AMI Overview

Advanced Metering Infrastructure (AMI)



RF Network Overview



Eaton RF Mesh Overview



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



Introduction to Wireless Communications



Network Types







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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



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.



Communications Range

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



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









Communications Range - Power

- Total Network Communications Range or Distance = *Node to Node Distance × 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)



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



Eaton RF Mesh Network Fundamentals



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



RF Mesh Network Components





RFN Hardware



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



Powered Nodes - Support twoway 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



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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





Deployment



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



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



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.)



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

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



RFN Gateway Configuration

twork Runner		- 8
	TTON Network Runner	
	Gateway Commissioning	
	Configuration Activation	
	NTP Servers	
	10.106.171.161 129.6.15.29 151.110.126.15	
	Ethernet IP	
	10.106.171.217	
	Ethernet Mask	
	2552552540	
	Ethernet Default GW	
	10.106.170.1 APN	
	APN User	
	APN Password	
	Interface	
	Cellular Modem	
	ICMP	
	Disabled	
		•



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



Eaton RF Network Operation



Network Concepts: Routes

- A Route defines the path from one node to another
- Four major components:

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- 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



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'





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- 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.





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- 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.





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



Nodes Broadcast every 5 sec to 24hrs, interval subjected to density



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

 $\widehat{\otimes}$)))) Ĭ, $\overline{\otimes}$ $\overline{\otimes}$)))) GW Broadcast every)))) 5 sec to 30 minutes Ľ Ľ, Node joins network and becomes READY after maximum time of $\overline{\otimes}$ (0.5 + 8hrs + 24hrs) $\widehat{\otimes}$ $\widehat{\otimes}$ GW ((((₩))))) Ľ, Ľ, Ĕ) $\overline{\otimes}$)))) $\widehat{\otimes}$ Ĭ,)))) Ĭ $\widehat{\otimes}$))) © 2024 Eaton. All rights reserved. Ľ



- 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





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



Wake up and broadcast



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





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.




Network Segmentation

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- 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



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





Ready Status

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





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





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





Network Steady State Operation



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





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'





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



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.





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	Rat e	Bandwidth Factor	Cost Multiplier
1/4x	19.2	2.5	9.6	1	5/1=5
1/2x	38.4	5	19.2	2.5	5/2.5=2
1x	76.8	10	38.4	5	5/5=1
2x	153.6	20			



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 \rightarrow Lower Rate
 - Lower link cost \rightarrow Higher Rate

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

• The convergence is designed to maximize throughput.





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}



Power Adaption

- Power level starts with neighbor density
 - 1/2 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



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.



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.





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



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





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.





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.





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



Outage Alarm	
Ignored Conn.	$\rightarrow \rightarrow$



Outage Delivery



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



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





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





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)



Applications



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



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



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



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



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



Outage Detection

Outage Detection and Reporting Steps





Outage Detection

Restoration Reporting Steps

Normal Restore





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



Broadcast (Real-time message delivery)



Original message
 Repeated message 1
 Repeated message 2

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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)

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


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.



RFN Data Streaming

 Yukon enables and select channels for Data Streaming





Data Streaming: Yukon Configuration

☆ Configure Data Streaming

Configure Data Stream	ning:		
Devices Selected: 5 te Note: Select the data stre	emporary coll eaming config	ection 🔍 juration you	wish to start using
Configuration Type:	Existing	New	
Interval (in minutes):	5 🗸		
Attributes 🙆			

Channels have to be enabled in the meter in order to strea

Delivered kWh:	Off	On
Demand:	Off	On
Received kWh:	Off	On
Voltage:	Off	On

☆ GW224

Gateway Information

Name:	GW224
Serial No:	10106171224
Hardware Version:	GW2.0
Software Version:	R_8_1_1
Upper Stack Version:	R_8_1_1_0_2
Radio Version:	R4.2.0qp
Release Version:	8.1.2
Version Conflicts:	None
Application Mode:	Normal
Streaming Capacity:	15.01% View History



Data Streaming: Yukon Configuration

FATON AMI - Demand Response - Volt/Var - Assets - Tools -	Admin 👻
Powering Business Worldwide	
Home / Data Streaming Configurations	
☆ Data Streaming Configurations	🔅 Actions 🔻
Attributes A	Data Streaming Summary Data Streaming Discrepancies
Average Voltage (Phase A), Delivered kWh, Received kWh, Sum kVAh, Sum kVArh, Voltage (Phase A), Voltage (Phase B), Voltage (Phase C)	Collection Actions
Delivered kVA, Delivered kWh, Demand, Voltage (Phase A), Voltage (Phase B), Voltage (Phase C)	Configure Other Devices
Delivered kWh	15 1 minutes
Delivered kWh, Demand, Power Factor, Voltage (Phase A)	1 minute 1
Delivered kWh, Demand, Received kWh, Voltage	5 minutes 2
Delivered kWh, Demand, Received kWh, Voltage	5 minutes 1
Delivered kWh, Demand, Received kWh, Voltage	30 1 minutes
Delivered kWh, Demand, Received kWh, Voltage	5 minutes 1
Delivered kWh, Demand, Received kWh, Voltage	5 minutes 1
Delivered kWh, Demand, Received kWh, Voltage	1 minute 1
Delivered kWh, Demand, Received kWh, Voltage	5 minutes 1
Delivered kWh, Demand, Received kWh, Voltage	1 minute 1
Delivered kWh, Received kWh, Voltage (Phase A), Voltage (Phase B), Voltage (Phase C)	1 minute 1



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 ondemand
 - Link quality







• Questions?



EAS Conference – Yukon 101



Dashboards



Dashboard – My Pages

My Pages	^
FAVORITES RECENTLY VIEWED	
AMI	
088030987	
133524814	
134183085	
134183088	
13444884	
138046131	
165380831	
165380832	
178855151	
332411090	
88875562	
Metering: Meter Events Report	
Assets	
5010068357	
5010071277	
5010073109	
5010121987	
5010132897	
5010137404	
5010152505	
Assets: Cellular Connected Devices	
Assets: Gateways	
Dashboard	
Dashboard: Default Main Dashboard	
Tools	
Tools: Data Streaming Summary	
0 ,	



Dashboard – Note Search Widget





Dashboard – Meter Search

Meter Search	0	^
Quick Search:		
Meter Number:		
Device Name:		
Device Type:		
Address/Serial:		
Route:		
	Search	







Dashboard – Actions Widget





Dashboard – Monitors

^

Outage Notification		Monitoring :
Default All Meters		789
Outage Notification Monitor		789
Porter Response		Monitoring
Default All PLC Meters		
Validation	Threshold	Monitoring :
Default All Meters		
		+ Create ~
Notes Search		Device Data Outage Tamper Flag
Note Text:		Porter Response Validation



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.

Infrastruc	ture V	Varnings		@ ()	^
Gateways		21 of 21	Relays	🛕 17 of 88	
IPLink Mete	rs 🛕	11 of 38			
Most Rece	nt Activ	e Issues:			
05:55 AM 04/12/2022	50100 An out	000064 tage notificati	on has been rec	eived.	>
10:58 AM 07/05/2022	GW22 Duplic	5-Phi ate color 2 co	onfigured into ga	teway.	>
11:37 PM 11/27/2022	GW22 Gatew the wa	5-Phi ay's total read rning thresho	dy node count (1 old (25).	5) is lower than	>
05:18 PM 02/14/2024	GW21 Gatew	7 ay detecting	AC power failure	i.	>
04:32 PM 04/16/2024	GW21 Gatew the wa	7 ay's total read rning thresho	dy node count (0 old (25).) is lower than	>
05:18 PM 02/14/2024	GW21 Gatew	7 ay security al	arm, SSH service	e enabled.	>
05:18 PM 02/14/2024	GW21 Gatew	7 ay detecting	low voltage on U	PS battery.	>
08:10 AM 04/26/2022	50100 An out	000072 tage notificati	on has been rec	eived.	>
09:24 AM 01/25/2021	GW22 Gatew	ay detecting	AC power failure	i	>
10:58 AM 07/05/2022	GW22 Duplic	: 1 ate color 20 d	configured into g	ateway.	>
View All Inf	frastruc	ture Warnin	gs		>
Last Refres	sh: 05/0	8/2024 12:3	1:41 PM		Ċ





Home / AMI / Meters / 68498678

* 68498678

☆ 68498678								A	ctions	~
Meter Information	n	^	Meter	Trend					?	^
Device Name:	68498678				Met	er: 6849	8678			
Meter Number:	68498678			Previous	Year's Mid	night Re	ading Usage	e Reading		
Туре:	RFN-410cL		5							
Serial Number:	68498678									
Manufacturer:	ITRN		4							
Model:	C1SX									
Status:	Enabled		kg 3							
	[🎤 Edit	HMY 2							
Meter Readings		^	0	Apr '2	весососос 3 Ju	1 '23	Oct '23	 Ja	an '24	•••
Usage Reading:	23.019 kWH 02/12/2024 23:00:00		Graph 1	уре:	Voltage Pr kWh per Ir	ofile Da iterval	aily Usage D	emand D	elivere	ed
Previous:	23.019 kWH 02/12/2024 23:00:00	~	Time Pr	riod	1D 1W	1M 2M	L 1V L Custor	m		
Total Consumption:	0.000		Timere	inou.						
Peak Demand:	0.000 kW 02/12/2024 23:00:00		Chart S	tyle:	Line Bar					
Demand:	0.000 kW 02/12/2024 23:00:00		Archive	d Usage Data	a HTML CS	V PDF				
Voltage:	238.3 Volts 02/12/2024 23:00:00		Daily U	age Data	HTML CS	V PDF				
View All Ouick View	v	Pead								
	-	Neau	Meter	Events						~







- 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

Meter Readings			^	
Usage Reading:	23.019 kWH 02/14/2024 23:00:00			
Previous:	23.019 kWH 02/14/2024 23:00:00	~		
Total Consumption:	0.000			
Peak Demand:	0.000 kW 02/14/2024 23:00:00			
Demand:	0.000 kW 02/14/2024 23:00:00			
Voltage:	237.6 Volts 02/14/2024 23:00:00			
View All Quick View	1		Read	



- 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

Network Informa	tion 🕜 🔨
Comm Status:	Ready
Comm Status Obtained At:	02/15/2024 09:38
Groups:	38.4 Meters, All_7.0_Nodes, GW186_nodes, R_7.1_GW217_PM_9.6, Regression 9_1_1, REL6_TO_REL8_UPGRADE_TEST, Release 9.1 Buffered, Release 9.1.2 (Buffered), Release 9.3.1 (buffered), Release_9_7
Hop Count:	1
Neighbor Count:	15
Node Serial Number:	3138?04000
Primary Forward:	GW219
Reverse Lookup:	GW219
Show All	🗘 Refresh



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



Network Information × The Network Information widget provides networking information for a device including the following: Primary Forward – Primary Forward is determined by the node and is the gateway the node has chosen to provide its data every reporting interval. Reverse Lookup – Reverse Lookup is determined by the software as the most likely gateway to successfully process an on demand function to the selected device. The Primary Forward and Reverse Lookup are generally the same for a node. In instances where they are different, it is likely a node has switched gateways and the new routing data has not been received or processed by the Yukon software. If this is the case, the Comm Status will be Unknown until the new routing data has been received and the gateways match again.



 Create, view, and manage notes attached to the meter

Notes	^
Note Text (255 characters max)	+ Create
Disconnected for non-payment on 2-14-2024 yukon - 02/15/2024 16:49:31	
All Notes	



 View and modify the Device Groups to which the meter belongs





- 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





- 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

Disconnect	? ^
Disconnect Status:	Disconnected 02/15/2024 16:45:11
	Disconnect Connect SQuery









	Outages ×
Outages	Blinks in the AMI system are power interruptions less than 10 seconds and are reported with the next set of interval data readings. Interruptions beyond 10 seconds are considered outages and generate a last gasp alarm to notify utility personnel within just a few minutes. The 10 second threshold is Eaton's recommended setting for optimal performance, but also configurable as needed.
Total Blinks and Outages: 47 Counts 03/04/2023 12:43:47 ? Outage Count: 33 Counts 10/19/2022 09:23:30	Both blinks and outages record a start time, stop time, and duration that can be used for reporting based on the utility's threshold for outage metrics.
Blink Count: 14 Counts 03/04/2023 12:43:47	The time required to first detect power interruptions varies as follows, based on meter type:
Blink Restore Count: 0 Counts 01/01/2010 12:00:00 !	CENTRON C1S - 435ms
REN Outages Log	CENTRON II C2SX - 1.16s
	SENTINEL - 1.8s
No Outage Logs	A3 - 158ms
	FOCUS AL - 547ms
	FOCUS AL/AX - 1.32s
	S4x - 946ms



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





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

Device Configuration		? ^
Assigned Configuration:	(none)	
Change Configuration:	C2SX	~
Change Configuration.	Change	



- 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













Meter Informati	on	^
Device Name: Meter Number: Type: Serial Number: Manufacturer: Model: Status:	12 Grimmauld Place 198987 ^{•••} RFW-201 70427504 WTR2 Encoder-201 Enabled	
		🖍 Edit



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

Water Meter Readings		^
Water Usage Reading:	27,063,374.000 Gallons 02/16/2024 10:00:00)
Previous:	27,063,374.000 Gallons 02/16/2024 10:00:00	~
Total Consumption:	0.000	
View All Quick View	1	



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

Network Informatio	n	^
Comm Status:	Ready	
Comm Status Obtained At:	11/30/2023 17:59	
Groups:	11WaterEventsTestRelease91, Jacobson Water, Regression 9_1_1, Release 9.1 Buffered, Release_9_7	
Hop Count:	2	
Node Serial Number:	4260043478	
Primary Forward:	GW219	
Reverse Lookup:	GW219	
Show All	🗘 Refresh	



 Create, view, and manage notes attached to the node

Notes	^
Note Text (255 characters max)	+ Create
Pit installation yukon - 02/16/2024 13:22:03	/
All Notes	


View and modify the groups to which the water meter belongs





 Snapshot trend of usage data collected from the water meter





Timestamp	Event	State
09/02/2023 21:00:03	Meter Read - No encoder found	E False
09/02/2023 20:45:01	Meter Read - No encoder found	True
09/02/2023 20:00:02	Meter Read - No encoder found	E False
09/02/2023 19:45:01	Meter Read - No encoder found	True
02/11/2023 21:15:02	Meter Read - No encoder found	E False
02/11/2023 21:00:01	Meter Read - No encoder found	True





 Allows changes to Recording and Reporting intervals of water nodes

Device Configuration	1		• •
Assigned Configuration:	(none)		
Change Configuration:	RFW201	▼ Change	



Assets – Gateways & Relays



Assets - Gateways

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





Assets – Gateways – List of Gateways

Sate	eways							Actions
tev	vay Informa	tion						
	Name 个	Streaming Capacity	Serial Number	IP Address	Firmware Version	Last Communication	Data Collection	
	7800000128	0.00%	7800000128	10.106.171.211	9.5.11	Successful	1009	6
	GW183	Unsupported	156000001	10.106.171.183	9.9.0	Successful	1009	6
	GW190	Unsupported	156000081	10.106.171.190	5.3.8	Failed	1009	6
	GW202	Unsupported	1560000748	10.106.171.202	9.5.10	Successful	85.7	1%
	GW203	0.00%	7800002084	10.106.171.203	9.4.0	Successful	1009	6
	GW204-DEC	0.00%	7800003290	10.106.171.204	9.3.3	Successful	1009	6
	GW206	Unsupported	1560000757	10.106.171.206	6.0.6	Successful	1009	6
	GW213	0.00%	7800002732	10.106.171.213	9.4.0	Successful	1009	6
	GW214	0.00%	7800002085	10.106.171.214	9.9.0	Successful	1009	6
	GW216	5.01%	10106171216	10.106.171.216	9.7.0	Successful	1009	6
	GW217	0.00%	780000005	10.106.171.217	9.5.10	Successful	1009	6
	GW218	7.02%	780000033	10.106.171.218	9.9.0	Successful	1009	6
	GW219	10.34%	780000827	10.106.171.219	9.7.0	Successful	1009	6
	GW221	3.05%	10106171221	10.106.171.221	9.8.0	Successful	1009	6
	GW222	0.00%	10106171222	10.106.171.222	9.9.0	Successful	1009	6
	GW224	0.00%	10106171224	10.106.171.224	9.3.3	Successful	1009	6
	GW225-Phi	0.00%	7800000182	10.106.171.225	9.1.4	Successful	1009	6
	GW226	5.03%	780000248	10.106.171.226	9.5.15	Successful	1009	6
	GW230-ERL	0.00%	7800002791	10.130.180.230	9.3.3	Failed	1009	6
	VCGW162	1.00%	22	127.0.0.1	9.8.0	Successful	1009	6
	VCGW228	0.00%	Virtual3	10.106.171.228	9.9.0	Successful	99.9	9%



Assets – Gateways – Adding a Gateway





Gateway Page

Gateway Information

Name:	GW216
Туре:	🔋 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

Notes

Note Text (255 characters max)

+ Create

🖍 Edit

Location 😮





Gateway Page

Communication

Admin:	admin	
Super Admin:	super	
Connection Type:	TCP/IP	
IP Address:	10.106.171.216 Port: 32030	
NM IP Address:	10.106.171.162 Port: 32030	
	EkaNet 915 MHz MAC Address: 00:14:08:18:DB:39 Version: DEVEL_230621_1519	
Radios:	EkaNet 915 MHz MAC Address: FF:FF:FF:FF:FF:FF Version: V_13_49	
	EkaNet 915 MHz MAC Address: 00:14:08:0D:60:22 Version: DEVEL_230724_1321	
Connection Status:	Connected 10/24/2023 09:54:39	
Last Communication:	Successful 10/24/2023 09:54 EDT	

Gateway Metrics

Ready Nodes:	6 Counts 03/03/2024 20:10:25
Streaming Capable Device Count:	3 Counts 03/03/2024 19:42:40
Streaming Active Device Count:	1 Counts 03/03/2024 19:42:40

Gateway Node Information

Cellular Capable Count:	0	
Wi-Fi Capable Count:	0	
Ready Nodes:		75%
Nodes with Info:		87.5%
Nodes with Serial Numbers:		87%



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



Assets – Relays – List of Relays

Filtered Results: 86		
Name 个	Serial Number	Туре
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
421000007	421000007	CRLY-856
4210000055	421000055	RFN Relay
4210005283	4210005283	RFN Relay



Relay Page

Relay Information	on	
Device Name: Type: Serial Number: Manufacturer: Model:	4110015041	
		🎤 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	W	arn	ings
----------------	---	-----	------

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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		



Device Groups



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



* Device Groups			
EDITOR UPLOAD			
Groups	Add Subgroup		×
 search Groups Badger Water Events Test Edge Addressing 	Group Name: Group Type:	Low Voltage Meters Basic	
Meters Monitors RF Test Service			Create



Groups				Operations: /I	ow Voltage Meters
 search Groups Badger Wat Edge Addre Low Voltage 	er Events Test ssing Meters			Edit Group Edit Group Name Modify Group Add Subgroup Generate Reports	e Delete Group Move Grou <mark>Add Devices</mark> Copy Contents
Generation Generation	ADD BY: DEVICE	GROUP	ADDRESS	FILE	×
• © Service • © System © test	Type of data:	Meter Num	<mark>ber</mark> (one per li	ne) 🔻	Î
	Data file:	Upload MeterNum	d bersForNewD	eviceGroup.CSV	•
		MeterNum	bersForNewD	eviceGroup.CSV	Cancel



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





- 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



Monitors		🔒 i n	Meter Search	@ ^
Bevice Data	Violations M	fonitoring : 🔺	Ouick Search:	
All Current Outages	37	260		
Approaching Max Voltage)0	3	Meter Number:	
Disconnected Meters	0	12	Device Name:	
High Temperature Alarms	0	2	Device Type:	
Low Battery Warning	0	15	Address / Engints	
Min Voltage Monitor	1	5	Address/Senal:	
Possible Tampering	0	3	Route:	
Renewable Generation Sites	0	7		
Voltage High (HV)	0	38		Search
Voltage Low (UV)	0	47 💌		
Outage	Violations	Monitoring :	Actions	~
Frequent Blinks	3	252		
Outage tamper			Aggregate Interval Data Report Archive Data Analysis	
Seasonal Residence			Meter Events Report	
Underground Fault Starting	0	90	Usage Threshold Report	
Status Point		Monitoring :		
Device Status		585		
Faulted Circuit Indicators		з		
Last Gasp and Restoration for (DMS	585		
Validation	Threshold	Monitoring :		
155 Meter Validation	1,500.0 kWh/day	8		
25 Meter Validation	600.0 kWh/day	211		
35 Meter Validation	75.0 kWh/day	131		
4S Meter Validation	75.0 kWh/day	5		
95 Meter Validation				
Soft Disconnect	2.0 kWh/day	3		

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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

Home / AMI / Device Data	Monitor / Approaching Max Voltage
* Approaching Max	Voltage
Settings 🕐	
Name:	Approaching Max Voltage
Violations:	0
Monitoring:	3
Supported Count:	Q 1 missing attribute: Maximum Voltage Daily ?
Device Group:	/Demonstration/Bellwether Voltage Meters
Violations Group:	/Monitors/DeviceData/Approaching Max Voltage
Status:	Enabled
Notify On Alarms Only:	Disabled
Status Processors @	
No processors	
Value Processors @	
Attribute	Rule
Maximum Voltage Daily	Greater than 246.0



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 ٠ Settings @ + 0 dots), the user may go directly to Name: All Current Outages a mappe B D F outage LONGITUDE LAST CHANGED DATE LAST CHANGED TIME NAME METER NUMBER LATITUDE -93.38322 10001001 10600075 44.97209 From the • 10001003 10600225 44.98737 -93.39281downloa 2/8/2017 11:03:51 another 4 10001004 10600300 45.011626 -93.385363 2/8/2017 10001005 10600375 44.97087 -93.36836 11:03:52 Note: Fre • 10001006 10600450 44.95241 -93.3972 2/8/2017 11:03:52 page, the 2/8/2017 10001007 10600525 45.01625 -93.37708 11:03:53 allows y 2/8/2017 10600600 44.98472 11:03:53 10001008 -93.37121 State perform 10001009 10600675 44.96005 -93.44423 2/8/2017 11:03:54 results Power Outage 10001010 10600750 45.0059 -93.36099 2/8/2017 10001011 10600825 44.98434 -93.35994 11:03:55 No processors On Off 📈 😰 🗷 📚 Live Update:

Monitored Devices: 260 Device Group /System/Attributes/Supported/Outage Status Q

* All Current Outages

Violations: 📆 Device Group /Monitors/DeviceData/All Current Outages 🤇

* Map Devices

Device Data

All Current Outages

Violations

Filter Devices:

37

Monitoring

26

Violations



Device Configurations



Home / Device Configu	uration / Create	
* Create Configu	ration	
Name:		
Description:		1.
Create	el	



Oevice configuration was successful and the succ	ccessfully written to the database.		×
dd Supported Types			
Select the additional device types Supported Device Types Meter	which this device configuration will support.	Can Bank Contro	bller
CRL-53054x MCT- MCT-410fL MCT- MCT-420cD MCT-	410cL 410iL 420cL Regulator	CBC 7020 CBC 7023 CBC 8020	CBC 7022 CBC 7024 CBC 8024
MCT-420fD MCT- MCT-430A MCT- MCT-43054 MCT- MCT-470 RFG-2004A	420fL 430A3 Gang Operated Regulator 430SL Load Tap Changer 201 Phase Operated Regulator	CBC DNP	CBC Logical
RFN-410cL RFN-4 RFN-410fL RFN-4 RFN-420cD RFN-4	410fD 410fX 420cL		
RFN-4201D RFN-4201RD RFN-4201RD RFN-4 RFN-4201X RFN-4 RFN-4201X RFN-4 RFN-430A3K RFN-4	420fL 420fRX 430A3D 430A3R		
RFN-430A3T RFN-4	430SL0		



Device Types	Categories		
RFN-410cL RFN-420cD	Please use	e the Create or Select buttons below to select a c	ategory for this type.
	Name:	(none selected)	
Add Types	Type:	Centron C1SX Display Items 🛛 😮	
			+ Create - Select
	Please use	e the Create or Select buttons below to select a c	ategory for this type.
	Name:	(none selected)	
	Type:	Centron C2SX Display Items 🛛 😗	
			+ Create 43 Select
	Please use	e the Create or Select buttons below to select a c	ategory for this type.
	Name:	(none selected)	
	Type:	Demand Freeze 🥝	
			- Create 5 Select
	Please use	e the Create or Select buttons below to select a c	ategory for this type.
	Name:	(none selected)	
	Type:	LCD Configuration 🥝	
			the Crapton Con Select
	I		+ Create +7 Select
	Please use	e the Create or Select buttons below to select a c	ategory for this type.
	Name:	(none selected)	
	Type:	RFN Channel Configuration 🥝	
			+ Create
	Optional of the second seco	ategory has no entry selected.	
	Name:	(none selected)	
	Type:	RFN Demand 🥝	
			+ Create C+ Select
			- create



eate Category		×
Fields		_
Enable TOU	True False When true, the device also stores usage into its TOU rate registers based on the TOU schedule specified below.	
Schedule 1	Midnight 00:00 Rate A B C D O Add Rate	
Schedule 2	Midnight 00:00 - Rate A B C D O Add Rate	
Schedule 3	Midnight 00:00 Rate A B C D O Add Rate	
Schedule 4	Midnight 00:00 Rate A B C D G Add Rate	
	Cancel Sar	/e



- 15 "intervals" can be used per channel configuration
- 80 "midnight" readings can be used per channel configuration

Name: Type:	(none selected) Demand Freeze 🔮			
		eate Category		
Please use	the Create or Select buttons below to se	Delivered Demand	Interval Midnight Disabled	
Name: Type:	(none selected) LCD Configuration 🥝	Delivered Peak Demand	Interval Midnight Disabled	
		Delivered Peak Demand Rate A	Interval Midnight Disabled	
Please use	the Create or Select buttons below to se	Delivered Peak Demand Rate B	Interval Midnight Disabled	
Name: Type:	(none selected) RFN Channel Configuration 🛛 🎯	Delivered Peak Demand Rate C	Interval Midnight Disabled	
		Delivered Peak Demand Rate D	Interval Midnight Disabled	
Optional ca	stegory has no entry selected.	Delivered kWh	Interval Midnight Disabled	
Name:	(none selected)	Delivered kWh Rate A	Interval Midnight Disabled	



Select Category		×
Search:	1 - 2 of 2	reate
Category Name	Category Type	
C1SX-Display	centron410DisplayItems)e.
RFN-410cL Display All	centron410DisplayItems	
	Cancel	ок
		reate



Billing

