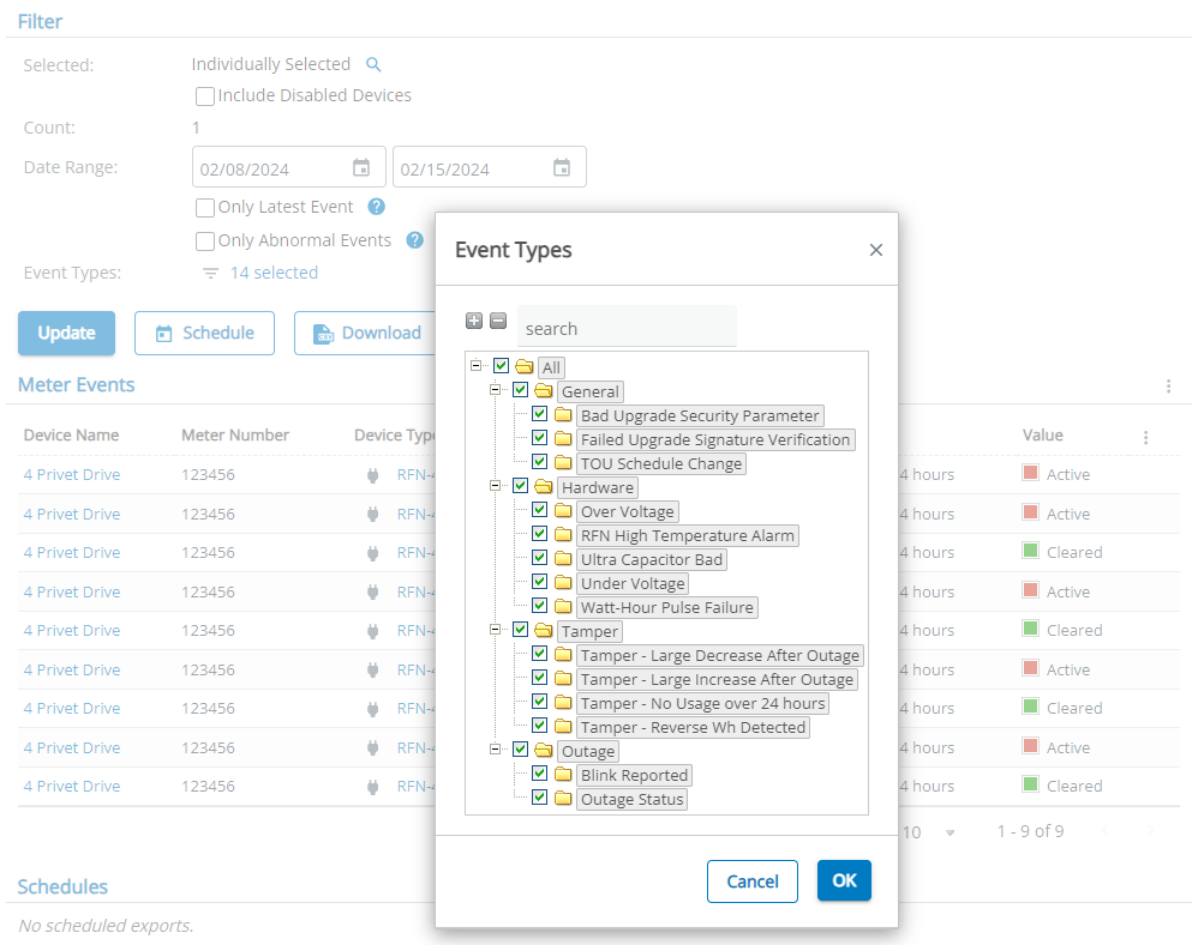
- Displays the current disconnect status of a meter with disconnect capability
  - RFN-420cD, RFN-410fD, RFN-420fD, RFN-420fRD, RFN-520fAXD, and RFN-520fRXD only

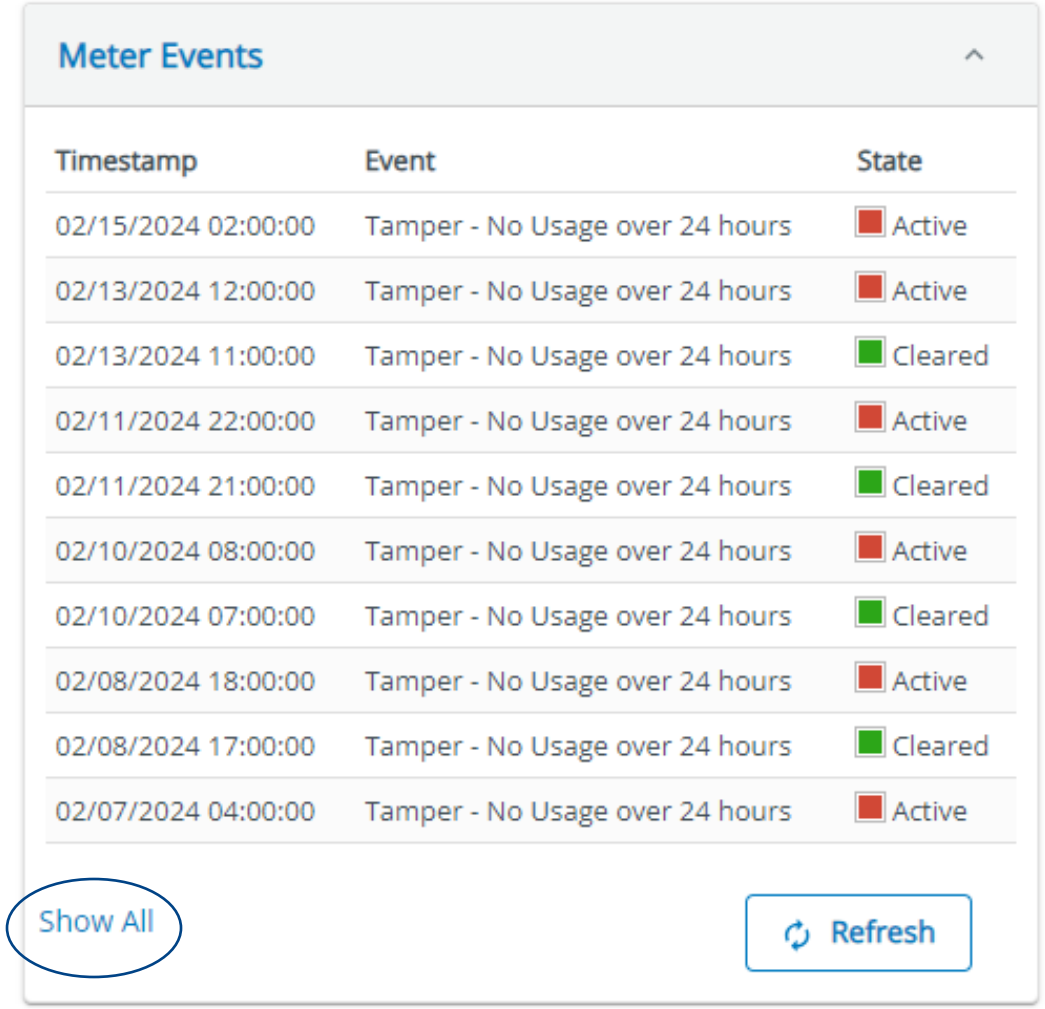


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

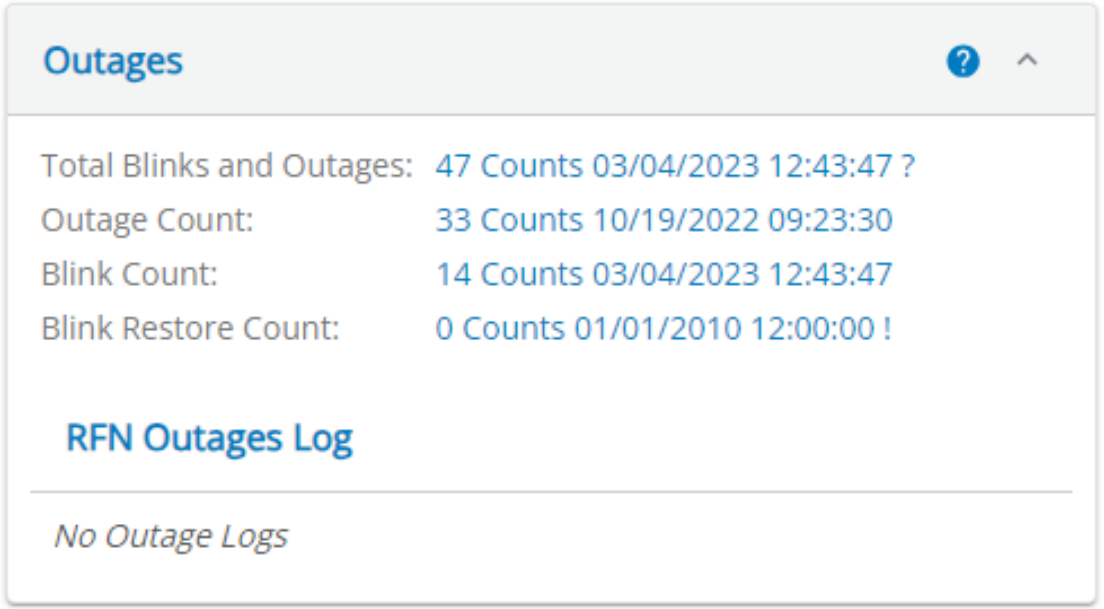


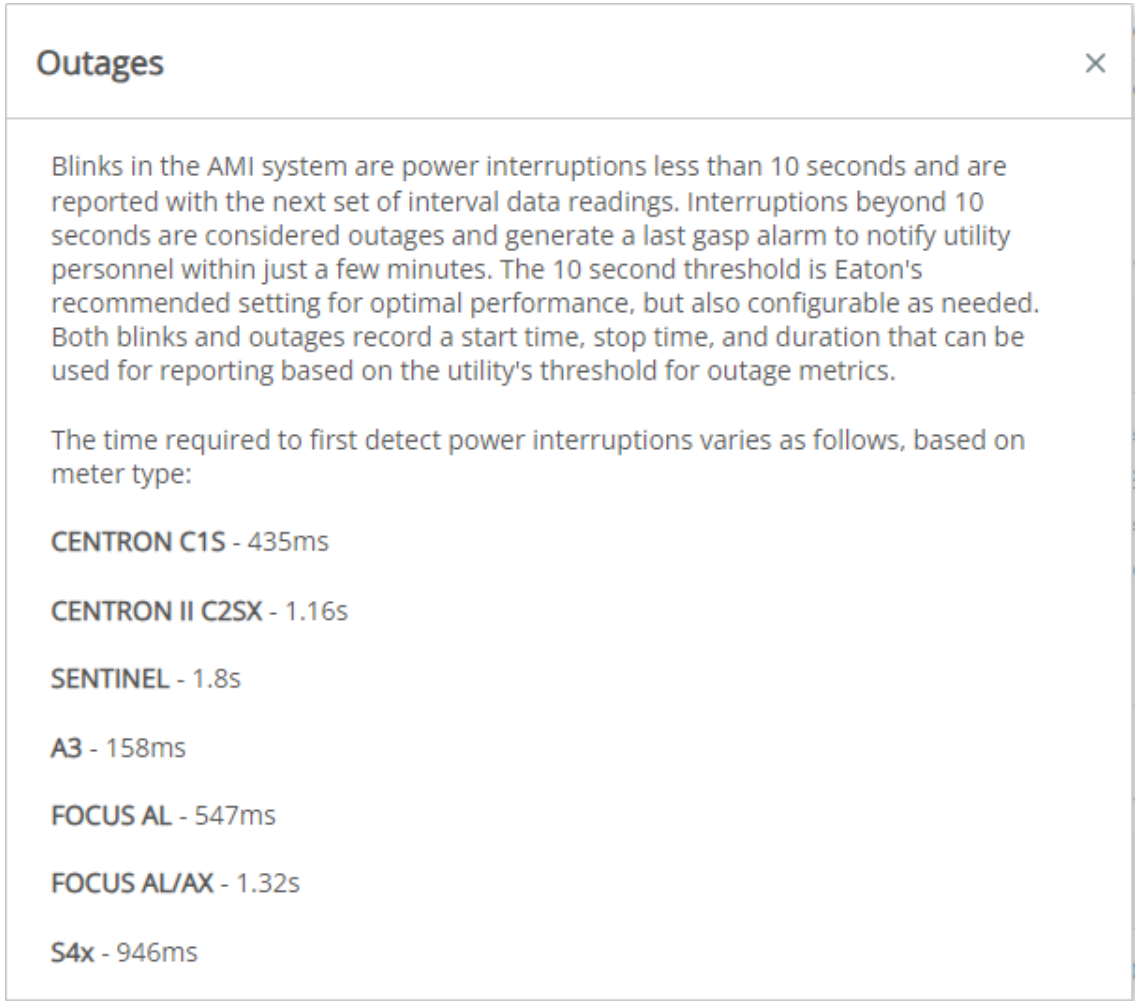


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter



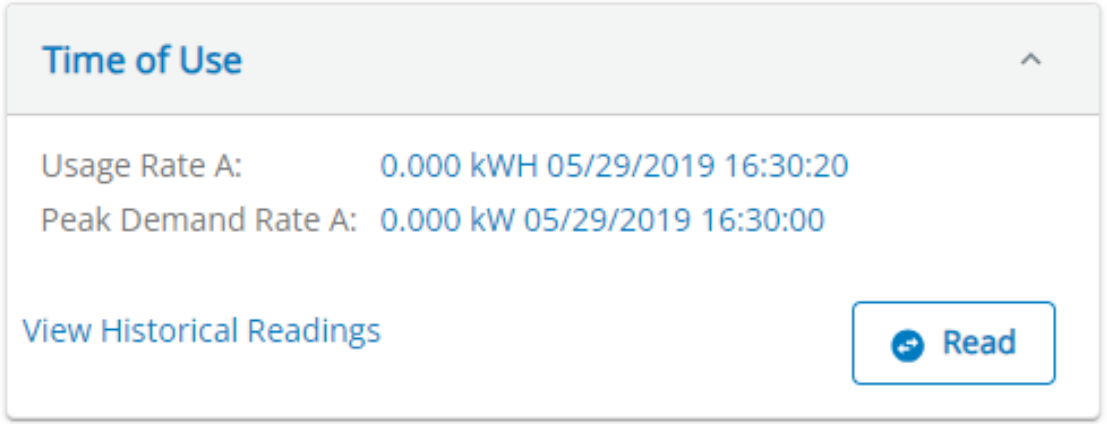


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- Provides a quick view of the usage (kWh) and Peak Demand (kW) readings for Time of Use Rates A
  - Read button provides on-demand, current TOU usage

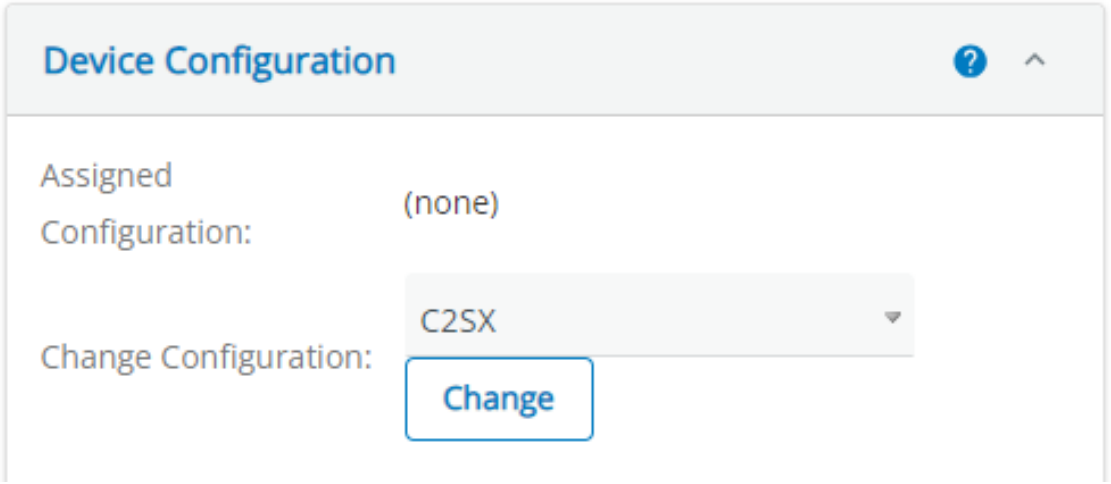


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- To assign or remove an existing device configuration to a meter
  - Device Configuration:

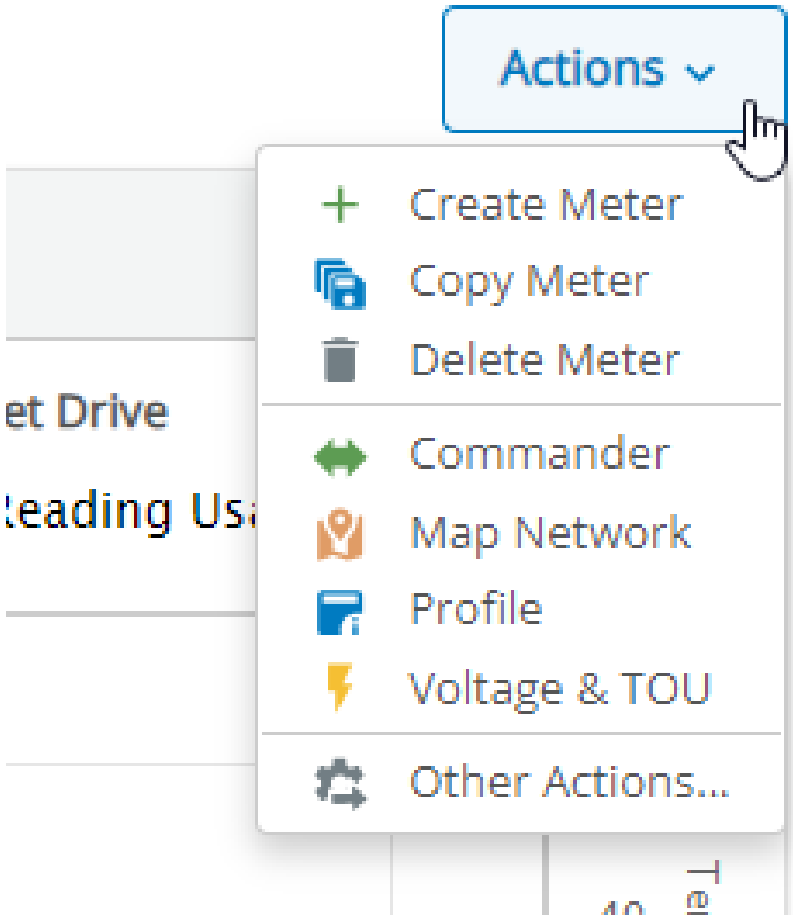


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Electric Meter

- Map Network: maps the device as long as there are coordinates assigned to the device
  - Add/Remove coordinates here
  - 0°N 0°E places device on Null Island



© 2024 Eaton. All rights reserved.

Device Page – Water Nodes

© 2024 Eaton. All rights reserved.

Device Page – Water Node

Home / AMI / Meters / 70427504

☆ 70427504

Actions

Meter Information

Device Name:	70427504
Meter Number:	70427504
Type:	RFW-201
Serial Number:	70427504
Manufacturer:	WTR2
Model:	Encoder-201
Status:	Enabled

Edit

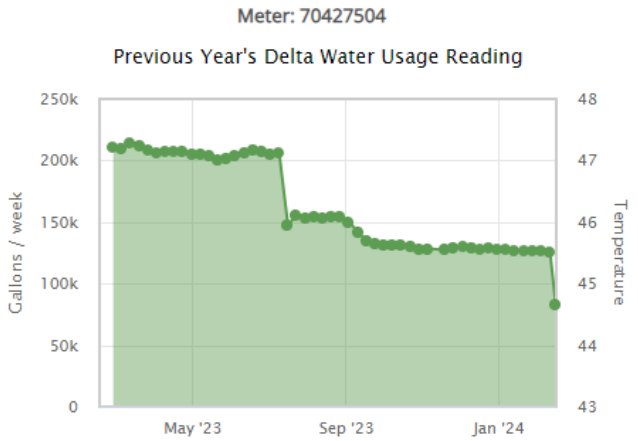
Water Meter Readings

Water Usage Reading:	27,048,293.000 Gallons 02/15/2024 14:00:00
Previous:	27,048,293.000 Gallons 02/15/2024 14:00:00
Total Consumption:	0.000

View All | Quick View

Network Information

Meter Trend



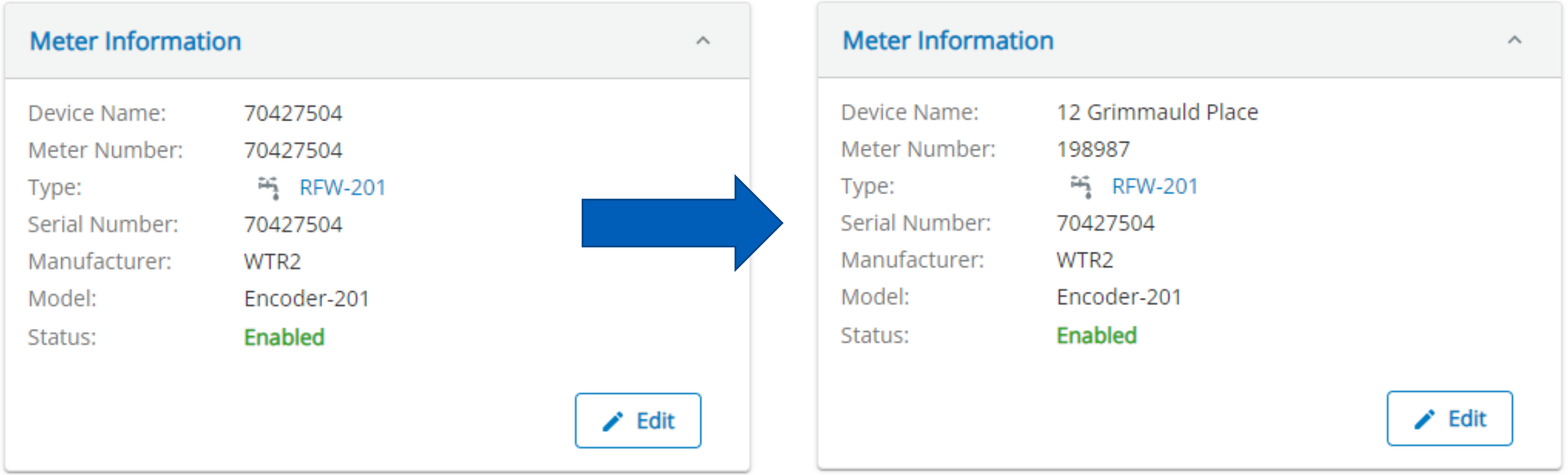
Graph Type:	Water Usage (Delta)
Time Period:	1D | 1W | 1M | 3M | 1Y | Custom
Temperature:	☑
Chart Style:	Line | Bar
Archived Usage Data	HTML | CSV | PDF
Normalized Usage Data:	HTML | CSV | PDF

Meter Events

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

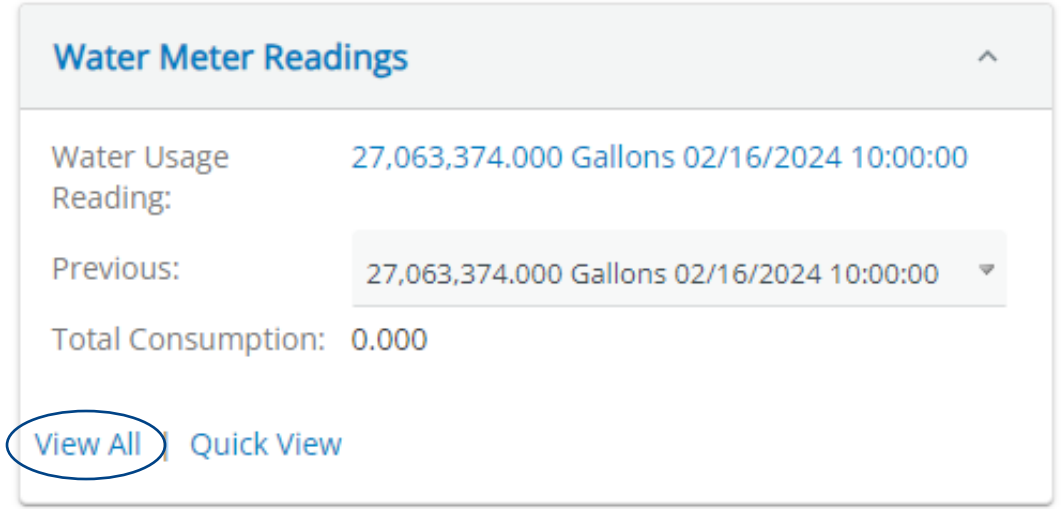


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

- View recent data collected from the water meter
- On-demand read functionality is not available for battery nodes

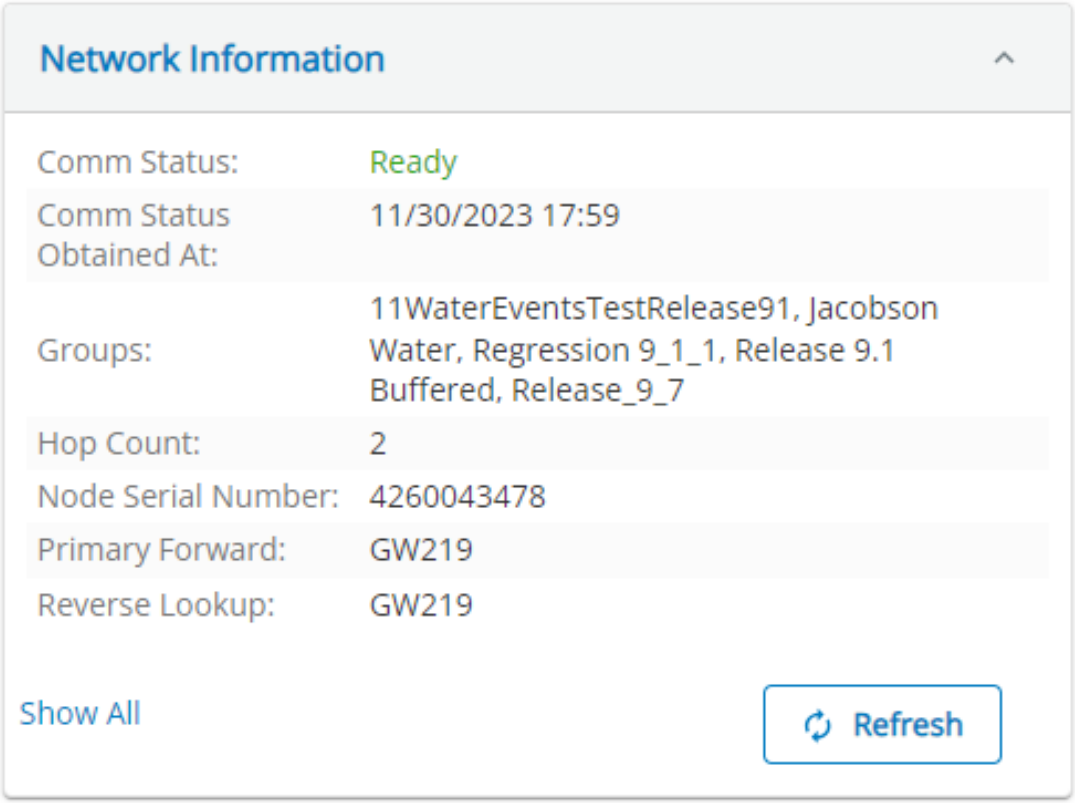


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

- Network Information for a water node
  - Comm Status: Ready, Not Ready, Unknown
  - Hop Count: number of hops away from the gateway

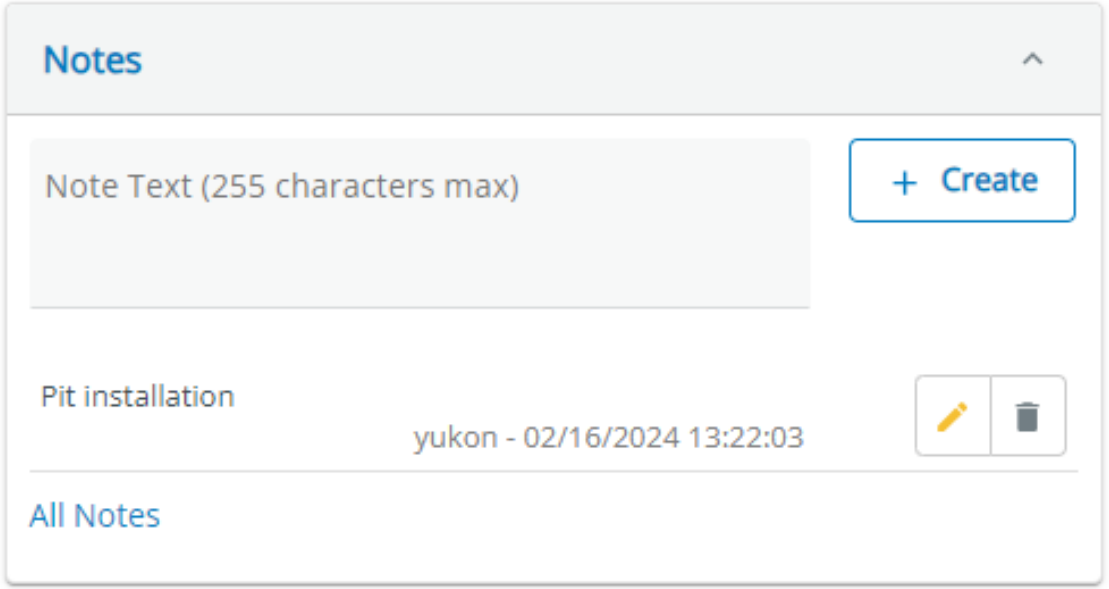


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

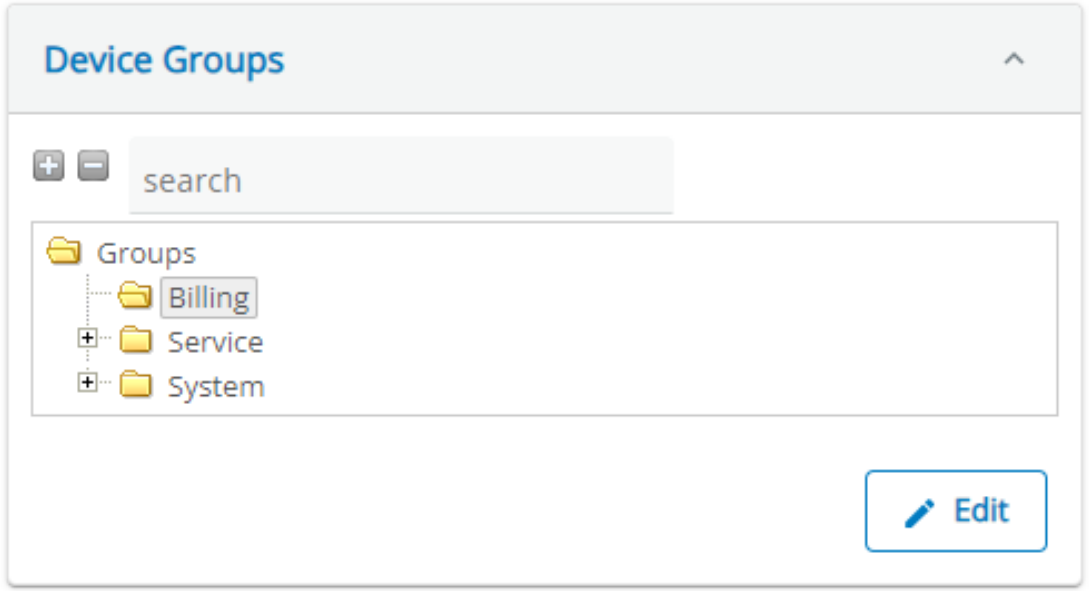
- Create, view, and manage notes attached to the node



Powering Business Worldwide
© 2024 Eaton. All rights reserved.

Device Page – Water Node

- View and modify the groups to which the water meter belongs

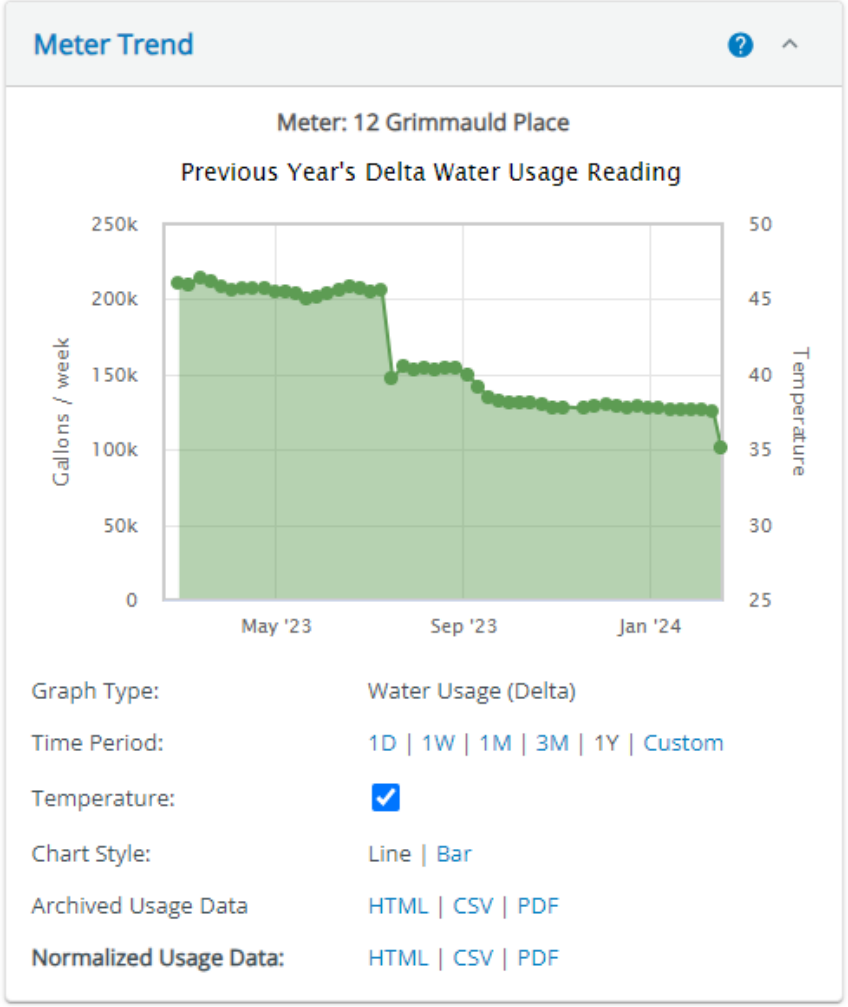


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

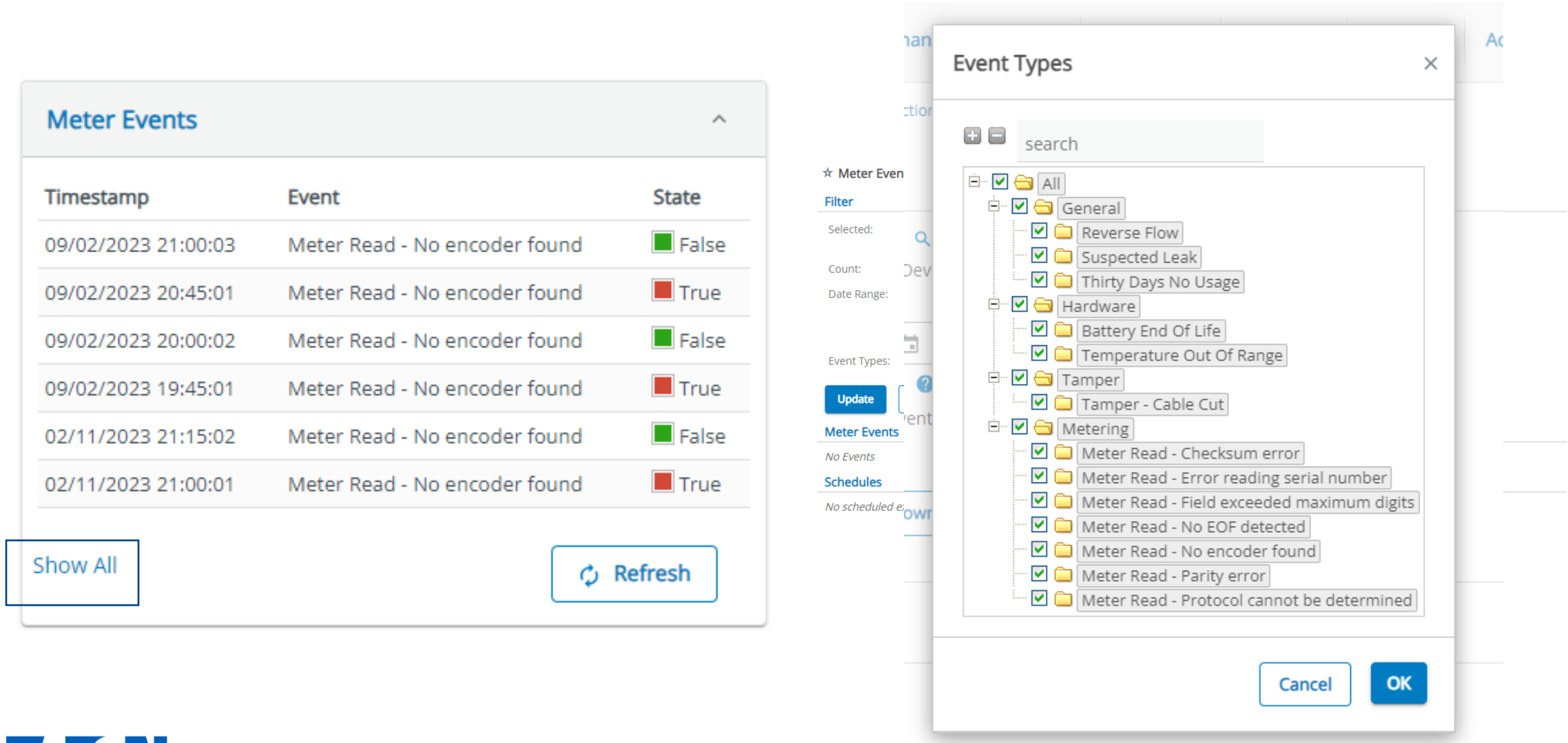
- Snapshot trend of usage data collected from the water meter



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

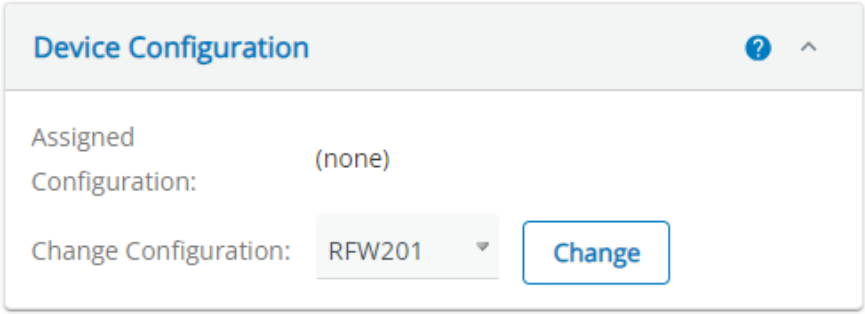


Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Page – Water Node

- Allows changes to Recording and Reporting intervals of water nodes



Powering Business Worldwide

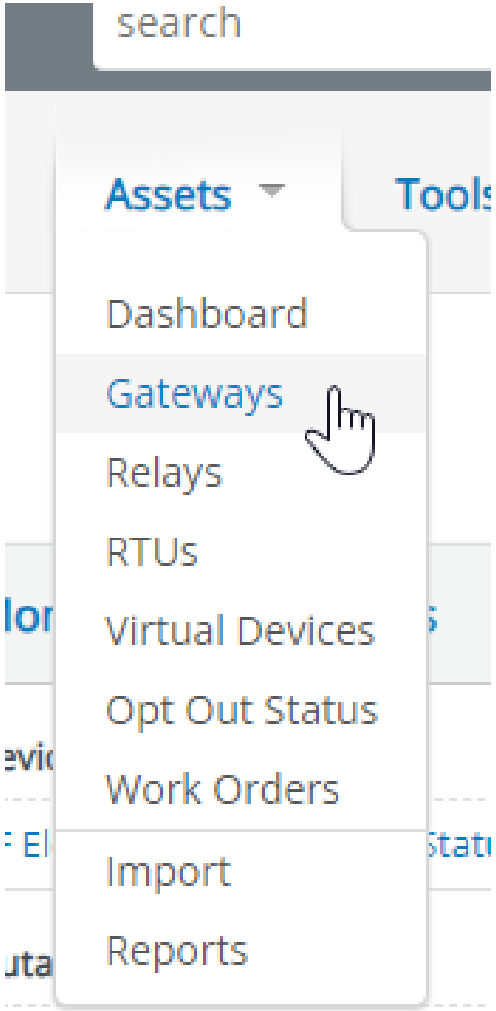
© 2024 Eaton. All rights reserved.

Assets – Gateways & Relays

© 2024 Eaton. All rights reserved.

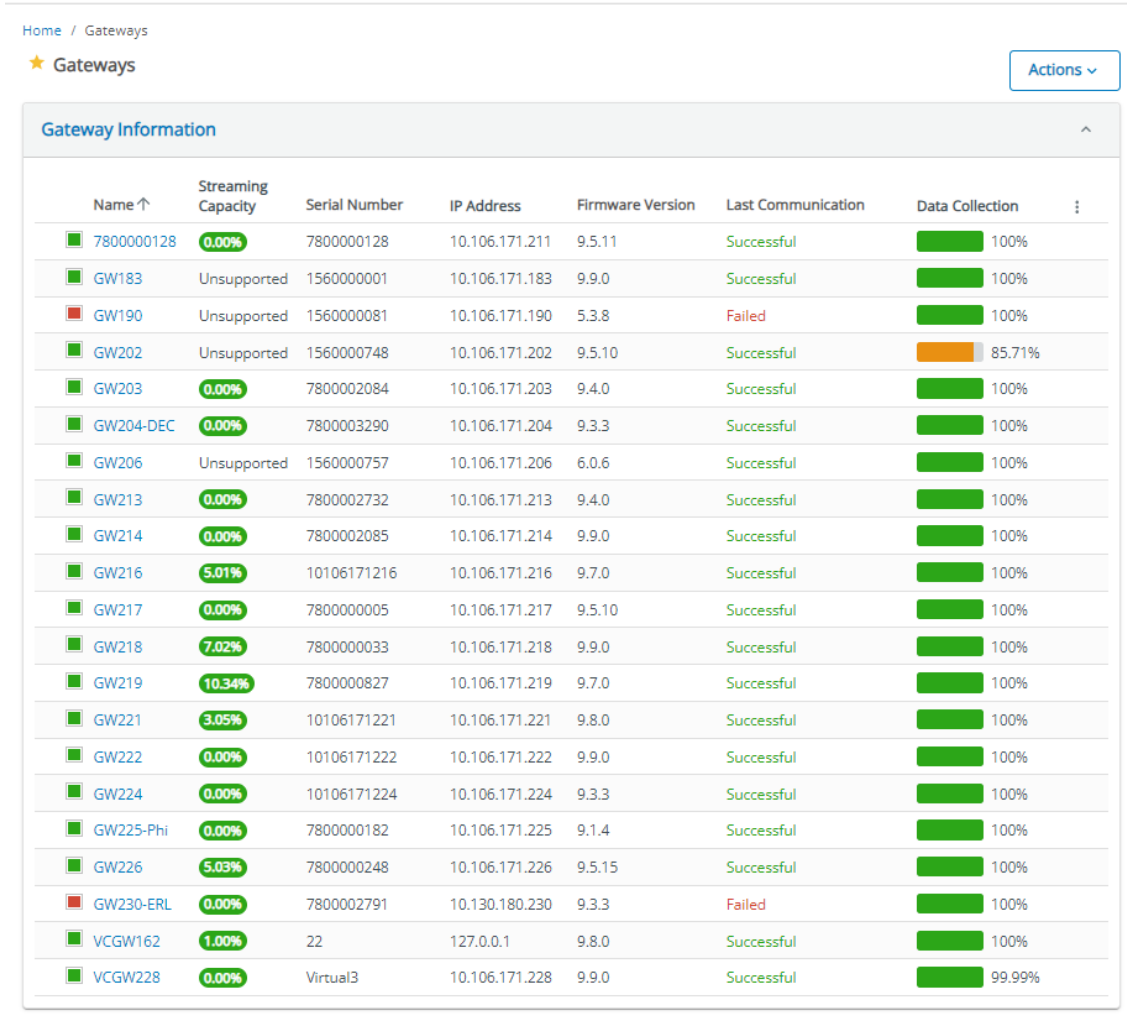
Assets - Gateways

- To see a list of Gateways in Yukon, navigate to Assets - Gateways



© 2024 Eaton. All rights reserved.

Assets – Gateways – List of Gateways



Name	Streaming Capacity	Serial Number	IP Address	Firmware Version	Last Communication	Data Collection
7800000128	0.00%	7800000128	10.106.171.211	9.5.11	Successful	100%
GW183	Unsupported	1560000001	10.106.171.183	9.9.0	Successful	100%
GW190	Unsupported	1560000081	10.106.171.190	5.3.8	Failed	100%
GW202	Unsupported	1560000748	10.106.171.202	9.5.10	Successful	85.71%
GW203	0.00%	7800002084	10.106.171.203	9.4.0	Successful	100%
GW204-DEC	0.00%	7800003290	10.106.171.204	9.3.3	Successful	100%
GW206	Unsupported	1560000757	10.106.171.206	6.0.6	Successful	100%
GW213	0.00%	7800002732	10.106.171.213	9.4.0	Successful	100%
GW214	0.00%	7800002085	10.106.171.214	9.9.0	Successful	100%
GW216	5.01%	10106171216	10.106.171.216	9.7.0	Successful	100%
GW217	0.00%	7800000005	10.106.171.217	9.5.10	Successful	100%
GW218	7.02%	7800000033	10.106.171.218	9.9.0	Successful	100%
GW219	10.34%	7800000827	10.106.171.219	9.7.0	Successful	100%
GW221	3.05%	10106171221	10.106.171.221	9.8.0	Successful	100%
GW222	0.00%	10106171222	10.106.171.222	9.9.0	Successful	100%
GW224	0.00%	10106171224	10.106.171.224	9.3.3	Successful	100%
GW225-Phi	0.00%	7800000182	10.106.171.225	9.1.4	Successful	100%
GW226	5.03%	7800000248	10.106.171.226	9.5.15	Successful	100%
GW230-ERL	0.00%	7800002791	10.130.180.230	9.3.3	Failed	100%
VCGW162	1.00%	22	127.0.0.1	9.8.0	Successful	100%
VCGW228	0.00%	Virtual3	10.106.171.228	9.9.0	Successful	99.99%

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Assets – Gateways – Adding a Gateway

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Gateway Page

Gateway Information

Name:	GW216
Type:	GWY-800
Serial Number:	10106171216
Hardware Version:	GW2.0
Software Version:	D_9_7_0
Upper Stack Version:	Q_9_8_0_1_taylorb_testing
Radio Version:	Q5.7.0.5qp
Release Version:	9.7.0
Version Conflicts:	Upper Stack, Application,
Application Mode:	Normal
Streaming Capacity:	5.01% View History

Edit

Notes

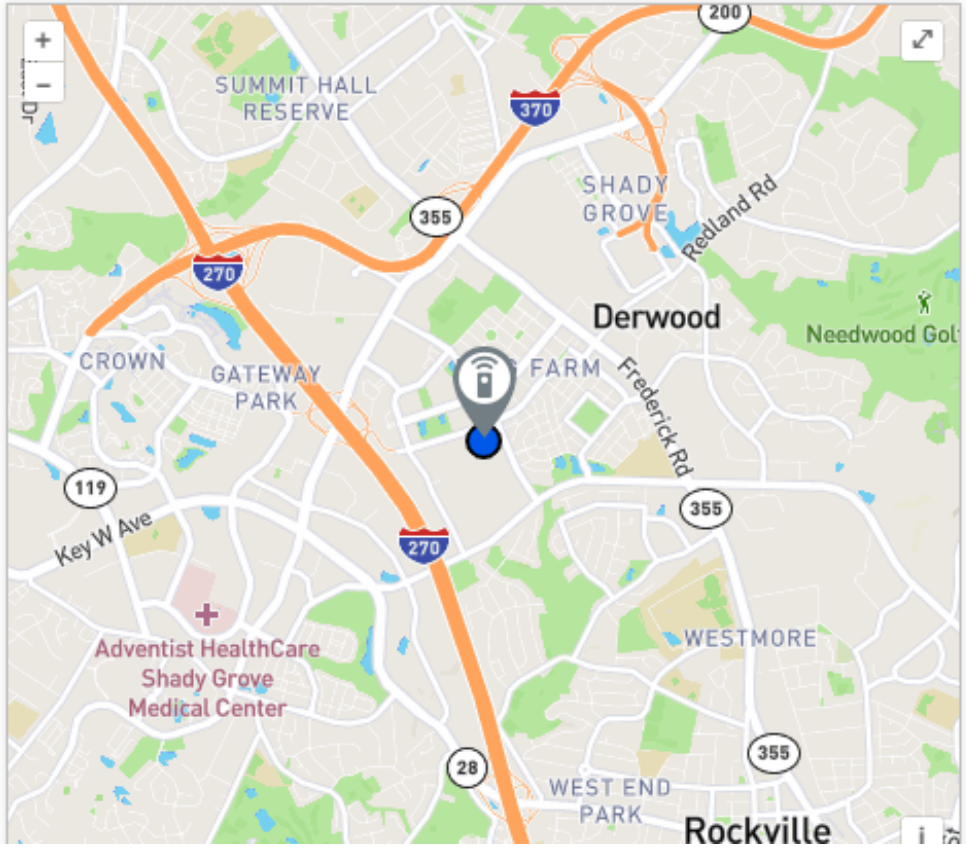
Note Text (255 characters max)

+ Create

Location

Latitude: 39.109311 Longitude: -77.175481

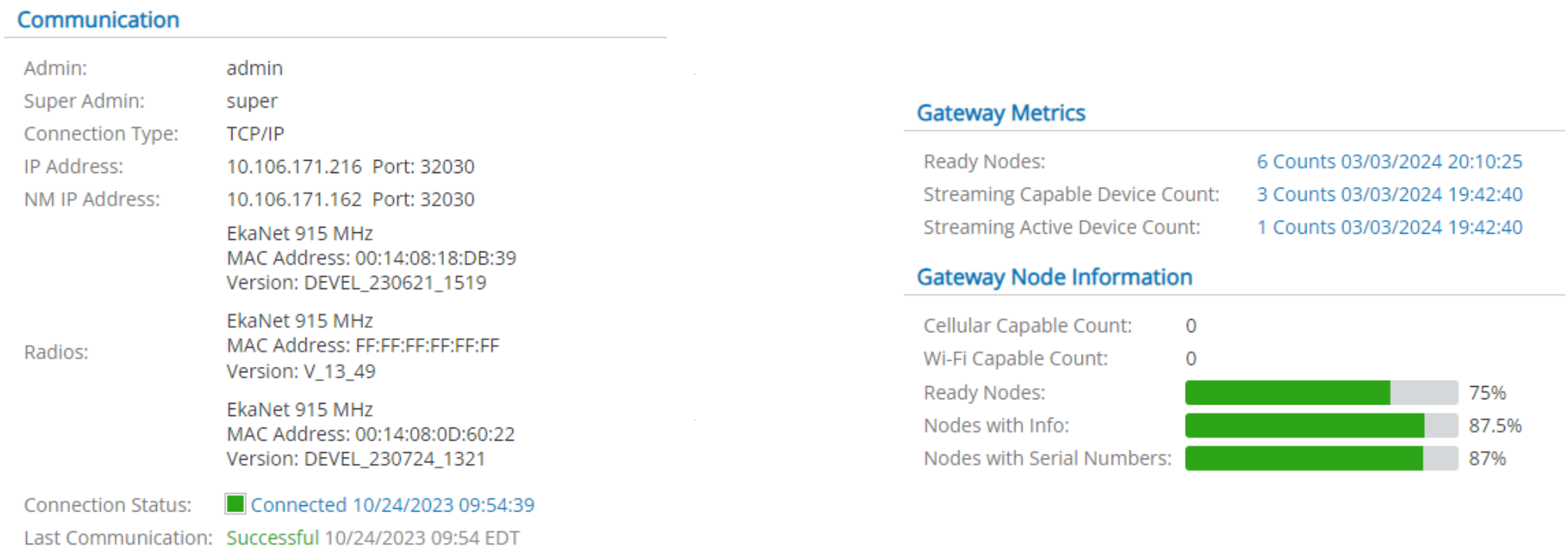
Infrastructu...



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Gateway Page



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Gateway Page

Infrastructure Warnings

10:02 PM 03/02/2024	Gateway detecting AC power failure.
10:58 AM 07/05/2022	Duplicate color 3 configured into gateway.
06:13 AM 07/06/2022	Gateway's total ready node count (6) is lower than the warning threshold (25).
02:40 PM 04/19/2022	Gateway security alarm, SSH service enabled.
04:39 PM 01/25/2021	Gateway detecting low voltage on UPS battery.

Gateway Events

Timestamp	Event	State
05/04/2023 12:38:16	Radio Failure	Cleared
05/04/2023 12:35:07	Radio Failure	Active
05/04/2023 12:16:56	Radio Failure	Cleared
05/04/2023 12:13:38	Radio Failure	Active
03/04/2023 12:43:43	Power Failure	Cleared
03/04/2023 12:43:42	Power Failure	Active
02/28/2023 14:32:45	AC Power Failure	Cleared
02/28/2023 14:32:45	AC Power Failure	Active
02/28/2023 14:32:44	AC Power Failure	Cleared
02/28/2023 14:32:44	AC Power Failure	Active

Show All

Refresh

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Assets – Relays – List of Relays

Filtered Results: 86

Name ↑	Serial Number	Type
123456789	123456789	CRLY-856
4110015041	4110015041	RFN Relay
4110061115	4110061115	RFN Relay
4110066771	4110066771	RFN Relay
4110173772	4110173772	RFN Relay
4110175262	4110175262	RFN Relay
4190000104	4190000104	RFN Relay
4200042167	4200042167	RFN Relay
4200042187	4200042187	RFN Relay
4200042199	4200042199	RFN Relay
4200042209	4200042209	RFN Relay
4210000007	4210000007	CRLY-856
4210000055	4210000055	RFN Relay
4210005283	4210005283	RFN Relay

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Relay Page

Relay Information

Device Name:	4110015041
Type:	RFN Relay
Serial Number:	4110015041
Manufacturer:	EATON
Model:	RFRelay

Edit

Network Information

Comm Status:	Ready
Comm Status Obtained At:	03/03/2024 20:03
Hop Count:	1
Neighbor Count:	6
Node Serial Number:	4110015041
Primary Forward:	GW216
Reverse Lookup:	GW216

Infrastructure Warnings

No recent warnings found.

Relay Events

Timestamp	Event	State
05/01/2023 09:55:07	Ultra Capacitor Bad	Active

Show All

Refresh

Outages

Outage Count:	0 Counts 01/01/2010 12:00:00 !
Blink Count:	0 Counts 01/01/2010 12:00:00 !
Blink Restore Count:	0 Counts 01/01/2010 12:00:00 !

RFN Outages Log

Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Groups

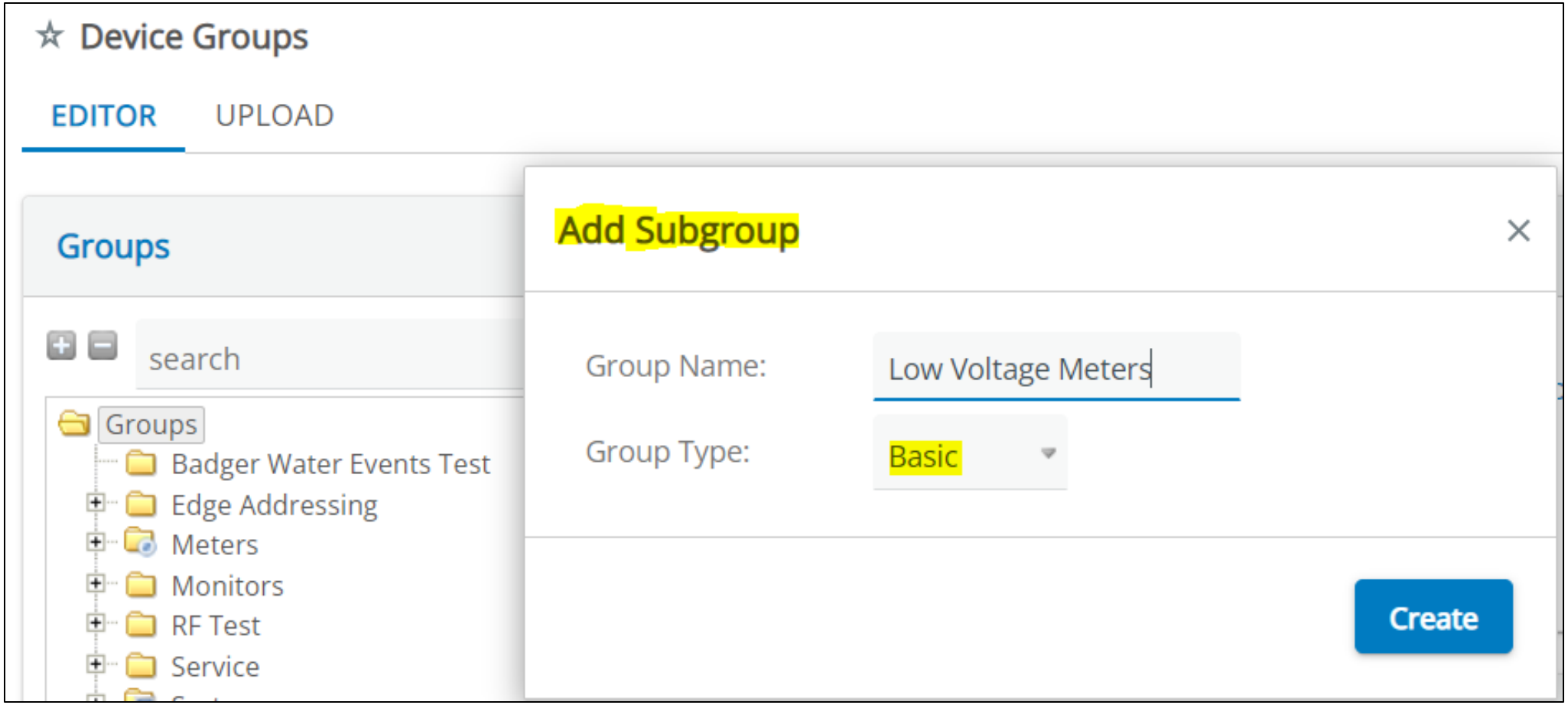
© 2024 Eaton. All rights reserved.

Device Groups – Use Case

- Create group(s) capturing meters for follow up
  - Identify subset of devices warranting review
  - Copy meter numbers into Notepad
  - Save file as a CSV
  - Import into Device Groups!
- Why use?
  - **Preserve** the subset of interesting devices for future review
  - **Group manipulation** on subset including map view, attribute reads, additional data exports

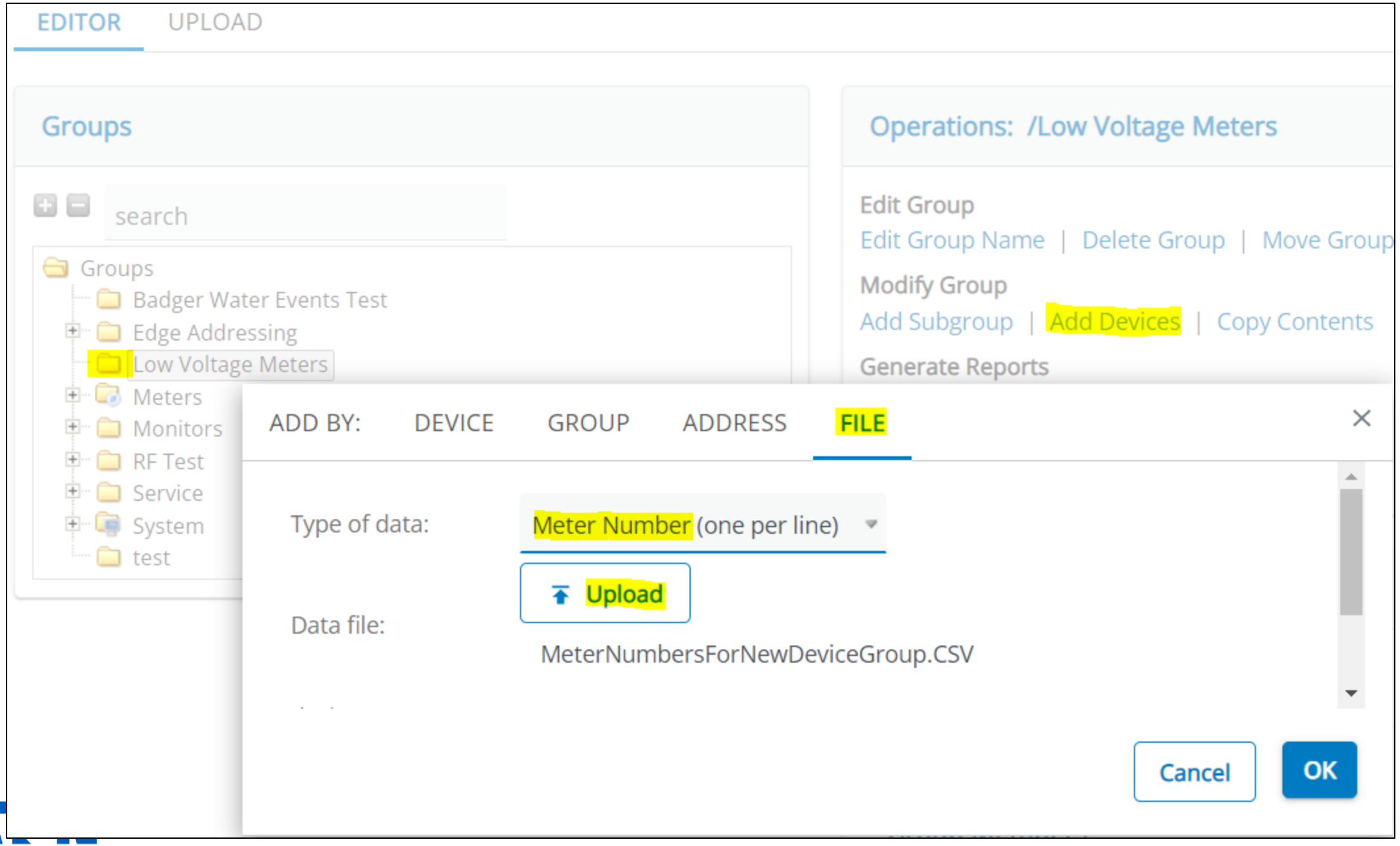
Powering Business Worldwide

© 2024 Eaton. All rights reserved.



Powering Business Worldwide

© 2024 Eaton. All rights reserved.



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Groups

search

- Groups
  - Badger Water Events Test
  - Edge Addressing
  - Low Voltage Meters
  - Meters
  - Monitors
  - RF Test
  - Service
  - System
  - test

Operations: /Low Voltage Meters

Edit Group

Edit Group Name | Delete Group | Move Group

Modify Group

Add Subgroup | Add Devices | Copy Contents

Generate Reports

HTML | CSV | PDF

Collection Actions

Send Command | Mass Change | Other Actions...

Members: /Low Voltage Meters

6 devices

Subgroups

Powering Business Worldwide

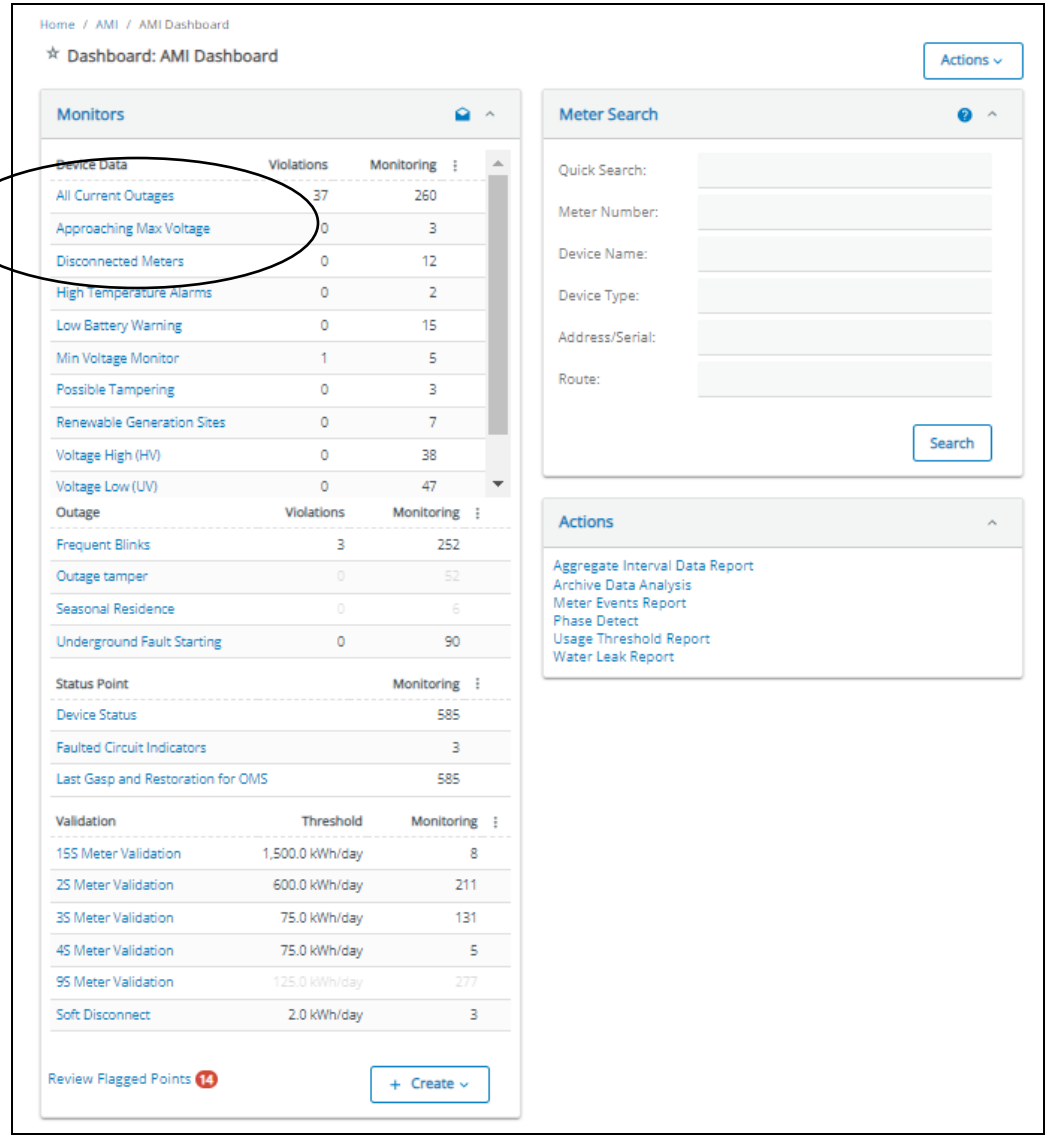
© 2024 Eaton. All rights reserved.

Device Data Monitor

© 2024 Eaton. All rights reserved.

Device Data Monitor

- Device Data Monitors allow you to set threshold and state rules to evaluate incoming data for possible field issues
- Common status monitors are evaluating outage and disconnect status
- Common value monitors are evaluating minimum or maximum voltage for high and low values



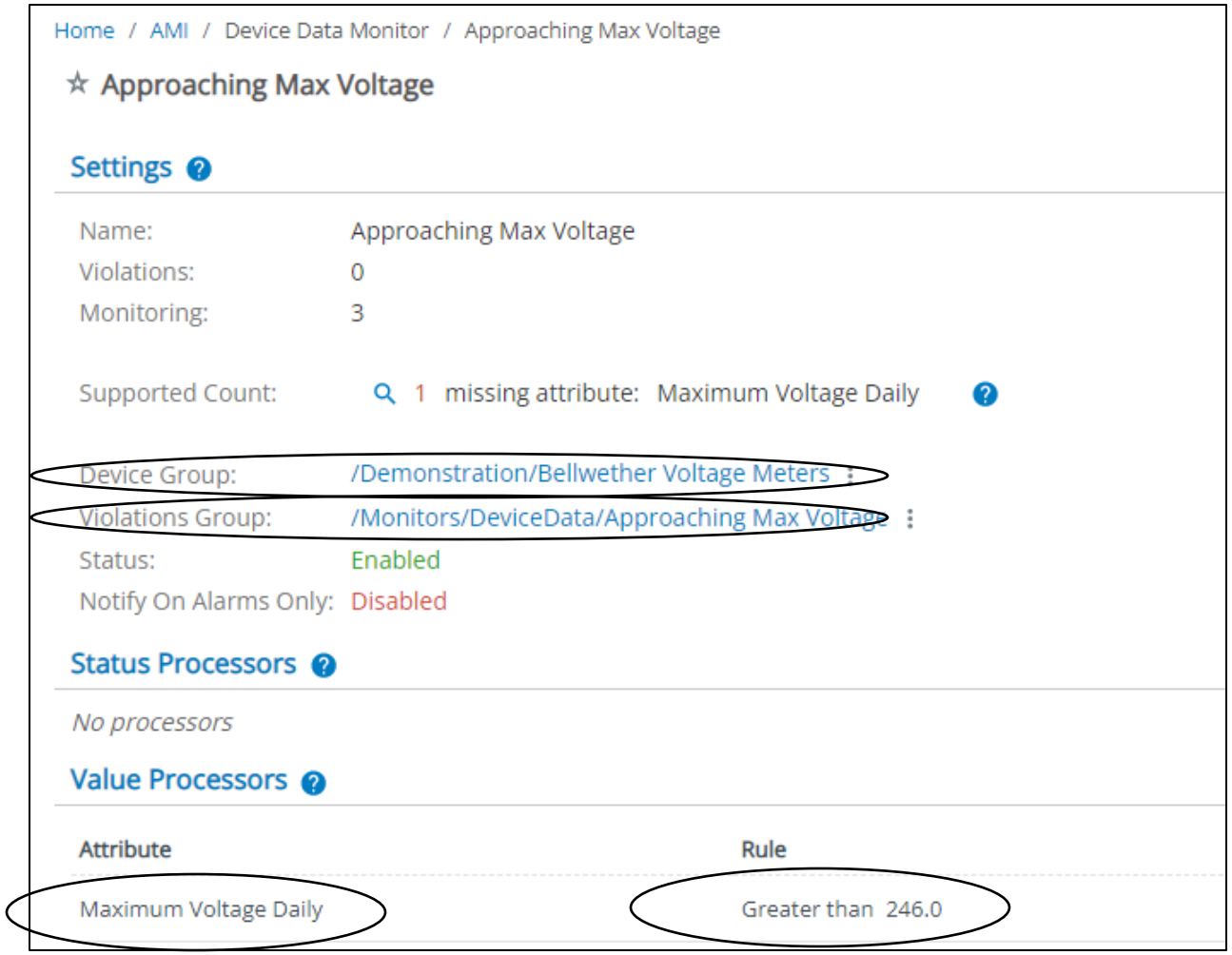
Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Data Monitor

Evaluating the Maximum Voltage Daily attribute

- Select the meters to evaluate, the attribute and the warning threshold
- In this case, Yukon will evaluate Maximum Voltage Daily from this set of meters each time data is reported
- The meter will be added and removed from the violations group based on whether the attribute value is greater than 246 volts



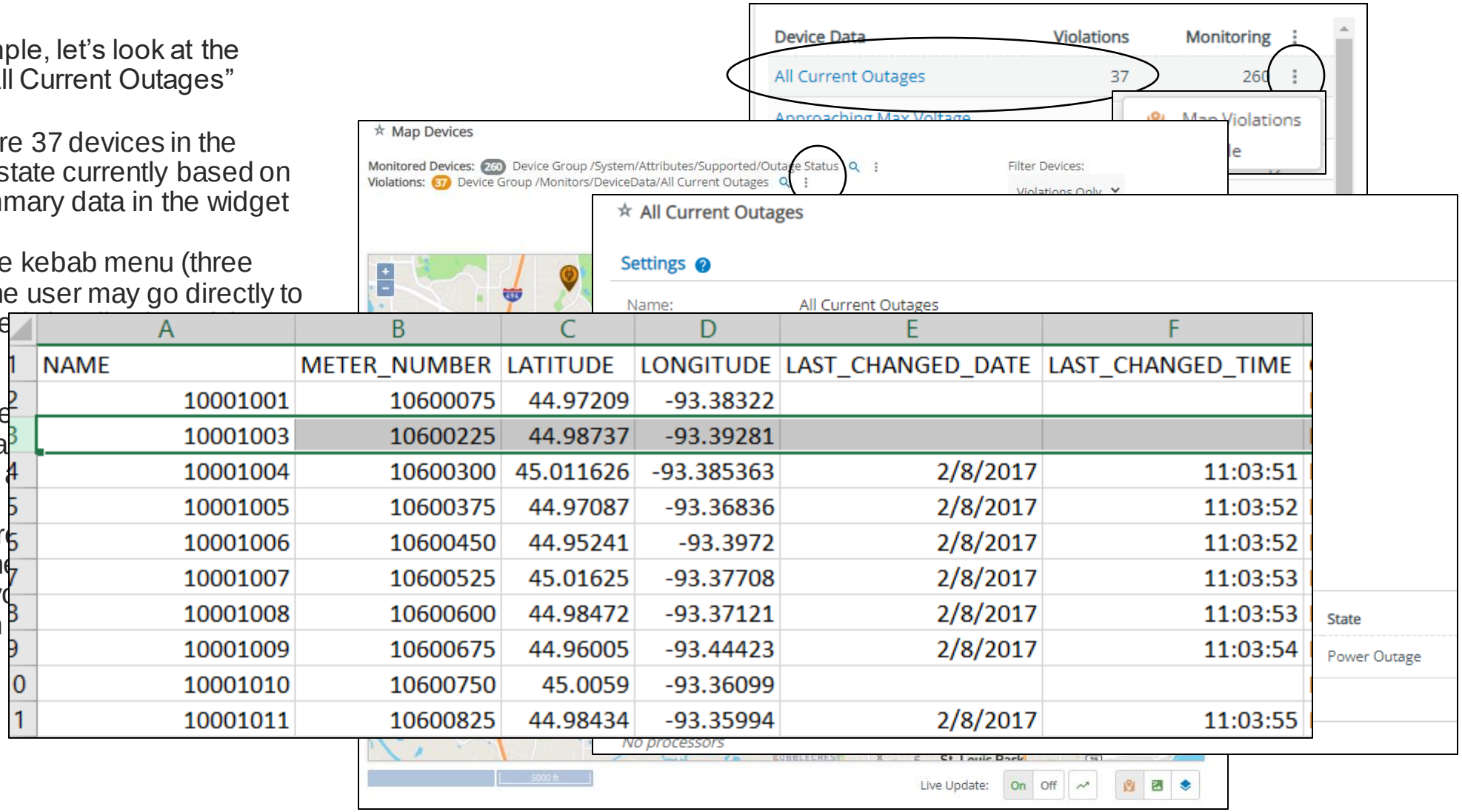
Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Device Data Monitor

Another example, let's look at the monitor for "All Current Outages"

- There are 37 devices in the outage state currently based on the summary data in the widget
- From the kebab menu (three dots), the user may go directly to a mappe outage
- From the downloa another
- Note: Fr page, the allows yo perform results



	A	B	C	D	E	F
1	NAME	METER_NUMBER	LATITUDE	LONGITUDE	LAST_CHANGED_DATE	LAST_CHANGED_TIME
2	10001001	10600075	44.97209	-93.38322		
3	10001003	10600225	44.98737	-93.39281		
4	10001004	10600300	45.011626	-93.385363	2/8/2017	11:03:51
5	10001005	10600375	44.97087	-93.36836	2/8/2017	11:03:52
6	10001006	10600450	44.95241	-93.3972	2/8/2017	11:03:52
7	10001007	10600525	45.01625	-93.37708	2/8/2017	11:03:53
8	10001008	10600600	44.98472	-93.37121	2/8/2017	11:03:53
9	10001009	10600675	44.96005	-93.44423	2/8/2017	11:03:54
10	10001010	10600750	45.0059	-93.36099		
11	10001011	10600825	44.98434	-93.35994	2/8/2017	11:03:55

Powering Business Worldwide

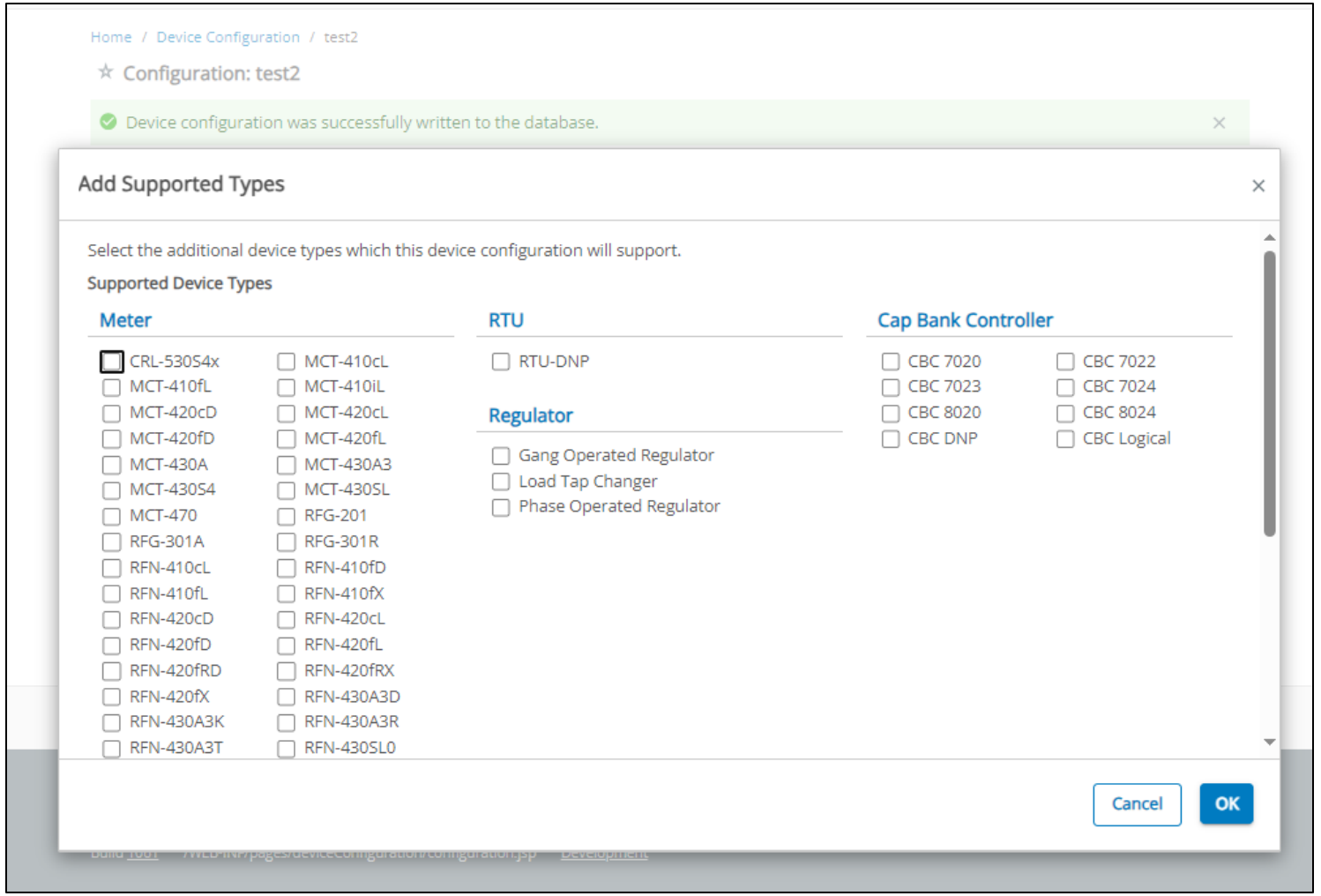
© 2024 Eaton. All rights reserved.

Device Configurations

© 2024 Eaton. All rights reserved.

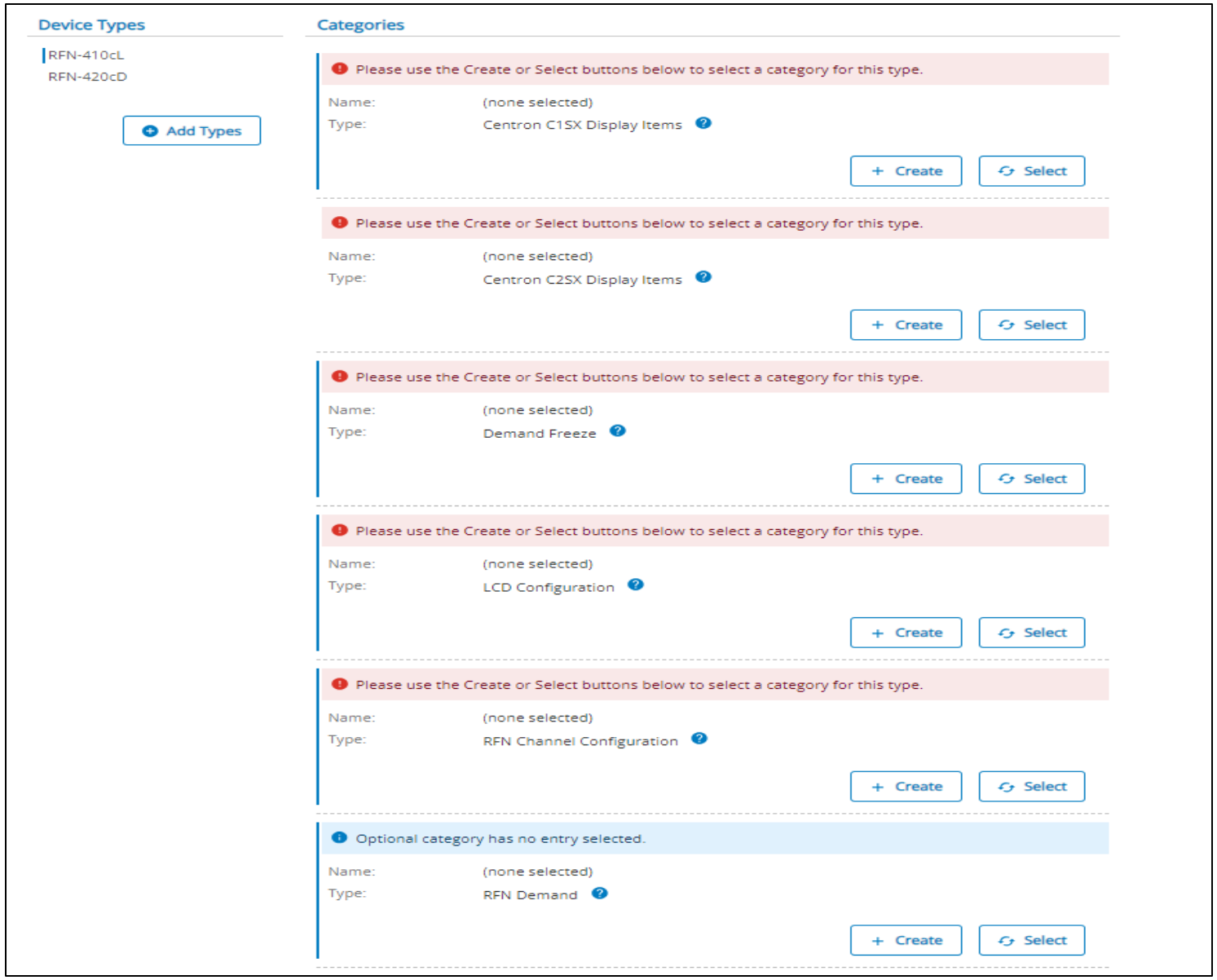
Powering Business Worldwide

© 2024 Eaton. All rights reserved.



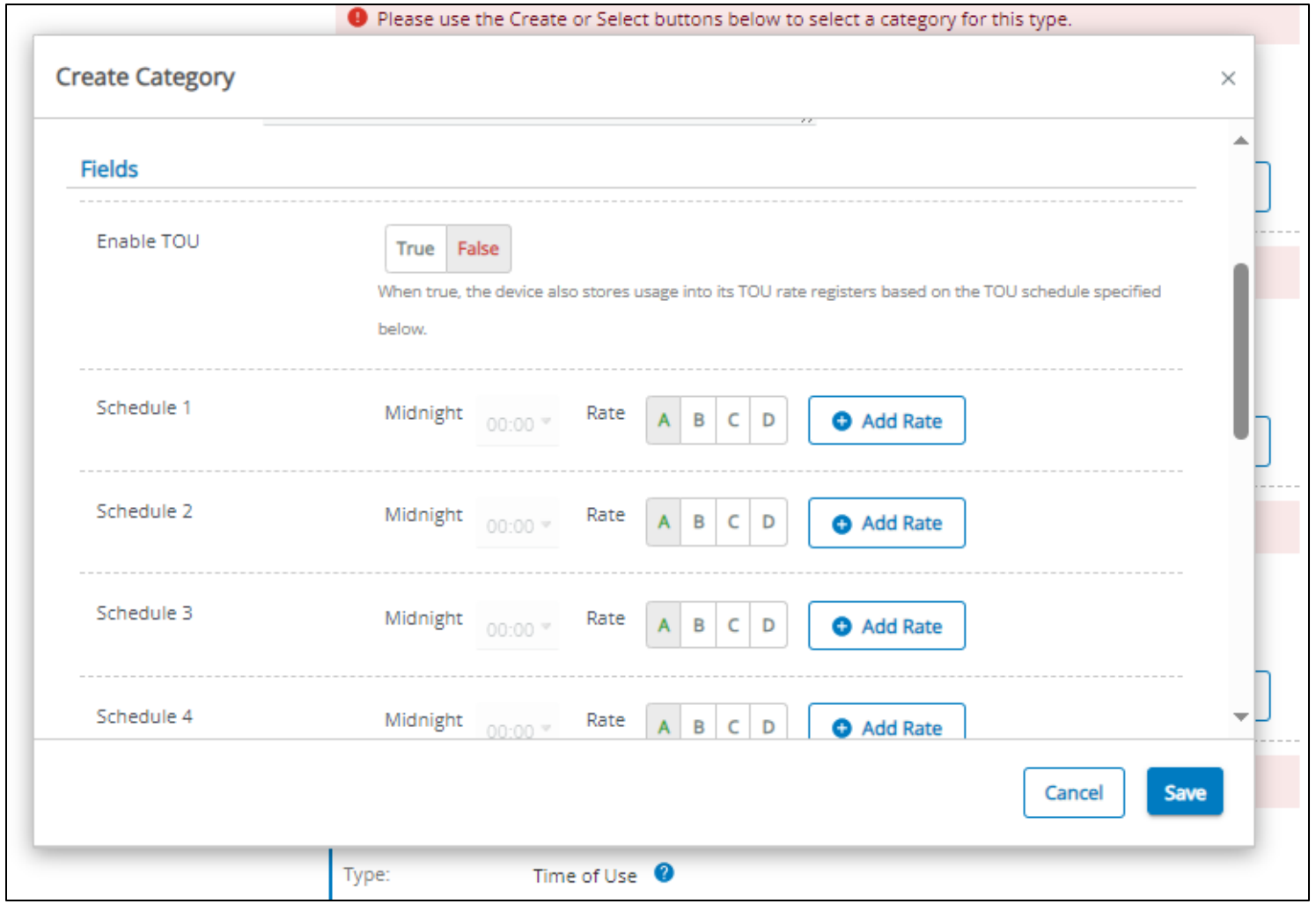
Powering Business Worldwide

© 2024 Eaton. All rights reserved.



Powering Business Worldwide

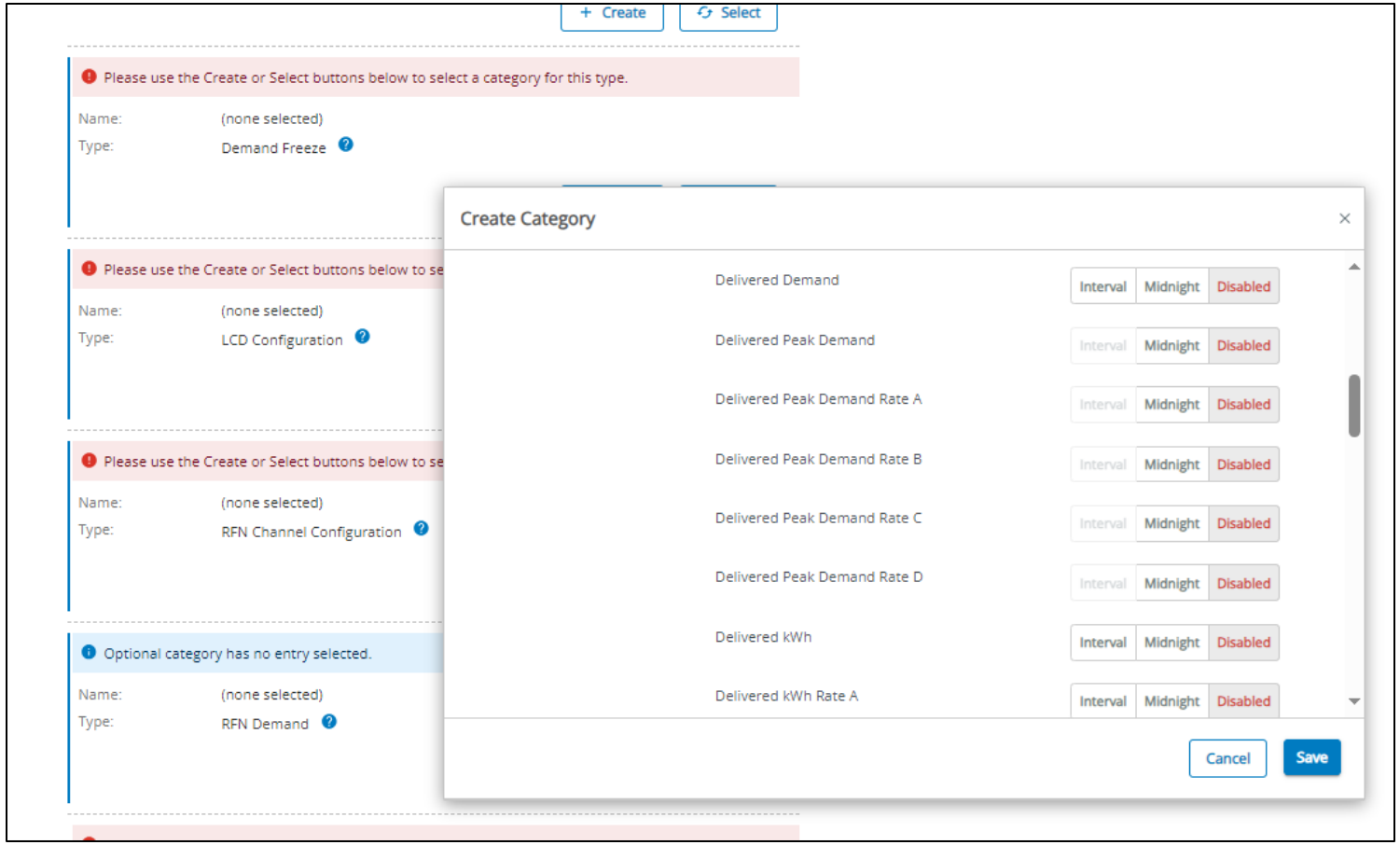
© 2024 Eaton. All rights reserved.



Powering Business Worldwide

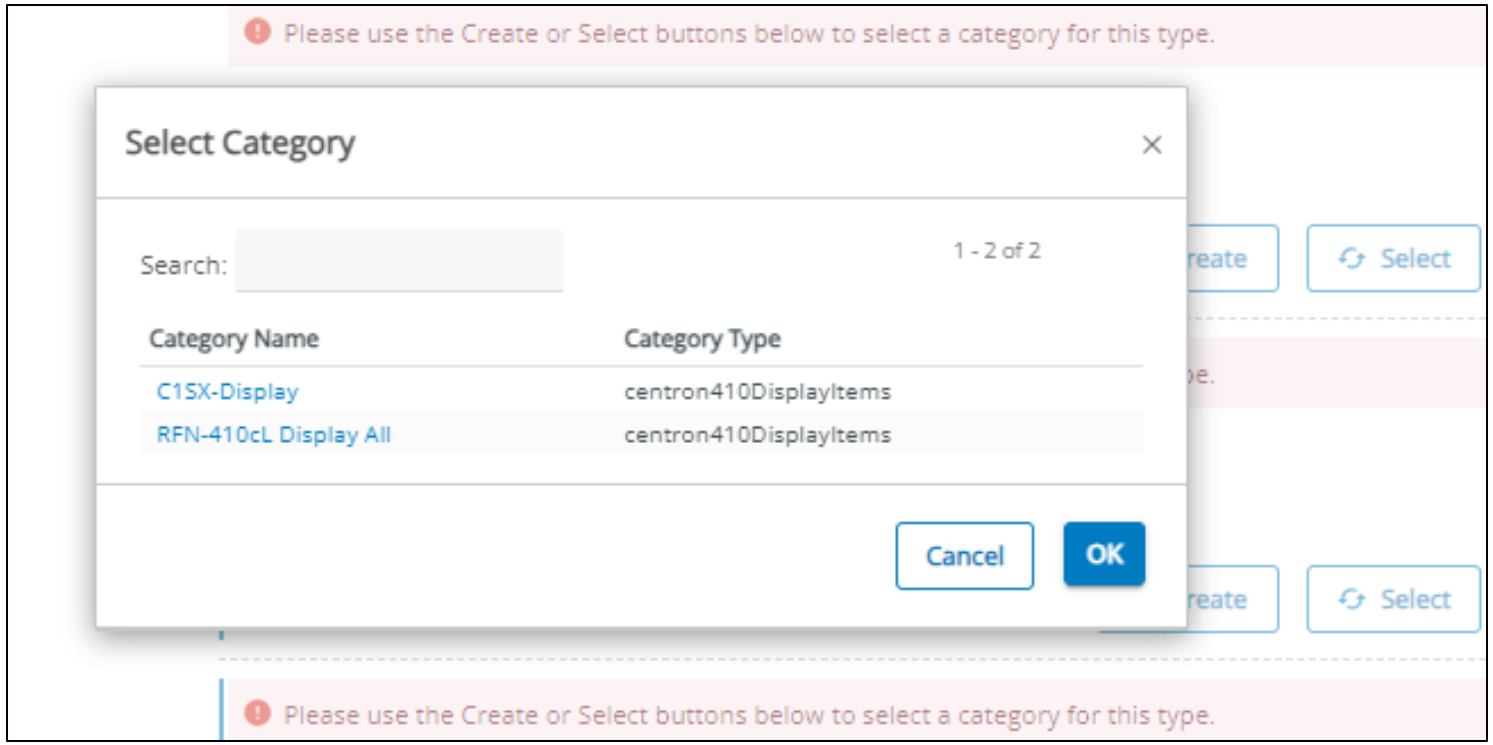
© 2024 Eaton. All rights reserved.

- 15 – “intervals” can be used per channel configuration
- 80 – “midnight” readings can be used per channel configuration



Powering Business Worldwide

© 2024 Eaton. All rights reserved.



Powering Business Worldwide

© 2024 Eaton. All rights reserved.

Billing

© 2024 Eaton. All rights reserved.