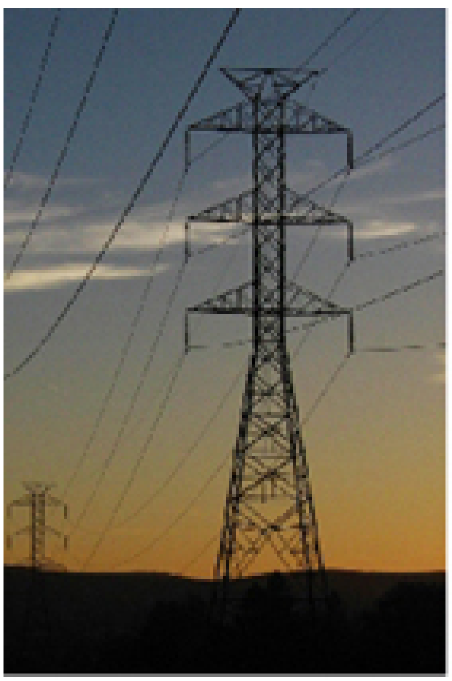
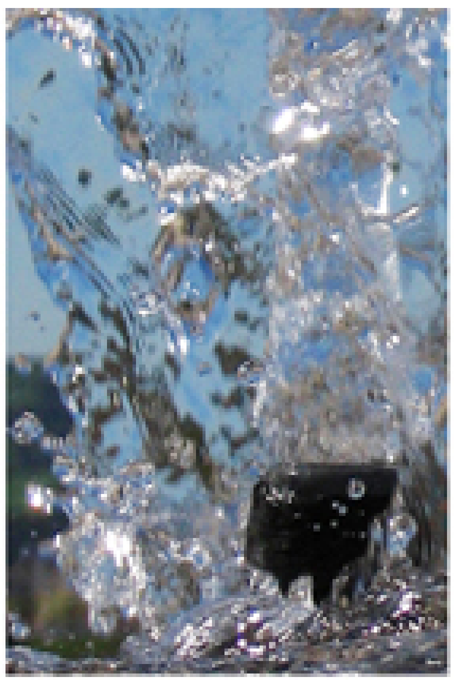
Bridges Hardware Guide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Bridges Hardware Guide

Document Number BRIDGESv2.0UG_Rev1

Revision number	Date	Revision
1	June 16, 2010	Add FCC 15.247 information to Appendix, and incorporate updates to specify max gain for sBridge and eBridge.

Contents

1 Introduction

Silver Spring Networks' Distribution Automation (DA) network is designed to help electrical utilities manage field devices such as reclosers, capacitor banks, voltage regulators, and transformers, through more efficient two-way communication. The utilities' primary tools for monitoring power distribution systems are called Remote Terminal Units (RTUs).

Utilities use Supervisory Control And Data Acquisition (SCADA) centers to remotely control substation and distribution equipment through these RTUs. Unfortunately, many RTUs don't communicate effectively to SCADA management systems, making fault detection and field response difficult. The DA network is designed to address this problem, by building a comprehensive fault-tolerant wireless IP network for two-way communications with distribution RTUs.

The devices used to improve communications between the utility's SCADA central office and its RTUs are the Silver Spring Networks eBridge® and the Silver Spring Networks sBridge®. Each are separate bridge types that differ based on their provided types of port connectors.

Note: In this document, whenever applicable, the eBridge and sBridge will be referred to generically as "bridges."

Silver Spring Networks bridges are devices that provide a network for reliable and secure IP-based two-way communications between RTUs and the SCADA system. Faster communication with RTUs helps create a smarter, more reliable electrical grid.

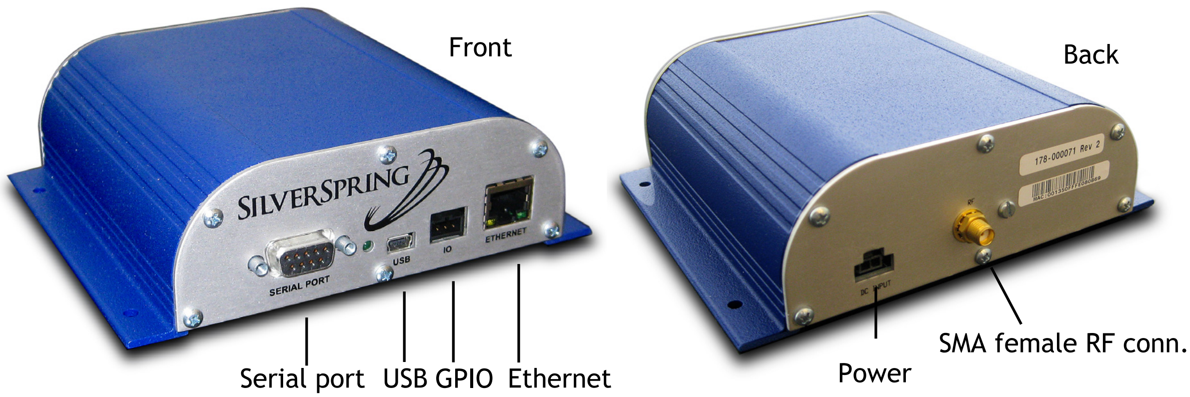
The eBridge

The eBridge provides the following interfaces:

- One (1) 100Base-T RJ-45 Ethernet interface.
- One (1) DB-9 nine-pin serial interface.
- One (1) 900 MHz RF wireless interface.

The Ethernet port on the eBridge often connects to the network leading to the back office or the electrical substation SCADA system. A remote eBridge can use its Ethernet port to connect to one or more RTUs. The RF interface connects all bridges together in a routable RF wireless network for DA communications. A serial port can also be used for RTU connections.

Figure 1. Front and back view of the eBridge



The sBridge

Note: sBridges can be used for meter connectivity and for DA RTU connectivity.The application described in this guide is for DA connectivity. sBridges are not designed for use as a master bridge.

The Silver Spring Networks sBridge provides similar functionality to the eBridge, with the primary difference being support for two serial interfaces as shown in Figure 2. Serial port 1 is designated as a remote communication port, passing raw serial traffic, for central offices to diagnose, monitor and remotely configure the device. Serial port 2 connects to an RTU and passes DNP3/IP traffic. Either port can be set to function in either mode. As with the eBridge, an RF interface connects the sBridges to the RF network.

Figure 2. Front and rear view of the sBridge

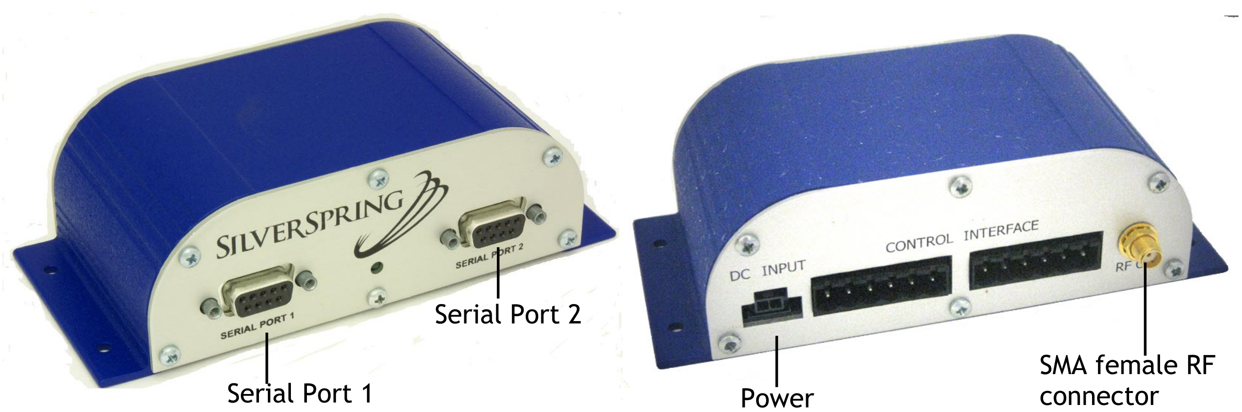
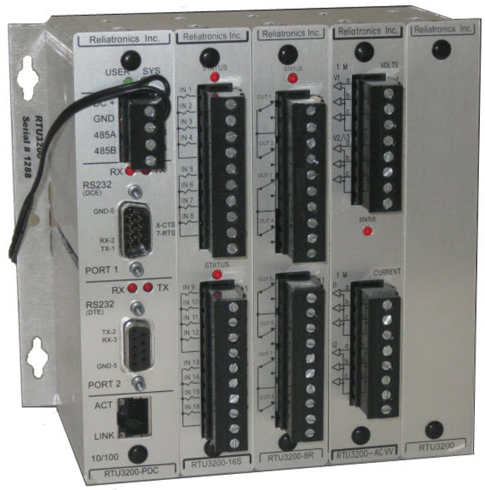


Figure 3 shows an example of an RTU, which provides an Ethernet port, two serial ports and terminals for the electrical equipment to which it connects.

Figure 3. An RTU



Note: For more information about network deployments of the eBridge and sBridge, refer to Chapter 2, Deploying Silver Spring Networks Bridges on page 8. For instructions on how to configure eBridges and sBridges, refer to the *Bridge Configurator 2.0 User's Guide*.

Audience

This guide is intended for networking and IT professionals and system administrators who perform one or more of the following tasks:

- Management of distribution electrical equipment
- Network Management
- Support information technology
- Install, monitor and troubleshoot devices

Silver Spring Networks Documentation

Silver Spring Networks provides the following documents:

- *Bridges Hardware Guide* (this document)
- *Bridge Configurator 2.0 User's Guide* (software for configuring bridges)
- *DA NEM 1.0 User's Guide*

Other documents may be available from the Silver Spring Networks web site:

www.silverspringnet.com

Customer Support

Silver Spring Networks offers expert technical support and guaranteed response times.

Table 1. Support Information

<table>
<tr><th>Country</th><th>Email</th><th>Telephone</th><th>Hours</th></tr>
<tr><td>Australia</td><td>aus-support@silverspringnet.com</td><td>+03 9607 8521</td><td>9:00 AM - 6:00 PM</td></tr>
<tr><td>Canada</td><td rowspan="3">support@silverspringnet.com</td><td rowspan="2">Toll free:
1-888-SSN-9876
(1-888-776-9876)</td><td rowspan="2">6:00 AM - 6:00 PM
US Pacific Time</td></tr>
<tr><td>United States</td></tr>
<tr><td>Worldwide</td><td>+1-650-298-4298</td><td></td></tr>
</table>

2 Deploying Silver Spring Networks Bridges

Essential to the complete creation of a DA network are the Silver Spring primary devices: the eBridge and the sBridge. The DA network is designed to help utilities effectively communicate with field-installed remote terminal units (RTUs) and power system device controllers in the electrical distribution network.

This chapter introduces the use of Silver Spring Networks eBridges and sBridges to create and support the Distribution Automation (DA) network, in the following topics:

Note: For complete information on configuring and deploying bridges, please see the *Bridge Configurator 2.0 User's Guide*.

Installing Bridges in the Network

Four basic steps are required to install eBridges and sBridges for supporting Distribution devices:

1. **Physical Installation:** bridges are not weather-hardened. They must be installed indoors or inside a weather-hardened enclosure, normally in the same enclosure as the RTU or device controller. Four mounting holes are located on the bottom edges of the bridge chassis.
2. **Bridge Powerup**: preferably, along with a battery backup.
3. **RF Antenna Attachment**: bridges may be connected with different antennas depending on the application. All antennas connect to the SMA female RF connector on the back of all bridges. Keep the following considerations in mind when attaching the proper antenna for the current device:

CAUTION: With the sBridge, using an antenna with greater than 3dBi gain is not allowed. Up to 6dBi is allowable with the eBridge.

   a. The recommended antennas for use in outdoor environments are listed in Table 2, below.
   b. An N-Female to SMA-male adapter is required for antenna cable connection to the SMA connector on the back of the bridge.
   c. Because the SMA connector is so small, physical stress may result when connecting a heavy coaxial transmission cable to the back of the eBridge or sBridge during installation. Use a pigtail on the SMA connector to support the weight of a heavy transmission line to the bridge.

4. **Interface Connections**: Connect the required interface cables between the bridge and the RTU.

Table 2. Available antennas for Silver Spring Network bridges

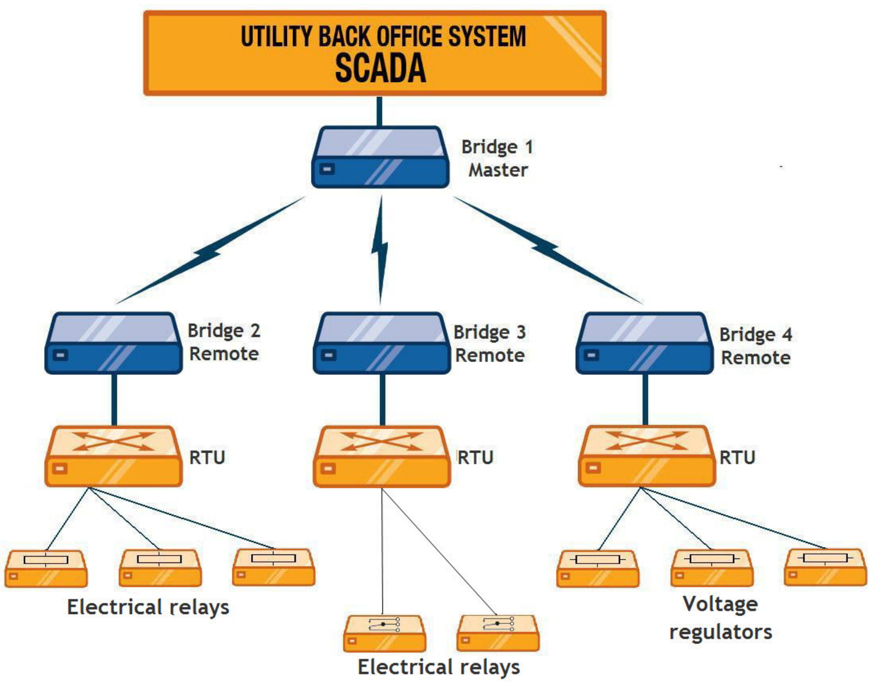
SSN Antenna Part #	Description
315-00012 Rev. 5	JPole antenna
315-000002 Rev. A	sBridge: Rubber Duck, 3dBI maximum gain, SMA Female, Antenna eBridge: Rubber Duck, 6dBI maximum gain, SMA Female, Antenna

Bridges can also connect to voltage, capacitor, tap changer and VAR management controllers, which usually provide their own serial and Ethernet ports. The eBridge or sBridge must be installed in the same enclosure as the controller.

Types of Bridge Deployments

RTUs are key components of the electrical system that act as collection points for sensor data and issue simple commands to control relays, regulators and other electrical system distribution devices. After installation, the bridges bring the RTUs into a new Distribution Automation (DA) network. Figure 4 shows a highly simplified example.

Figure 4. Example of a Master/Remote bridge deployment



Deployment Considerations

Before deploying bridges, allow for the following deployment considerations:

- Network topology
- Interfaces and protocols
- Deployment modes

Table 3 summarizes bridge deployment choices in the network.

Table 3. Bridge Deployment Topologies and Modes

Deployment Considerations	Description
Network topology	Bridges can be deployed in the following network topologies: • Master/Remote (with a centralized Master or decentralized Masters) • Teaming • Combination of Master/Remote and Teaming For more information about DA network topology, refer to Supported Network Topologies on page 11.
Interfaces and protocols	The **eBridge** supports the following interfaces and protocols: • Ethernet using IPv4 • Serial using IPv4 or IPv6 For more information on this topic, refer to Supported Interfaces on page 13. The **sBridge** supports the following interfaces: • Serial using IPv4 or IPv6 All bridges operate RF interfaces in a wireless network, running IPv6 by default.
Deployment modes	The **eBridge** supports the following deployment modes: • Mixed IPv4 (Ethernet Master/Serial Remote) • Mixed IPv6 (Ethernet Master/Serial Remote) • Ethernet Master/Ethernet Remote • Ethernet Master/Serial and Ethernet Remotes • Serial Master/Serial Remote • Ethernet Teaming and Serial Teaming The **sBridge** supports the following deployments: • Serial Remote • Serial Teaming

Note: The sBridge operates only as a Remote or in teaming mode. sBridges do not operate as a Master.

Supported Network Topologies

To accommodate placements of existing RTUs in the field, bridge units can be deployed in the following network topologies:

- Master/Remote Topology
- Teaming Topology on page 13
- A combination of Master/Remote and Teaming Topology

In the Master/Remote topology, a master bridge connects to the SCADA (Supervisory Control And Data Acquisition) master. The master bridge communicates over RF to remote bridges that connect in turn to RTUs.

Master/Remote Topology

In the Master/Remote topology, an eBridge master residing at the substation communicates with a larger set of remote bridges in the field.

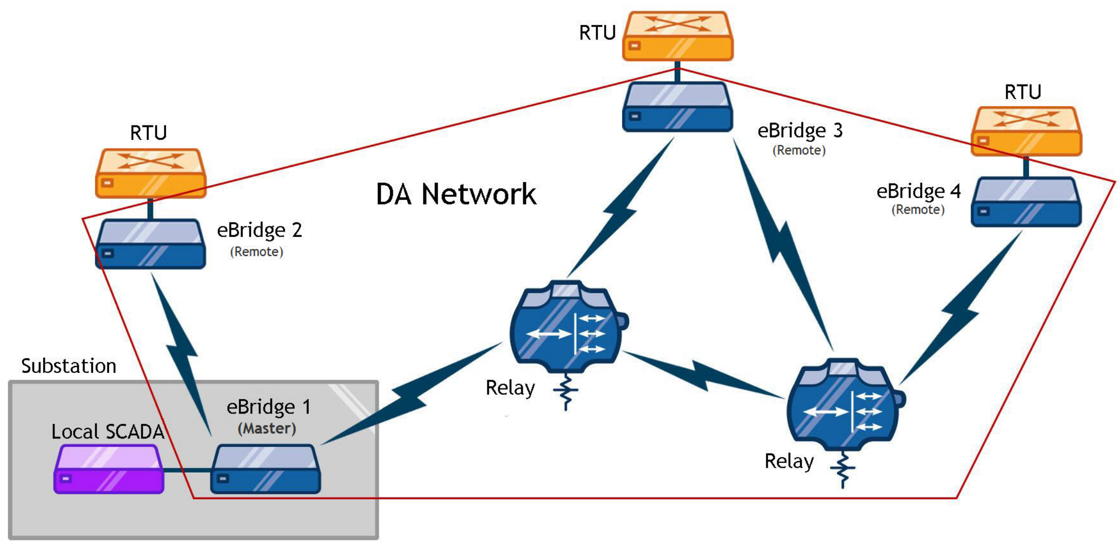
Note: Master and Remote bridges are configured as Masters and Remotes at the manufacturing facility. The first device to be deployed in the DA network is the master device, which can act as the takeout point for DA management traffic bound for the CO. The master bridge may also connect to an Access Point, that itself acts as the takeout point for the DA network. In our examples for this chapter, an Access Point is not shown.

To deploy bridges in a Master/Remote topology:

- At a substation, connect the master bridge to the local SCADA master.
- In the field, connect an eBridge or sBridge Remote to the RTU.

  When the SCADA master sends a message to the RTU, it passes through the master bridge, which sends it on to the remote bridge in the field, wirelessly via RF. The remote, in turn, passes the message to the RTU. In an extremely simplified manner, this system represents the DA (Distribution Automation) network, as indicated in Figure 5. Here, the pre-existing electrical distribution grid is overlaid with the bridge-based DA network deployment.

Figure 5. Master/Remote Example

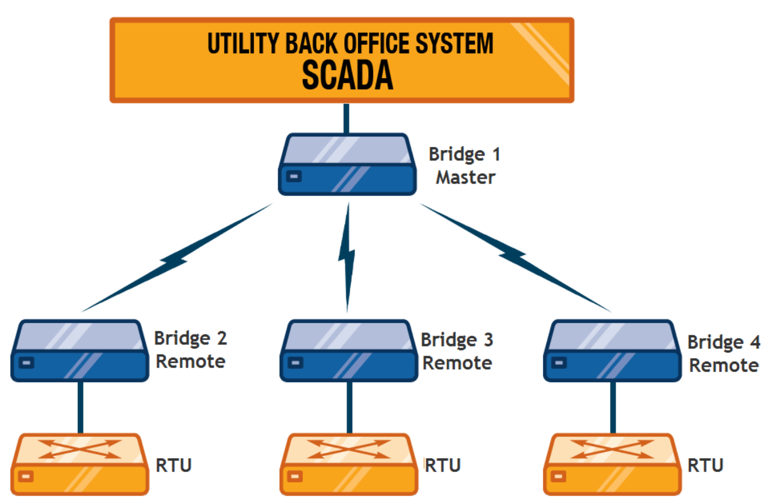


Relays are used to extend the RF signal to greater distances and to extend the signal around obstacles in the field.

Centralized and Decentralized Master/Remote Deployments

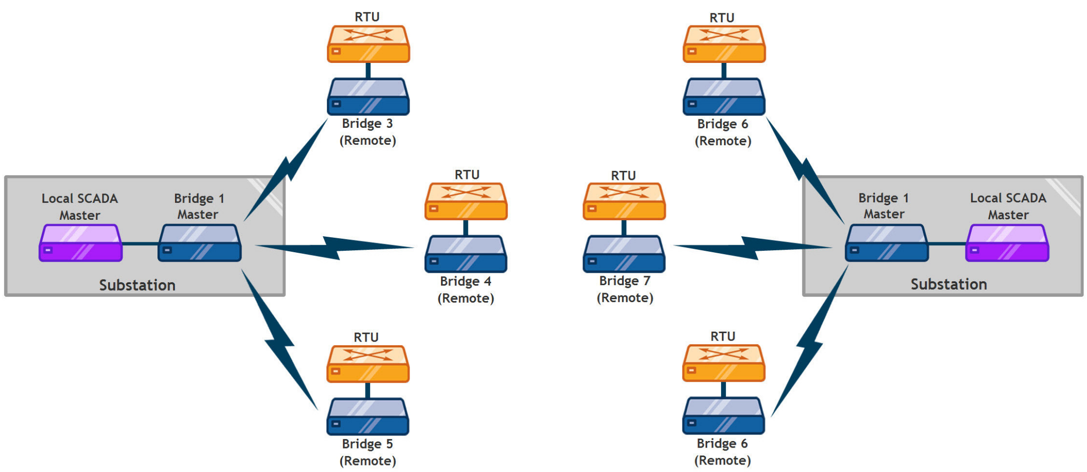
A Master/Remote deployment can be centralized or decentralized. In a centralized Master/ Remote deployment, the SCADA system resides at the back office and all data is drawn back to the central location. This resembles the classic "star" network.

Figure 6. Example of a Centralized Master/Remote Deployment



In a decentralized Master/Remote deployment, multiple SCADA systems exist (for example, substations in different locations) and data is drawn back to multiple points. Larger DA networks will roughly follow this model.

Figure 7. Example of a Decentralized Master/Remote Deployment



Teaming Topology

In the Teaming topology, a small set of bridges send each other messages to accomplish specific tasks. There can be up to ten members in a team and an unlimited number of teams. In Teaming, bridges communicate with each other, maintaining all routes to all members of the team.

Teaming is useful when dealing with devices such as reclosers that need to communicate with each other to accomplish group switching and fault isolation. These devices require a Teaming topology because it supports routing tables to all possible combinations of paths.

Refer to Figure 10 for an illustration of a Teaming topology.

Supported Interfaces

Connect bridges to a SCADA network and/or RTUs through either of the following interfaces:

- Ethernet
- Serial

Ethernet

eBridge only: In Ethernet mode, the eBridge connects to an RTU through an Ethernet interface. Because all communication between bridges over the Silver Spring Networks RF network always uses IP, the end point of the network is the RTU. When an eBridge uses Ethernet to communicate with an RTU, it operates like a router and does not require DNP information. When a packet comes across the RF network, the bridge makes a routing decision to send the packet to the destination IP address (an RTU).

On master bridges, Ethernet is used to communicate with the SCADA network.

Serial

In serial mode, the remote or teaming bridge connects to an RTU through a serial interface. Because serial RTUs have DNP addresses, the end point of the IP network is the bridge device.

Note: The Silver Spring Networks sBridge provides two DB-9 serial interfaces. (The eBridge provides a single DB-9 serial port.) On the sBridge, one port is dedicated to DNP3 traffic for the RTU (Serial Port 2) and the second serial port (Serial Port 1) passes raw serial traffic regardless of protocol, operating as a terminal communication port for remote troubleshooting and control. Either port can function with either setting; use the Bridge Configurator software to configure the ports.

When the remote or teaming bridge receives a packet, it removes the IP header and forwards the DNP3 payload serially to the RTU device.

During network configuration, a DNP3-to-IP mapping table is created by the Bridge Configurator software; this mapping table is stored on the master bridge. When the master bridge receives a DNP3 packet from the SCADA system, it uses that table to look up the destination IP address, encapsulates the DNP3 packet into an IP header and sends it to the destination bridge, where it is de-encapsulated back into DNP3 and forwarded over the serial port to the destination RTU.

The RTUs communicate with the master bridge using the master bridge's IP address. The eBridge and sBridge support both IPv4 and IPv6 in serial mode.

Deployment Mode Examples

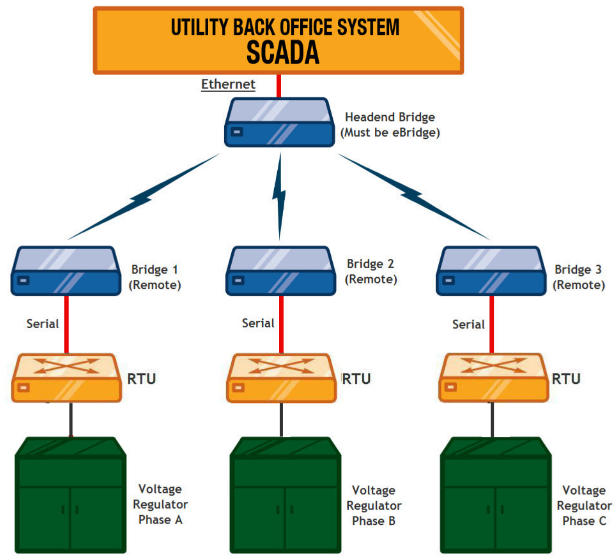
This section provides the following deployment mode examples:

- Mixed IPv4 Sample Deployment (Master eBridge only) below
- Serial Master/Serial Remote IPv6 Sample Deployment on page 15
- Ethernet Teaming Sample Deployment on page 16

Mixed IPv4 Sample Deployment (Master eBridge only)

In Mixed deployments, the master bridge connects to the SCADA master through its Ethernet interface, while its associated remote bridges connect to RTUs, in this case voltage regulators shown in Figure 8, through serial ports. The master bridge acts as a router, routing packets between its Ethernet and RF interfaces, and does not perform DNP encapsulation. The remotes encapsulate DNP messages coming from the voltage regulators into IP messages, and pass them on to the master bridge. The remote bridges also de-encapsulate incoming IP messages from the master bridge into DNP messages, and pass them on to the RTU. The remote bridges require the DNP address of the RTU to which they are serially connected.

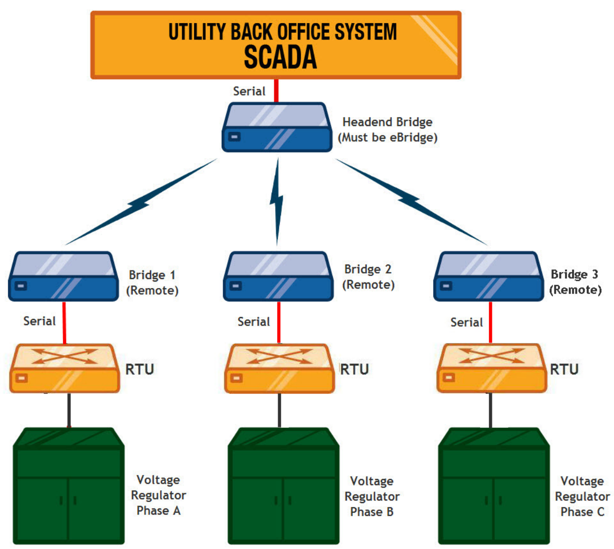
Figure 8. Example of a Mixed IPv4 Deployment



Serial Master/Serial Remote IPv6 Sample Deployment

In Serial Master/Serial Remote deployments, no Ethernet/IP network appears at the master bridge location. The master connects to the SCADA network using DNP3 over serial. In this case, the master requires the DNP address from both the SCADA system and from the voltage regulators. The master bridge performs DNP encapsulation and de-encapsulation from its serial interface to IP over the RF network. The master requires the DNP3 address of the voltage regulators because it routes to the remote bridges using IPv6 addresses across the RF network.

Figure 9. Example of a Serial Master/Serial Remote IPv6 Deployment Mode



The Bridge Configurator program provides the settings to associate the DNP3-based RTU address with each Remote bridge.

IPv6 Addressing in the RF Network

When a device registers with a subnet, the master bridge assigns it an IPv6 prefix, which the device appends to its MAC address to create a globally unique IPv6 unicast address, formatted according to the IEEE EUI-64 standard.

All Silver Spring IPv6 network addresses contain the prefix **2001:1868:209::/48** (defined at the manufacturing facility, this value cannot be changed) with a 16-bit reserved subnet value (**0xfffd**) and the MAC address of the device.

For example:

```
2001:1868:209:fffd::/64+MAC Address
```

When the master sends a message to one of the RTUs, it contains the IPv6 prefix plus the MAC address of the eBridge master.

For example, given an original Ethernet MAC address for an eBridge master:

```
00-0C-F1-56-98-AD
```

Each Silver Spring Networks bridge provides a sticker on the rear of the case showing the 64-bit MAC address of the device. This value is the EUI-64 value, containing the inserted **0xfffd** value to extend the original 48-bit MAC to a 64-bit MAC address.

```
00:0C:F1:FF:FE:56:98:AD
```

When operating in the RF network in IPv6, the bridge recalculates the MAC to the bridge's IPv6 unicast address by complementing the high-order byte of the EUI-64 MAC address and appending it to the prefix.

```
2001:1868:209:fffd:020C:F1FF:FE56:98AD
```

When the remote bridge sends a message back to the master eBridge, the message must contain that same prefix and IPv6 unicast address in its packet header. This value also appears in diagnostics and logs, in the Bridge Configurator software, as a true IPv6 unicast address.

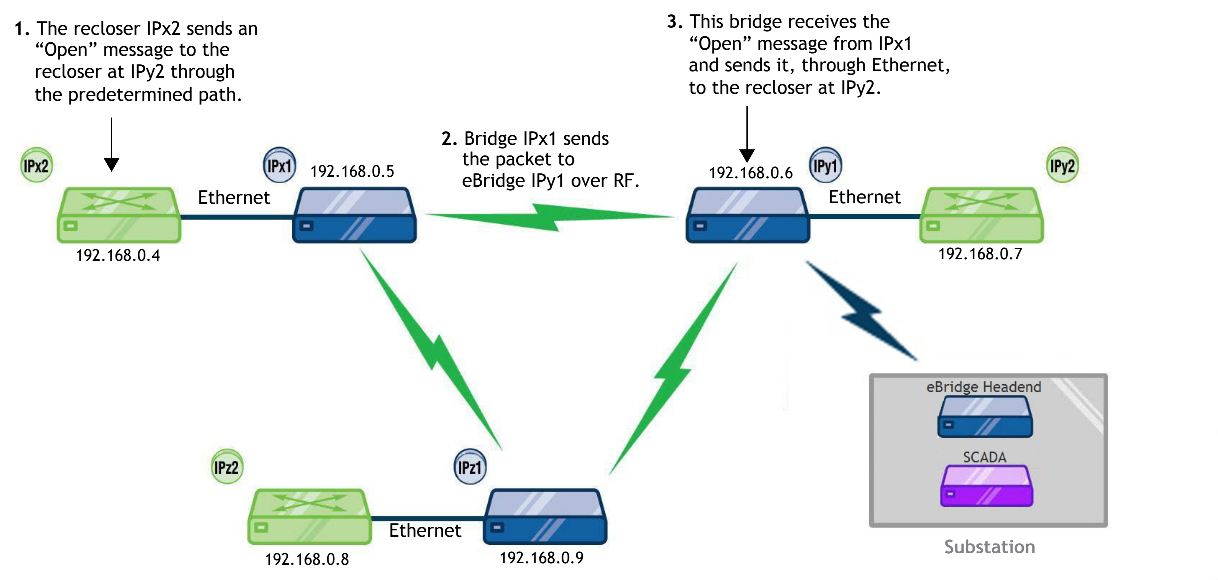
Note: Each sBridge and eBridge provides the device's unique IEEE EUI-64 MAC address in a sticker on the back of the bridge chassis. In this case, the high-order byte is not complemented, remaining as 0x00, as it is the 64-bit MAC hardware address of the device.

Ethernet Teaming Sample Deployment

In Ethernet teaming, a group of bridges send each other messages to accomplish specific tasks with reclosers. In a traditional DA communications network, all devices communicate with one or more SCADA masters. Individual DA devices, such as capacitor banks or reclosers, do not communicate with each other.

However, new types of reclosers can communicate with their neighbor reclosers to effect a coordinated switching action in the event of an electrical fault. This helps rapidly isolate the electrical fault and reduce the duration of the electrical outage. For reclosers to communicate with each other, Teaming mode is required. Teaming mode forces each member of a team to determine the routing paths to all other members of the team. Figure 10 shows the path of various messages between the teaming members.

Figure 10. Example of an Ethernet Teaming Deployment Mode



All team members exist on the same subnet. An eBridge or Access Point acts as the master for the teaming network.

Note: For more information on configurations and bridge deployment modes, see the *Bridge Configurator 2.0 User's Guide.*

A Specifications

Specifications are provided in the following topics:

Overview

The eBridge and sBridge are Commercial and Industrial SCADA products that are attached to the Silver Spring Networks Smart Energy Networks. Their primary function is remote control of local devices such as capacitor banks, instrument transformers and reclosers to utilize the Smart Grid network. The eBridge can also be used as a network bridge into the Smart Grid network. The Silver Spring Networks' RF network uses multi-protocol, multi-priority mesh routing for the smart grid distinguished by the following features:

- Low-latency, high-priority, DA/SCADA applications supported at 10-15 hop/second
- High-capacity, normal-priority AMR applications transport 5-15 packets per second at the eBridge or sBridge

eBridge and sBridge Features

- Built on a scalable platform that is easily integrated it into the existing network
- Supports industry standard protocols; DNP3.0 and TCP/IP
- Integrates with capacitor bank controllers, circuit reclosers, and other devices through built-in serial and Ethernet interfaces, supporting IPv6 and 256-bit encryption
- Integrates with all Silver Spring Networks solutions and products
- Small size and easy replacement
- Two-way frequency-hopping spread spectrum (FHSS) communications
- One-watt transmitter
- Dynamic IP-based network routing
- Time synchronization and management
- Continuous self-healing neighbor monitoring and route calculation

Silver Spring Networks eBridge Specifications

This section contains the following tables to provide eBridge specifications:

- eBridge Communications Specifications
- eBridge Environmental Specifications
- eBridge Interfaces
- eBridge Isolated Input/Output
- eBridge Power Consumption
- eBridge Approvals
- eBridge Protocols/Security
- eBridge DB-9 Interface Definition
- eBridge RJ-45 Hub Interface Definition

Table 4. eBridge Communications Specifications

Data Rate	100 kbps
Frequency[1]	902-928 MHz
Spread Spectrum Technology	FHSS (Frequency Hopping)
Transmitter Output	30 dBm
Channels[2]	83
Output Impedance	50 ohms
Receiver Sensitivity	-102 dBm for 10-3 PER
Modulation	Binary FSK
UtilOS	1.6 or later
Antenna Connector	SMA, Female
Antenna	See Table 2 on page 9: sBridge max 3dBi gain, eBridge max 6dBi gain
Serial	RS-232, DB9, Female
Serial Data Rates	2400 bps to 115K bps
USB	Mini-USB v2.0 Client
Ethernet	RJ45
LED	Network (Transmit, Idle, Receive, Error)

1.Frequency range adjusted to meet country-specific requirements.
2.Channels are adjusted to meet country-specific requirements. Australia limited to 43 channels on frequency range 915-928 MHz.

Table 5. eBridge Environmental Specifications

Operating Temperature	-40°C to +85°C (-40°F to +158°F)
Humidity	0% to 95%, non-condensing
Size	15 cm (6") L x 14 cm (5.5") W x 4.2 cm (1.75") H"
Weight	425 g (15 oz.)
Enclosure	IP50, blue, aluminum
Power	DC 10-60 120 to 277 VAC. 50 to 60 Hz
POE	802.3af (class 2)

Table 6. eBridge Interfaces

RS-232	DB-9 Serial, DCE device, RS-232 levels
Ethernet	RJ-45, 10-100BaseT Hub, 36-57 VDC PoE input
Mini-USB	USB Serial device
DC Voltage Input	10-30VDC DC Input

Table 7. eBridge Isolated Input/Output

Pin#	Signal	Direction	Description	Current
1	Input	Input	Isolated Output	1 mA (min) 2 mA (max)
2	Output	Output	Isolated Input	1 mA (min) 2.3 mA (max)
3	GND	—	Signal Ground (Common)	—
An isolated input and an isolated output are located at P2.				

Table 8. eBridge Power Consumption

Nominal - Idle	0.88 W
Nominal - TX	5 W
Max	7 W

Table 9. eBridge Approvals

FCC	Part 15.247
Industry Canada	RSS-210

Table 10. eBridge Protocols/Security

Addressing	Internet Protocol Version 6 (IPv6)
Security	Secure Hash Algorithm 256 bit (SHA-256)
RSA-1024 and / or ECC-256	
Encryption	256 bit Advanced Encryption Standard (AES-256)
Serial	Encapsulation over IPv6 (tunneling) for asynchronous serial (DNP3)

Table 11. eBridge DB-9 Interface Definition

Pin#	Signal	Direction	Description
1	DCD	Output	Data Carrier Detect
2	TXD	Output	Transmit Data
3	RXD	Input	Receive Data
4	DTR	Input	Data Terminal Ready
5	GND	--	Signal Ground
6	DSR	Output	Data Set Ready
7	RTS	Input	Request To Send
8	CTS	Output	Clear To Send
9	RI	Output	Ring Indicator

All RS-232 receptacles are standard DB-9 receptacle DCE pinout.

Table 12. eBridge RJ-45 Hub Interface Definition

Pin #	Signal	Direction	Description
1	RX+ (+V1)	Input	Receive Data + (+ Voltage Supply type 1)
2	RX- (+V1)	Input	Receive Data - (+ Voltage Supply type 1)
3	TX+ (-V1)	Output	Transmit Data + (- Voltage Supply type 1)
4	No Connect (+V2)	—	(+ Voltage Supply type 2)
5	No Connect (+V2)	—	(+ Voltage Supply type 2)
6	TX- (-V1)	Output	Transmit Data - (- Voltage Supply type 1)
7	No Connect (-V2)	—	(+ Voltage Supply type 2)
8	No Connect (-V2)	—	(+ Voltage Supply type 2)

Silver Spring Networks sBridge Specifications

This section contains the following tables to provide sBridge specifications:

- sBridge NAN Transceiver
- sBridge NAN Network
- sBridge Processing
- sBridge Physical
- sBridge Interfaces
- sBridge Environmental
- sBridge DB-9 Interface Definition
- sBridge DC Power Input
- sBridge Physical

Table 13. sBridge NAN Transceiver

Frequency[1]	902-928 MHz
Spread Spectrum Technology	FHSS (Frequency Hopping)
Transmitter Output	30 dBm
Channels[2]	83
Receiver Sensitivity	-98 dBm for 10-3 PER
Power, transmit	5.2 W nominal

1.Frequency range adjusted to meet country-specific requirements.
2.Channels are adjusted to meet country-specific requirements. Australia limited to 43 channels on frequency range 915-928 MHz.

Table 14. sBridge NAN Network

Addressing	8 byte MAC Address
Protocol	UDP/IPv6
Image Security	Secure bootloader
Payload Confidentiality	AES-256 Encryption
Authentication	ECDH and RSA Signatures

Table 15. sBridge Processing

Processor	ARM7
Clock Speed	19.2 MHz
RAM	4 MB
Flash	4 MB/8 MB

Table 16. sBridge Physical

Size	4.50” (w) x 2.48” (l) x 0.7’ (d)
Weight	
Power, idle	0.88 W nominal
Power, Max	7.0 W max

Table 17. sBridge Interfaces

RS-232	DB-9 Serial, DCE device, RS-232 levels
DC Voltage Input	10-30VDC DC Input

Table 18. sBridge Environmental

Temperature, operating	-40°C to +85°
Humidity	95%, non-condensing

Table 19. sBridge DB-9 Interface Definition

Pin#	Signal	Direction	Description
1	DCD	Output	Data Carrier Detect
2	TXD	Output	Transmit Data
3	RXD	Input	Receive Data
4	DTR	Input	Data Terminal Ready
5	GND	--	Signal Ground
6	DSR	Output	Data Set Ready
7	RTS	Input	Request To Send
8	CTS	Output	Clear To Send
9	RI	Output	Ring Indicator

All RS-232 receptacles are standard DB-9 receptacle DCE pinout.

Table 20. sBridge DC Power Input

Pin #	Signal	Direction	Input definition
1	GND	--	Signal Ground
2	+Voltage	Input	Voltage supply

Regulatory Compliance - Module Certifications

This section contains the following regulatory compliance information:

- FCC Certification (Radiated/Conducted Emissions Compliance FCC Part 15.247)
- Industry Canada Certification (Radiated/Conducted Emissions Compliance RSS-210)
- C-Tick Level 3 (Radiated/Conducted Emissions Compliance AS/NZS4268, AS/NZS4778)
- Silver Spring Networks NIC, FCC IDs: OWS-NIC515 IC: 5975A-NIC515 (sBridge) OWS-NIC506, IC:5875A-NIC506 (eBridge)

FCC Certification (Radiated/Conducted Emissions Compliance FCC Part 15.247)

The sBridge is compliant to FCC regulations for radiated and conducted emissions. The sBridge uses a 1W, 900 MHz, FHSS radio.

15.247(a)(1)

The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

15.247(g)

Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

15.247(h)

The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

Industry Canada Certification (Radiated/Conducted Emissions Compliance RSS-210)

The sBridge is compliant to ICC regulations for radiated and conducted emissions. The sBridge uses a 1W, 900 MHz, FHSS radio.

This device has been designed to operate with the antennas listed below, and having a maximum gain of 3 dBi (sBridge) and 6 dBi (eBridge). Antennas not included in this list or having a gain greater than 3 dBi (sBridge) or 6 dB (eBridge), are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

Table 21. Available antennas for Silver Spring Network bridges

SSN Antenna Part #	Description
315-00012 Rev. 5	JPole antenna
315-000002 Rev. A	sBridge: Rubber Duck, 3dBI maximum gain, SMA Female, Antenna eBridge: Rubber Duck, 6dBI maximum gain, SMA Female, Antenna

C-Tick Level 3 (Radiated/Conducted Emissions Compliance AS/NZS4268, AS/NZS4778)

The NIC is compliant to C-tick testing for radiated and conducted emissions in compliance with Australian Communications Authority (ACA) adopted standards from CISPR, CENELC, and IEC. The sBridge uses a 1W EIRP, 900 MHz, FHSS radio.

The C-Tick EIRP mark is filed under number N1571 for Silver Spring Networks.

Silver Spring Networks NIC, FCC IDs: OWS-NIC515 IC: 5975A-NIC515 (sBridge) OWS-NIC506, IC:5875A-NIC506 (eBridge)

The NIC515 must be professionally installed by a properly trained technician. Improper installation could void the user's authority to operate the equipment.

The device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

1. The device may not cause harmful interference.
2. The device must accept any interference received, including interference that may cause undesired operation.

Antenna

The antenna of this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

The device should be installed so that people will not come within 20 cm (8 in.) of the antenna.

This equipment has been tested and found to comply with Part 15 of the FCC Rules. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver disconnected.
- Consult the dealer or an experienced Radio/TV technician for help.

CAUTION: Changes or modifications not expressly approved by Silver Spring Networks could void the user's authority to operate the equipment.

Glossary

A

Access Point (AP) An Access Point is a router that performs the function of communicating over both a *Wide Area Network* (WAN) and the *Neighborhood Area Network* (NAN). See also *primary Access Point*.

alternate Access Point See *secondary Access Point*.

AMR (Automated Meter Reading) A form of advanced metering that uses communications devices to send data from the meter to the utility. This includes simple energy consumption data to outage detection and over-the-air meter programming.

ANSI American National Standards Institute. A standards organization that administers the standardization and conformity assessment system used in the U.S. and around the world. When ANSI adopts a standard, it disseminates a code to identify the standard. For example, ANSI Standard C12.19.

asynchronous In networking communications, an asynchronous signal occurs without a corresponding request for that signal. A last gasp from a meter is an example of an asynchronous signal.

attenuation The decrease in amplitude of a signal during its transmission from one point to another.

B

backbone device Normally a poletop device such as an Access Point or a Relay. In some cases, a meter that acts as a relay can be designated as a backbone device. In some cases, a Relay may not be a backbone device. All backbone devices are included in the backbone ping schedule.

backhaul To transmit data to a point from which it can be sent over a network (hauled back) to the data center.

bandwidth The amount of data transmitted in a given amount of time, usually measured in bits per second, kilobits per second, or megabits per second.

C

C&I (Commercial & Industrial) The reference to commercial and industrial energy and water customers.

capacitor bank Used to improve electric power system efficiency and to aid in transmission voltage stability during disturbances.Two varieties exist: distribution capacitor banks and substation capacitor banks. An example of an RTU device.

CDMA Code-Division Multiple Access. A digital wireless technology that uses *spread spectrum* technology to send its signals over a wider bandwidth than the original signal.

child A meter that is associated with a Relay is a child of that Relay. Similarly, a Relay is a child of the Access Point to which it is associated. A meter can also be a child of another meter. In this case, the parent meter is acting as a Relay.

churn Refers to endpoint devices recalculating the egress route to their preferred Access Point on a frequent basis. This is a sign of network instability because an endpoint's IP address may become stale, resulting in missed reads.

crumb A single node in a series of hops comprising a source-routed path. As a source-routed path is defined by the Master bridge or an Access Point, each hop in the dedicated downstream path is termed a 'crumb' as in a trail of 'bread crumbs.'

Customer Premise Equipment (CPE) Customer Premise Equipment is all telecommunications terminal equipment located on the customer premises, such as a cable modem, router, or access point.

D

DA-NEM Distribution Automation-Network Element Manager. A software application that allows users to manage the devices comprising a DA network. See also *distribution automation (DA)*.

DA Network A network of Silver Spring Bridges, Relays, and an Access Point, designed and deployed to establish communications to help manage electrical distribution devices such as reclosers, switches, transformers and capacitor banks.

dB Decibels. A logarithmic unit of measurement that expresses the magnitude of radio power.

dBm The power ratio in decibels (dB) of radio power relative to one milliwatt (mW).

dead area Locations from which effective transmission cannot be established because the transmitted signal is blocked by clutter. Also known as shadow.

decimal degrees A numerical way of expressing degrees, minutes, and seconds longitude from Greenwich, England and latitude from the equator:

`decimal degrees = degrees + (minutes / 60) + (seconds / 3600)`

Positive numbers indicate East longitude or North latitude. Negative numbers indicate West longitude or South latitude. For example, W 122° 28’, 39.3” longitude by N 37° 49’, 11.2 latitude expressed in decimal degrees is:

`-122.477583 longitude by 37.819778 latitude`

demand The highest requirement for power, that is, the amount of power required to satisfy the demand. There is no time element involved. The highest requirement for power can occur in an instant. In practice, most demand meters measure the average peak demand over the 15 or 30 minute period.

This definition of demand differs from *energy* in that energy is the usage of power over time whereas there is no time element in measuring demand. Demand is measured in kilowatts (kW) and energy is measured in kilowatt-hours (kWh).

For example, a demand for 100 kW continuous for an hour equals 100 kWh. If the demand rose to 400 kW continuous for the next hour, the demand for that hour equals 400 kWh. For the two hour period, the demand is 400 kW because that is the highest requirement for power. The energy used is 500 kWh because that is the actual usage of power over time.

See also *energy* and *time of use*.

device Access Point, Relay, or meter. Meters can be electric, gas, or water. See also *IMU*.

dissimilar neighbor A neighbor device that, because of its dissimilarity, maximizes the odds of receiving a last gasp from another device.

distance vector One of the two major classes of routing protocols, distance vector routing requires that a router periodically inform its immediate neighbors of any changes in its topology. A distance vector means that routes are advertised as a vector comprising several characteristics, including next hop address, egress interface, and metrics such as hop count. routers using such a protocol do not have knowledge of the entire path to a destination unless that destination is directly connected to them. Routing in the Silver Spring system uses a distance vector protocol on Layer 2.

distributed generation A distributed generation system involves small amounts of generation or pieces of generation equipment applied to a utility’s distribution system for the purpose of meeting local peak loads and/or displacing the need to build additional infrastructure. Distributed generation may be in the form of gas or propane generators, fuel cells, or solar.

distribution automation (DA) The computerized or intelligent control of the electrical power grid down to the distribution level. In recent years, DA has become nearly synonymous with *SCADA*.

distribution power A packaged power unit located at the point of demand. While the technology is still evolving, examples include fuel cells and photovoltaic cells.

DNS Domain Name System. An Internet service that translates alphanumeric domain names into numeric IP addresses. For example, the alphanumeric domain `www.silverspringnet.com` translated to its IP address through DNS is `64.207.187.4`.

downstream / upstream Refers to the relationship between devices along the route. Downstream refers to moving toward a meter. Upstream means moving toward an Access Point. See also *child* and *parent*.

E

eBridge A Silver Spring device that routes between an RF interface, an ethernet port and a serial port.

endpoint Meters, distribution controls, cap bank switches, and other specialized network devices. Many endpoints are assigned to nodes. See also *node*.

energized See *set*.

energy \The use of power over time, expressed in kilowatt-hours (kWh). See also *demand* and *time of use*.

ESN Electronic Serial Number. A unique identifier embedded on every cellular phone device by the manufacturer. The ESN is transmitted with each cell phone call and is used to authenticate the phone with the cellular service the phone is attempting to use.

exception polling A proactive outage detection technique where pings are sent to devices to see if they are still alive. Devices that do not respond may signify an outage.

export Meter read data, for a specific date and time, contained in a XML and HHF (Hand Held Format) files for integration with business systems.

F

FCI Faulted Circuit Indicator. A device that, if tripped, indicates a failed utility condition such as a power failure.

FHSS Frequency-Hopping Spread Spectrum. Originally developed during the Second World War to avoid jamming, FHSS is a method of sending radio signals over several frequency channels. Unlike DSSS, FHSS switches between channels in a pattern known to both sender and receiver, thereby avoiding interference in any one channel.

filter Band-pass filter, used to minimize out-of-band interference issues.

firmware A computer program embedded in a hardware device. See also *image*.

fresnel zone Refers to the elliptically shaped area formed by RF waves between a transmitter and a receiver.

FSU Field Service Unit. A portable NIC from Silver Spring used to install, test, and send commands to other SSN devices, including eBridges and sBridges.

ftp File Transfer Protocol. A protocol for transferring files over any network that supports TCP/IP.

G

gap Refers to a gap in the usage data collected from a meter. AMM automatically detects and fills such gaps. See also *end gap* and *unfillable gap*.

gas day A specific time of day when a gas meter begins its 24-hour day. For many utilities, the gas day is 9:00 AM, but this is not always the case.

generation capacity The maximum output (MW) that generating equipment can supply to system load.

grid operator The entity that oversees the delivery of electricity over the grid to the customer, while assuring consistently high levels of reliability, and public and worker safety. The grid operator potentially could be independent of the utilities and suppliers.

GWh Gigawatt-hours One billion watt-hours.

H

hash value A block of data represented as a string of bits. See also *program seal*.

Hata model A path loss estimation model based on empirical research of various mophologies such as Urban Core, Dense Urban, and Suburban.

HHF Files Hand Held Format file. Contains meter interval read data. See also *export*.

Home Area Network (HAN) A data communications system contained within the home.

hop When data is transmitted across a network, the packet hops from device to device. A hop is a point along a network route between the Access Point and the meter. Though technically not a device, a hop is always associated with a device, usually a Relay or meter acting a a Relay. See also *link* and *route*.

hosting location The physical location of an Access Point or Relay.

I

IDR Interval Data Recorder. A solid-state electronic device that measures consumption among high-usage commercial and industrial accounts. The data collected is used by a utility to determine peak demand times and adjust its distribution system accordingly.

IEEE Institute of Electrical and Electronics Engineers, a prominent standards body for the electrical, telecommunications, aerospace, and engineering industries.

IETF Internet Engineering Task Force, a prominent standards body for the development and evolution of the Internet networking architecture and the stable operation of the Internet.

image Firmware or software programming code that can be copied to multiple programmable chips in one or more devices, such as NICs or electricity meters. See also *firmware* and *code float*.

IMU Interface Management Unit. A two-way radio integrated with gas and water meters that provides consumption reads and can be remotely configured.

in-band interferers Transmitters in the same ISM band that are not part of Silver Spring' transmitters.

info success rate The percentage of *data* packets that succeed when a process sends a poll to a specific node and receives an acknowledgement. Calculated by:

```
(successes / (successes +
failures)) * 100
```

instrument transformer A step-down transformer for scaling down actual power system quantities for metering, protective relaying and system monitoring equipment. An example of an RTU device.

interferers See *in-band interferers* and *out-of-band interferers*.

IPv6 Internet Protocol Version 6. A network layer standard enables devices to communicate over a packet-switched network.

ISM band Industrial, Scientific, and Medical band. The 902-928 MHz band, an unlicensed frequency band governed by FCC, Part 15.

J

job In AMM, a job is a running or scheduled process, including but not limited to metering schedules, imports, exports, and reports. In common usage, the term *schedule* is reserved for jobs that read meters over the network.

jobs interface The web services API used to run and manage jobs.

joined A NIC and its meter are said to be joined when they have been assembled, configured, tested, and communicating together as designed. See also *unjoined*.

K

kVA Kilo Volt Ampere.

kVAh Kilo Volt Ampere Hours.

kVAR Kilo Volt Ampere Reactive. A measure of reactive energy usage. See also *V*, and *Vrms*.

kVAR lag The inductive reactance, or how much the voltage lags the current, of the circuit.

kVAR lead The capacitive reactance, or how much the voltage leads the current, of the circuit.

kVARh Kilo Volt Ampere Reactive Hours. A unit of energy equivalent to one kVAR of power expended for one hour. See also *V*.

kW Kilowatt. A unit of power equal to 1000 watts.

kWh Kilowatt-hour. A unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour.

L

lag See *kVAR lag*.

LAN Local Area Network. Computers and other devices that share a common wireless link within a geographic area. See also *NAN (Neighborhood Area Network*) and *Wide Area Network*.

last gasp An asynchronous message from an electricity meter that indicates the meter has lost power. Also known as a power out message. Last gasps can result when the loss-of-power pin becomes active, when a number of *zero crossing* events are missed, or when a transition from utility power to battery power occurs. There is no guarantee that a last gasp will be received by any other device in the network. See also *Verified Single No Current*.

link A connection between devices in a network. See also *hop* and *route*.

link quality The overall RF quality of a link between a transmitter and receiver. Often expressed in terms of message success rate and signal strength. See MSR and *RSSI*.

link budget The total amount of RF power available to establish a link between the transmitter and receiver, expressed mathematically:

```
PLinkBudget = PTx - PTxLoss +
PTxAntenna + PRxAntenna -PRxLoss -
PRxSensitivity
```

LOS Line of Sight. A direct path, free of clutter, between a transmitter and a receiver.

M

MAC Media Access Controller. A unique hardware identifier for network equipment.

MLME Media access control (MAC) Sublayer Management Entity. An internal process handler for establishing L2 network adjacencies and routing in the Silver Spring RF wireless mesh network.

MSR Message Success Rate. The percentage of packets that are transmitted (by the Access Point) *and also* acknowledged (by the meter). The MSR is derived from successful packet transmission during scheduled reads, On Demand reads, and segment retries. MSR is a metric for *packet transmission* and how well the Access Point can communicate with a meter. See also *BSR* and *RSR*.

N

neighbor table A memory structure within each NIC to store data about its neighboring NIC-enabled devices.

net metering Net metering applies to energy customers, such as commercial and industrial users, who both generate and purchase power. Utilities need to meter the power generated by customers to determine the credit the customer should receive. A net register calculates energy to be billed by subtracting power received from the customer from the power delivered to the customer.

network discovery When a new meter is first installed, it broadcasts a discovery message. The discovery message is received by all NIC-enabled devices in range, which in turn, forward the message upstream through an Access Point to AMM.

node A network device. Examples include electricity meters, Relays, and IMUs.

NIC Network Interface Card. Attached to electricity meters and integrated with Water and Gas IMUs, the NIC card provides two way radio communications across the network.

O

ODS Outage Detection System. An application from Silver Spring that manages outage-related messages from electricity meters, including *last gasp* and *power restore* messages. Unlike an OMS, and ODS does not include a *work order management system*.

OMS (OM) Outage Management System. A centralized system that manages the identification of all outage events and the restoration of service in a utility grid. An OMS system usually is tightly integrated with a *work order management system.*

one-time schedule A schedule with a frequency of one-time. See also *schedule*.

OSI Open Systems Interconnection. A standard reference model for how messages are transferred between any two points in a network. The OSI reference model defines seven layers of function that take place at each end of a communication. It serves as a standard by which diverse applications can communicate with one another.

over-the-air Wireless communications between devices. Sometimes used to refer to the programming of devices through wireless communications.

P

packets Packets consist of a header, which contains data such as destination address, and a payload, which contains application data such as interval read results. See *payload* and *ping*.

packets in flight The number of simultaneous packets being transferred between a sender and a receiver. A packet in flight is one that the sender has sent but the receiver has not yet acknowledged as received.

parent A network device to which other devices are registered.

path Refers to how cells, nodes, and endpoints are connected together. For example, the path from cell A to endpoint Z runs through node B. See also *route*.

path loss Total amount of power lost in the propagation of the RF signal from the transmitter to the receiver.

payload The payload is that part of a packet that is not the header. Payloads consist of application data such as interval read results. In the case of an On Demand ping, the user can set the payload size to increase or decrease the size of the packet. In RF networks, small packets can traverse the network more successfully than larger packets. When performing an On Demand ping, you can configure the payload up to 255 bytes. See also *packet* and *ping*.

peak demand The maximum level of use by customers of a system during a specified period.

peaking capacity Capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly, or seasonal loads.

peaking plant A power plant that normally operates only during peak load periods.

percentile Similar to the meaning of *median*, the percentile is a value within a range of values at which the percentage of the values lie at or below the expressed percentile. For example, 25% of the values lie at or below the 25th percentile, which implies that 75% of the values lie at or above the 25th percentile. Similarly, 75% of the values lie at or below the 75th percentile. The *median* can also be expressed as the 50th percentile.

ping Packet InterNet Groper or Packet InterNet Gopher. A program to test the reachability of devices on a network. The ping program sends a *packet* to the named device and returns data indicating how long, in milliseconds, the packet took to reach the device and return (also known as round trip time). See also *On Demand*, *packet, reachable*, and *traceroute*.

port In networking, a port is used in conjunction with a computer address and specifies a process running on the destination computer.

potential transformer A step-down transformer used to scale down very high voltages to levels that are safer for instrument operation. For example, 600:1 scale factors are not uncommon with potential transformers. A common device in substations.

power out message See *last gasp*.

preferred Access Point See *primary Access Point*.

primary Access Point The best performing, most reliable Access Point as determined by the endpoint device. See also *secondary Access Point*.

protocol An agreed upon format for transmitting data between two devices. Protocols have rules that govern the syntax, semantics, and synchronization of communication. Protocols may be implemented by hardware, software, or a combination of both.

Q

queue A list. In AMM, a list of meters associated with a schedule is referred to as a queue. In general computing, a queue can be a list of commands to execute one by one. See also *requeue*.

R

rate structure The various rates charged by a utility for its services.

RDBMS Relational Database Management System, such as Oracle.

reactor High-voltage inductors used as a shunt to regulate transmission voltage and to reduce fault current in transmission lines. An example of an RTU device.

read (meter read) The collection of usage data from a meter. Collections of meter reads are referred to as read data.

reachable The ability to send and receive data to and from a meter. A reachable meter is usually readable. However, a meter may be reachable with small packet sizes, but may not be readable with the larger packet sizes necessary for a successful read.

recloser Similar to a circuit breaker, a recloser is equipped with a mechanism to automatically close the breaker after it has opened due to a temporary electrical fault. An example of an RTU device.

relay A device on a network used to extend the reach of a network. Relays are typically placed high for best line-of-sight to meters. Normally, several meters are associated with each Relay and several Relays are associated with an Access Point. Meters can also act as a Relay. See also *reachability*.

remote CHAP password See *CHAP*.

remote provisioning See *remote service management*.

remote telemetry units (RTUs) A broad category of electrical distribution devices including different types of transformers, capacitor banks, reclosers/ circuit breakers, and many other device types.

route The route from an Access Point to a Relay or a bridge, or to one or more meters. Routes can be network discovered, static, or temporary. In the context of DA, a network discovered route is determined automatically by the takeout point (an eBridge or Access Point) when a new remote bridge is set and it broadcasts a discovery message across the network. A static route is a user-defined route saved and used for all subsequent communications. A user-defined static route overrides all network discovered routes. When performing an On Demand ping, a user can specify a one-time route to a destination that is not saved or re-used.

RF Radio Frequency.

RSSI Received Signal Strength Indicator. A way to measure the strength of a received radio signal.

run A schedule run consists of the initial attempt and all retries of all meters associated with the schedule, plus the initial attempt and all retries of re-queued meters.

S

sBridge A Silver Spring device that routes between an RF interface, and two serial ports.

SCADA (Supervisory Control and Data Acquisition) A computer system that supervises and controls the electric utility distribution and transmission system. In recent years, SCADA has become nearly synonymous with *distribution automation*.

secondary Access Point The next best performing, most reliable Access Point as determined by the endpoint device. See also *primary Access Point*.

set A device is set once it is physically installed and connected to electricity. Sometimes, this is referred to as *energized*.

Smart Grid Refers to technologies that enable a highly communicative, predictive, and self-healing utility grid.

SOAP Simple Object Access Protocol. A protocol for exchanging XML-based messages over a computer network. SOAP provides a basic messaging framework for web services.

source select Corresponds to a measurement channel configured on an electricity meter. Each channel measures a particular source, such as energy delivered in dWh.

source route A TCP routing construct, normally termed a ‘Loose Source route,’ in which a distant node establishes the best possible path, hop by hop, through a complex network to its destination..

sparse deployment A range-limited deployment where relatively few endpoints operate at minimum signal strength. See also *dense deployment* and *spot deployment*.

spot deployment Deployments to read a small number of relatively contained endpoints, such as in an office park. See also *dense deployment* and *sparse deployment*.

spectral inspection A spectrum analyzer can be used to determine potential sources for *out-of-band interference*.

standard tables Tables in electricity meters that conform to ANSI Standard C12.19.

standby facility A facility that supports a utility system and is generally running under no-load. It is available to replace or supplement a facility normally in service.

standby service Support service that is available as needed to supplement a consumer, a utility system, or to another utility if a schedule or an agreement authorizes the transaction. The service is not regularly used.

states The states that apply to devices in a Silver Spring Network are of three types: CIS device states, network states, and operational states.

static route A user-defined route between Access Points, Relays, and meters. When you define a static route, it overrides all network discovered routes. See also *network discovery*.

substation A facility in an electricity distribution system used for switching and / or changing or regulating the voltage of electricity. A substation is the location where high voltage transmission lines connect to switchgear and step-down transformers to produce lower voltages at lower power levels for local distribution networks.

switching station Facility equipment used to tie together two or more electric circuits through switches. The switches are selectively arranged to permit a circuit to be disconnected, or to change the electric connection between the circuits.

T

TCP/IP Transmission Control Protocol / Internet Protocol. A suite of communications protocols used to connect hosts on the Internet. TCP/IP is the defacto standard for transmitting data over networks.

topology The physical layout of a distribution network infrastructure with specific hierarchical identification of all components.

traceroute A networking utility to track the routes taken by packets across a network. See also *ping*.

trap An asynchronous event, often in a managed subsystem.

tunnel In networking, a tunnel allows the encapsulation of the data of one protocol within another protocol. By using a tunnel, you can pass the encapsulated data over an incompatible network or provide security for transferring data over an untrusted network.

U

UTM Universal Transverse Mercator. The UTM system divides the globe into 60 North-South zones, each measuring six degrees wide in longitude. Zones are numbered consecutively from West to East. Positions on the globe are given by zone coordinates, then the number of meters East (easting) or West (westing) from the center of the zone, and finally by the number of meters North (northing) or South (southing) from the center of the zone. UTM coordinates for the Golden Gate Bridge are zone 10 S, 545980m E. 4185742m N.

V

V Volts or voltage. See also *kVA*, *kVAh*, *kVAR*, and *kVARh*.

VEE Validation, Estimation, and Editing. Software tools that manage data collected from *endpoints*.

Verified Single Outage (VSO) A *last gasp* followed by a *measurable duration*.

Voltage regulator An electrical device for regulating the voltage through a circuit, to provide customers with steady and consistent voltage flow. Normal practice is to try to regulate voltage flow within nominal 124Vac to 116Vac. An example of an RTU device.

W

WAN Wide Area Network. A dispersed telecommunications network. In contrast to a local area network (LAN) or neighborhood area network (NAN), a WAN often includes public networks. See also *Local Area Network* and *Neighborhood Area Network*.

Work Order Management System (WOMS) In the utility industry, a software application used to dispatch work crews to perform repairs. Such systems are often integrated with *outage management systems*.

X

XML Extensible Markup Language. An standard, structured file format for exchanging business data over networks. Silver Spring exports interval data to XML files, which can then be imported into back-end business systems.

Z

zero crossing The event of standard AC line voltage crossing the zero volt, or reference level, from positive to negative or negative to positive. An electricity meter monitors its zero crossings and interprets their absence as a loss of power.

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