Secondary Network Monitoring with Meshed PLC Communications

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Value of a Secondary Network Monitoring System

- **A Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.**

- **This will translate into significant capital investment savings for electric power delivery companies.**

Typical Secondary Network Monitoring System

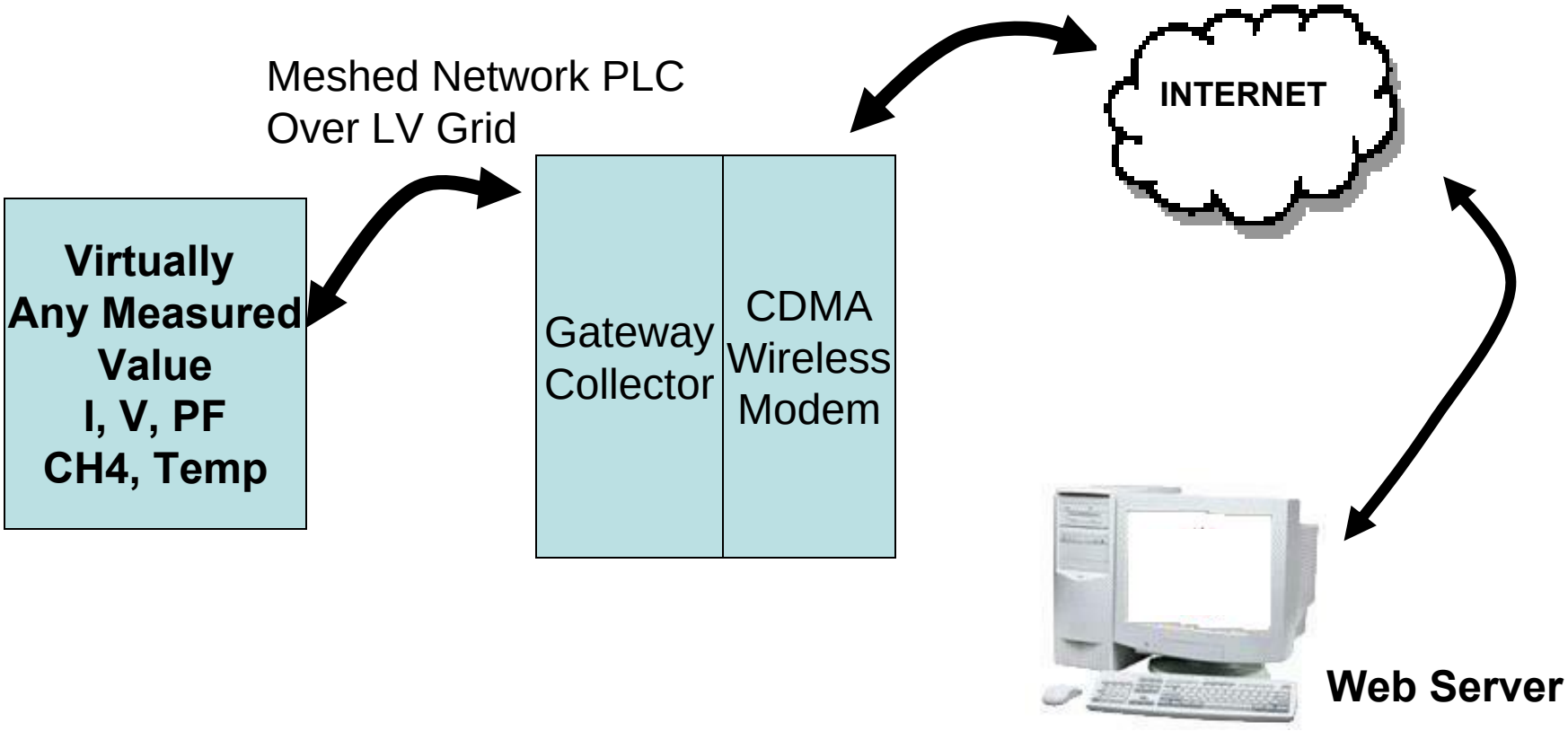
Utilities Can Monitor Virtually Any Measured Parameter in the Manhole or Transformer Vault

Bi-Directional PLC Communications over the LV Grid

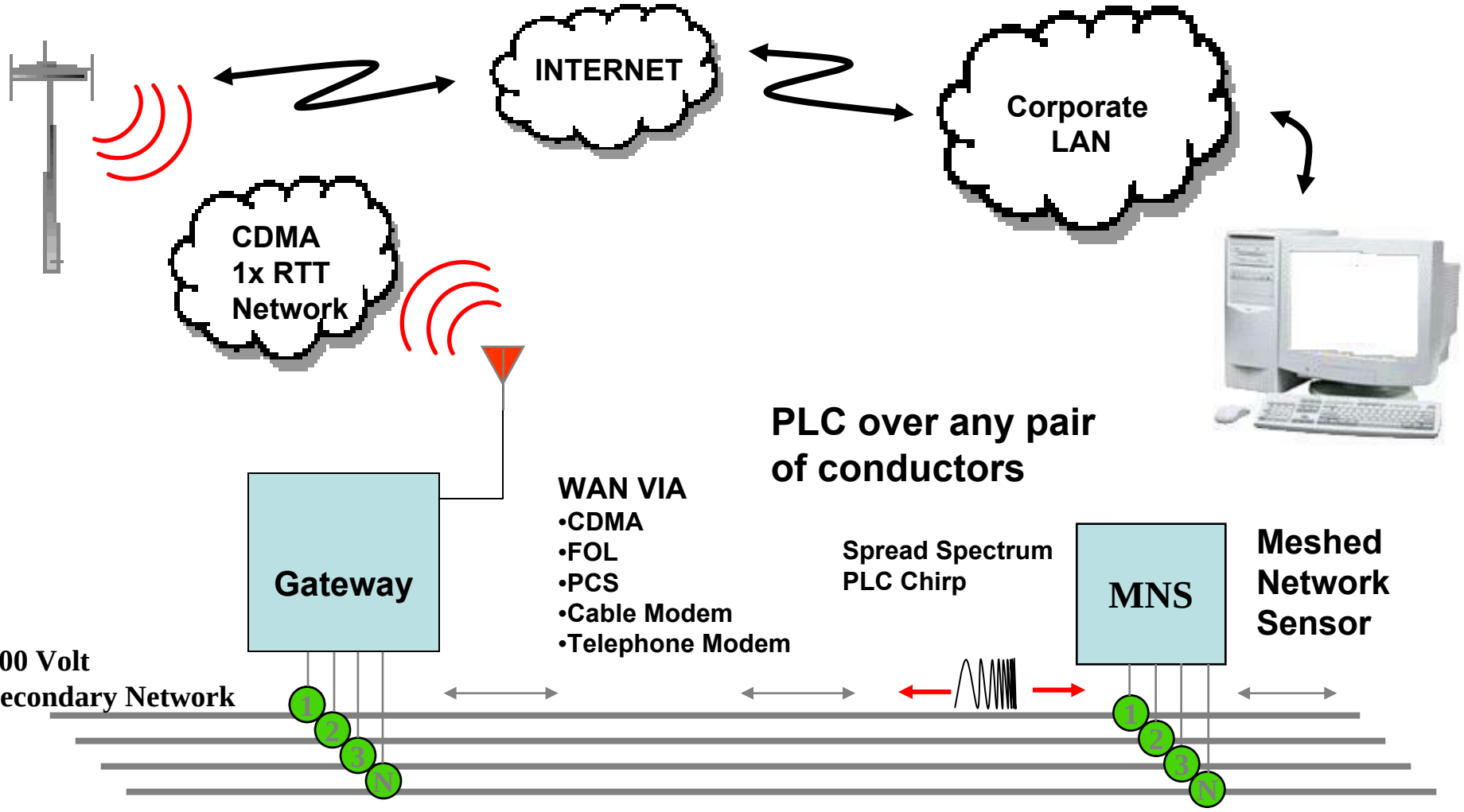
Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers

Secondary Network Monitoring
WAN Communications

An integrated communication system to back-haul virtually any measured value using Meshed Network Power Line Carrier (PLC) Communications.



Meshed PLC to CDMA Communications Over The LV Power System

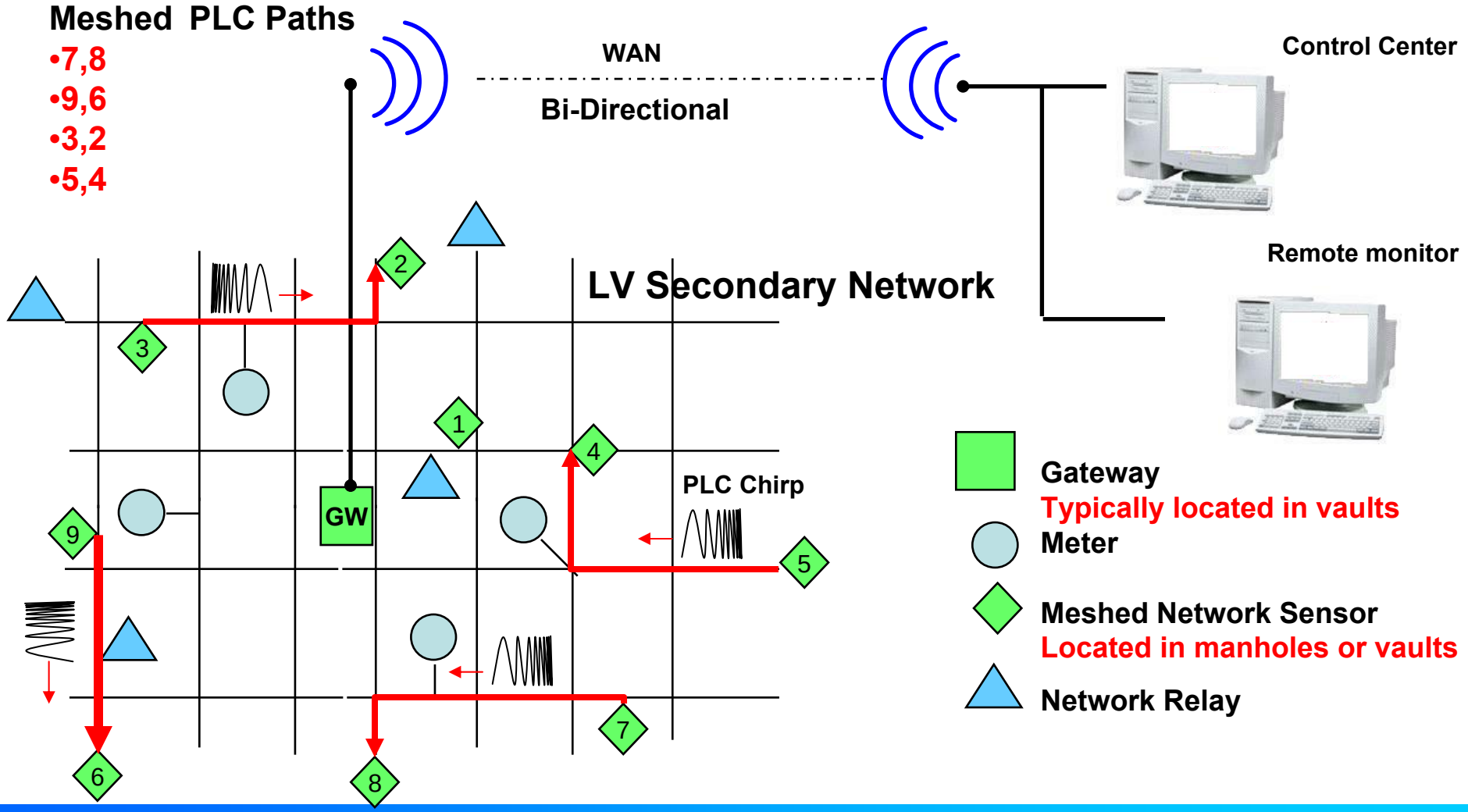


Smart System Build-out

1. Site and install the GW
2. Install 1 or more Modular and Scalable Meshed Network nodes
3. Use the Phase Identification System to guarantee proper phase installation
4. The system monitors the network performance so you don’t have to!
   - Each Utility can select the measured parameters, warning thresholds, and what is reported.

MESHED Data Flow

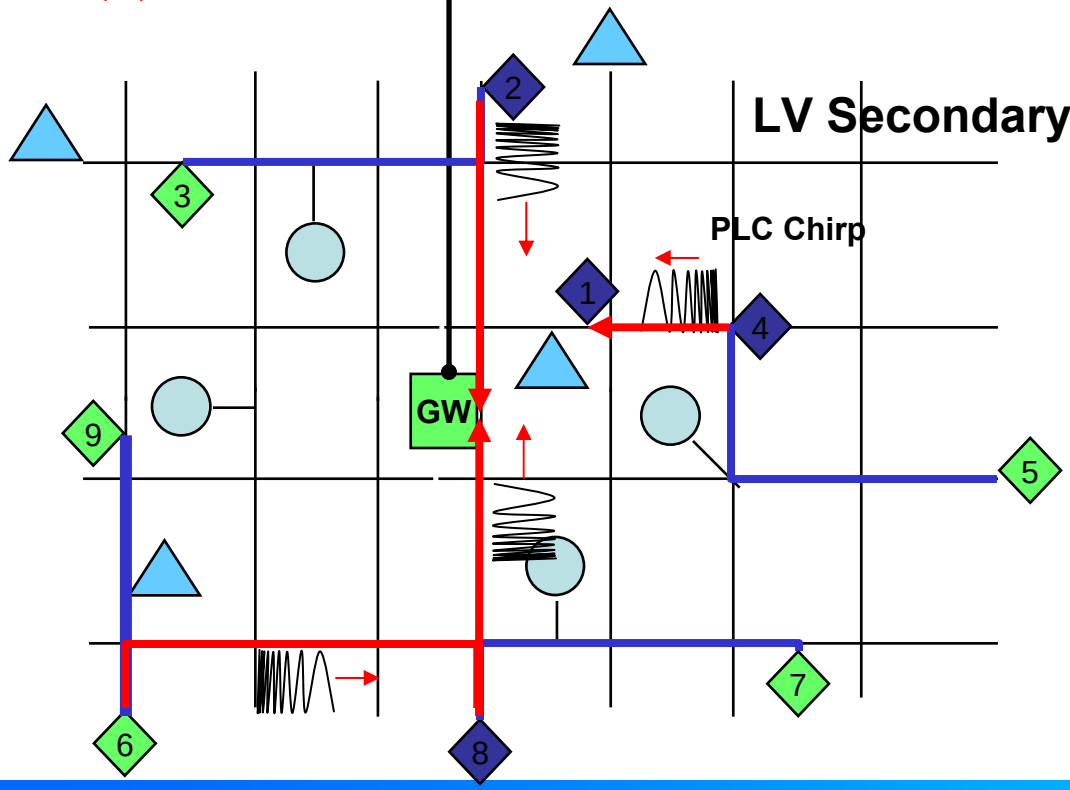
1St Hop Toward GW



MESHED Data Flow

2nd Hop Toward GW

Meshed PLC Paths
- 7,8,GW
- 9,6,8
- 3,2,GW
- 5,4,1



MESHED Data Flow

3rd Hop Toward GW

Meshed PLC Paths
- 7,8,GW Complete
- 9,6,8,GW
- 3,2,GW Complete
- 5,4,1,GW

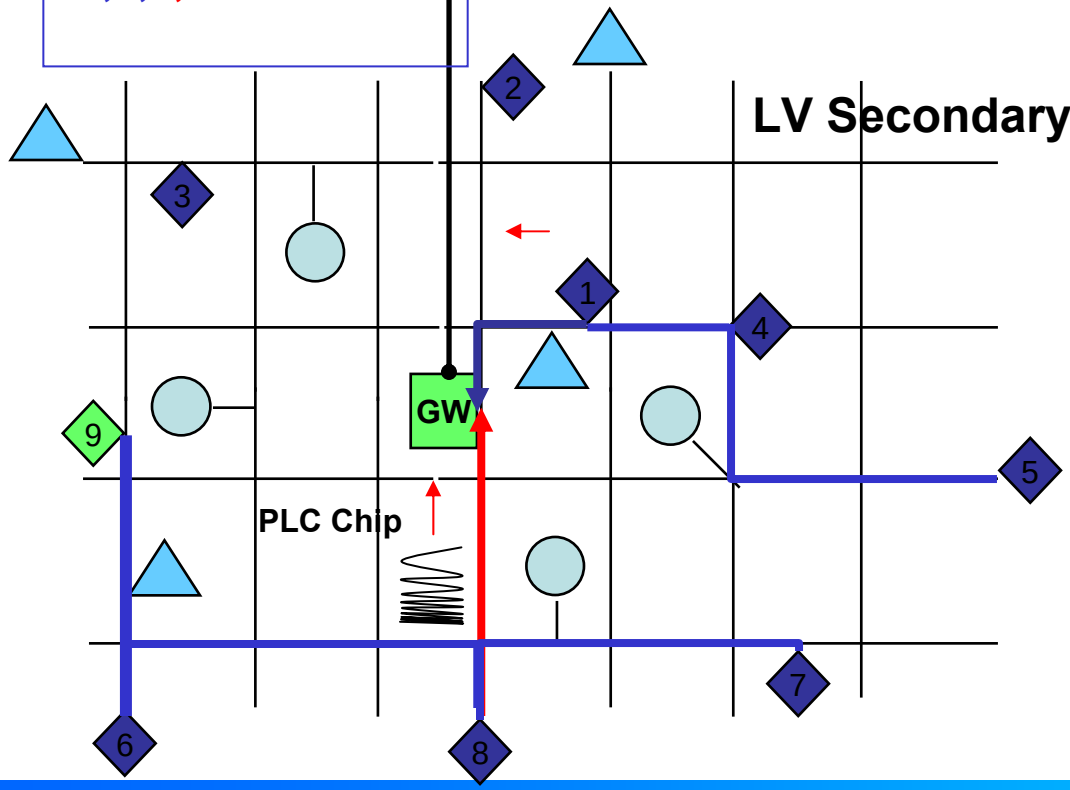
WAN

Bi-Directional

Control Center

Remote monitor

LV Secondary Network



Gateway
Typically located in vaults

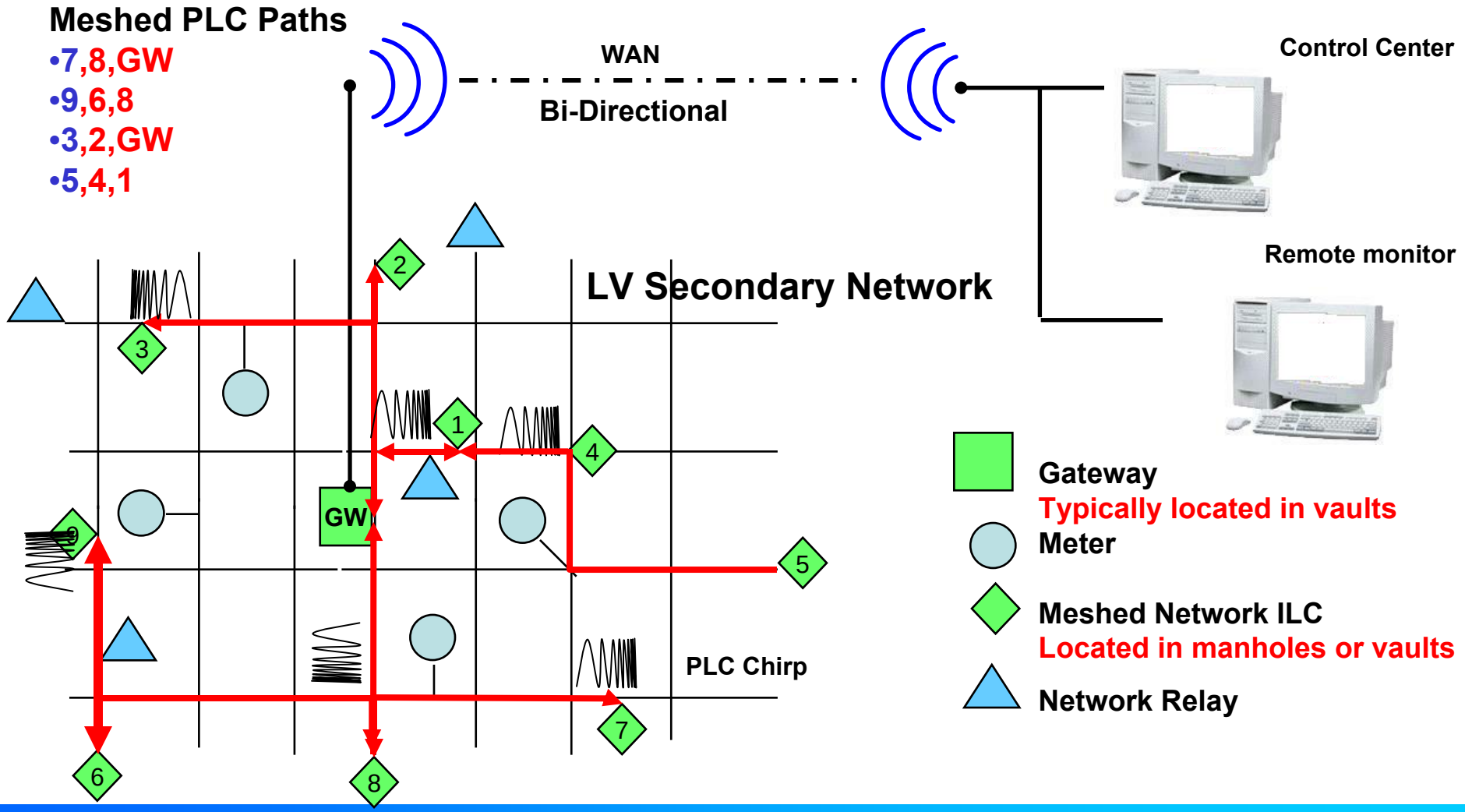
Meter

Meshed Network ILC
Located in manholes or vaults

Network Relay

MESHED Data Flow

Active Communications



Equipment Installation

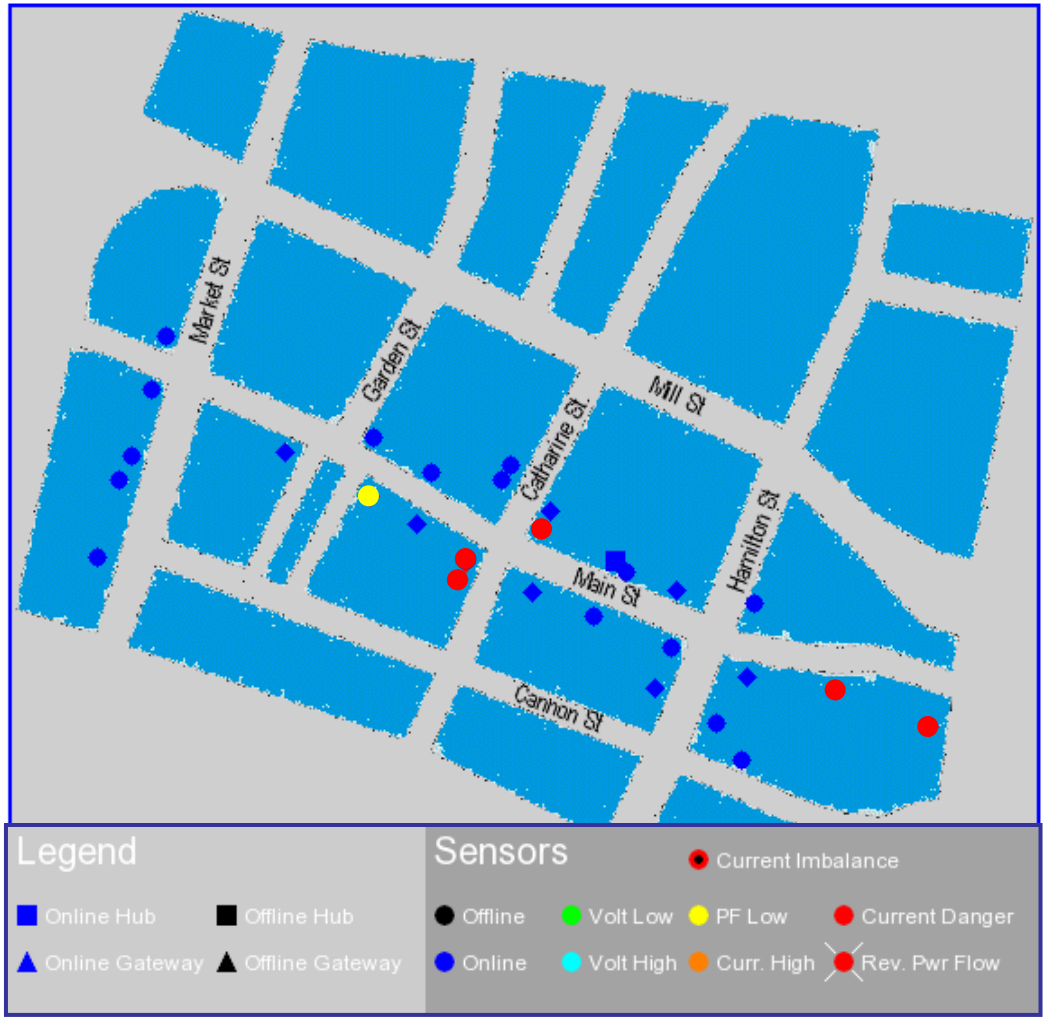
- Spliced LV Connections were easily installed by the Service Crews at Con Ed and CHU
- Gateway, and CDMA Antenna were easily installed by Service crews at Con Ed and CHU
- CDMA antenna easily communicates through grated vault covers
- Cable Phase Identification was simple with the Phase ID System
- Meshed PLC communications enable 98 Percent or higher communication reliability

Secondary Network Monitoring
“List View”

Gateway Information			
Location	**Gateway**	**Number of remotes**	**Last Update Received**
Unknown (Unkn)	01	0	Sun 4 Feb 16:54:03 EST 2007
MAN0110151 (MH 151)	04	22	Mon 12 Feb 12:30:03 EST 2007

Remote Data (Click Here For Map)						
Location (click for details)	**Xform**	**Address**	**Gateway**	**Last Upd.**	**Type**	**Data**
MAN0110148 (MH 148)	PK1329	2131	04	Mon 12 Feb 12:25:36 EST 2007	Volts/Amps/Phase	Amps: 408.00 395.90 396.90
MAN0110042 (MH 42)	PK0309	2128	04	Mon 12 Feb 12:25:58 EST 2007	Volts/Amps/Phase	Amps: 0.00 0.00 0.00
MAN0110146 (MH 146)	PU1270	2110	04	Mon 12 Feb 12:24:31 EST 2007	Volts/Amps/Phase	Amps: 1012.00 1478.00 907.00
MAN0110147 (MH 147)	PO1351	2136	04	Mon 12 Feb 12:26:36 EST 2007	Volts/Amps/Phase	Amps: 0.00 0.00 0.00
MAN0110138 (MH 138)	PU1168	2102	04	Mon 12 Feb 12:24:53 EST 2007	Volts/Amps/Phase	Amps: 232.70 257.20 249.60
PB0110113 (PB 113)	(Hub)	2123	04	Mon 12 Feb 12:24:20 EST 2007	Hub	Hop count: 1
PB0110130 (PB 130)	(Hub)	2112	04	Mon 12 Feb 12:24:47 EST 2007	Hub	Hop count: 1
PB0110171 (PB 171)	(Hub)	2124	04	Mon 12 Feb 12:21:04 EST 2007	Hub	Hop count: 2
PB0110086 (PB 86)	(Hub)	2116	04	Mon 12 Feb 12:25:31 EST 2007	Hub	Hop count: 2
PB0110260 (PB 260)	(Hub)	2117	04	Mon 12 Feb 12:25:47 EST 2007	Hub	Hop count: 2
PB0110106 (PB 106)	(Hub)	2122	04	Mon 12 Feb 12:26:09 EST 2007	Hub	Hop count: 2
MAN0110115 (MH 115)	PK0307	2108	04	Mon 12 Feb 12:24:58 EST 2007	Volts/Amps/Phase	Amps: 603.00 566.00 601.00
MAN0110030 (MN 30)	PK0305	2134	04	Mon 12 Feb 12:25:14 EST 2007	Volts/Amps/Phase	Amps: 283.70 279.90 287.70
MAN0110141 (MH 141)	PU1167	2135	04	Mon 12 Feb 12:23:20 EST 2007	Volts/Amps/Phase	Amps: 0.00 0.00 0.00
MAN0110151 (MH 151)	PO1307	2105	04	Mon 12 Feb 12:23:36 EST 2007	Volts/Amps/Phase	Amps: 0.00 0.00 0.00
MAN0110083 (MN 83)	PU1164	2127	04	Mon 12 Feb 12:23:58 EST 2007	Volts/Amps/Phase	Amps: 229.90 206.40 240.90
MAN0110049 (MH 49)	PK0249	2141	04	Mon 12 Feb 12:26:31 EST 2007	Volts/Amps/Phase	Amps: 383.50 370.20 364.30
MAN0110154 (MH 154)	PO1560	2150	04	Mon 12 Feb 12:26:42 EST 2007	Volts/Amps/Phase	Amps: 14.20 2.70 15.40
MAN0110140 (MH 140)	PU1098	2106	04	Mon 12 Feb 12:24:14 EST 2007	Volts/Amps/Phase	Amps: 302.20 293.90 314.00
MAN0110155 (MH 155)	PU1053	2107	04	Mon 12 Feb 12:25:09 EST 2007	Volts/Amps/Phase	Amps: 0.00 0.00 0.00
MAN0110182 (MH 182)	PO1344	2130	04	Mon 12 Feb 12:25:03 EST 2007	Volts/Amps/Phase	Amps: 0.00 0.00 0.00
PB0110076 (PB 76)	(Hub)	2118	04	Mon 12 Feb 12:23:42 EST 2007	Hub	Hop count: 4

Secondary Network Monitoring "Map View"



Transformers Overloading can be added to the Map View

The interactive map allows single-click access to each individual mesh network node's detail data page. If a mesh network node has sensors (indicated by a filled circle icon), additional data can be accessed from the detail data page.

Map Visualization Key

Rank	Indication	Symbol
1 or lowest	No Data	
2	No Communications, ≥ 1Hr	
3	System Nominal	
4	Voltage Low, ≤ 114 V	
5	Voltage High, ≥ 126 V	
6	Low PF, ≤ 0.7	
7	High current, ≥ 100% load	
8	Very High current, ≥ 150% load	
9	Current imbalance, ≥40 %	
10 or highest	Reverse power flow	

Map Icons are prioritized in order of importance.

A higher rank event will supersede lower rank conditions.

Reverse power flow supersede all other conditions for map display.

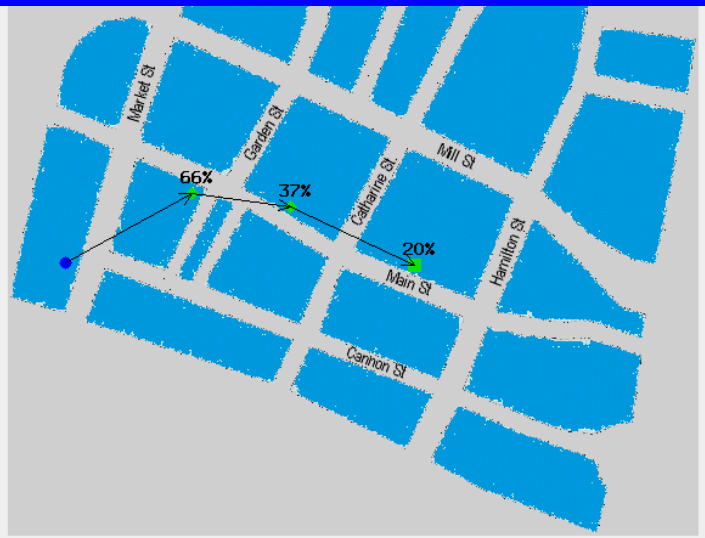
Secondary Network Monitoring
“Graph List View”

Detailed Information	Back to Map Selection Screen	Back to Text Summary Screen
Manhole MAN0110141 (MH 141)	Transformer PU1167, 750 kVA	Unit Serial Number 2135
Graph List	Text View	History View

The route taken by the last data transmission. The blue circle is this unit, the green diamonds (if any) are units acting as hubs, and the green square is the gateway in use. The RSSI value at each hop is shown above that hop.

Graph Data Times:
Start data point:
Sun 11 Feb 13:42:15 EST
Ending data point:
Mon 12 Feb 12:22:31 EST

By combining the Load History and Communication Path History, CHU can triangulate on cable trouble locations.



Select a different graph:

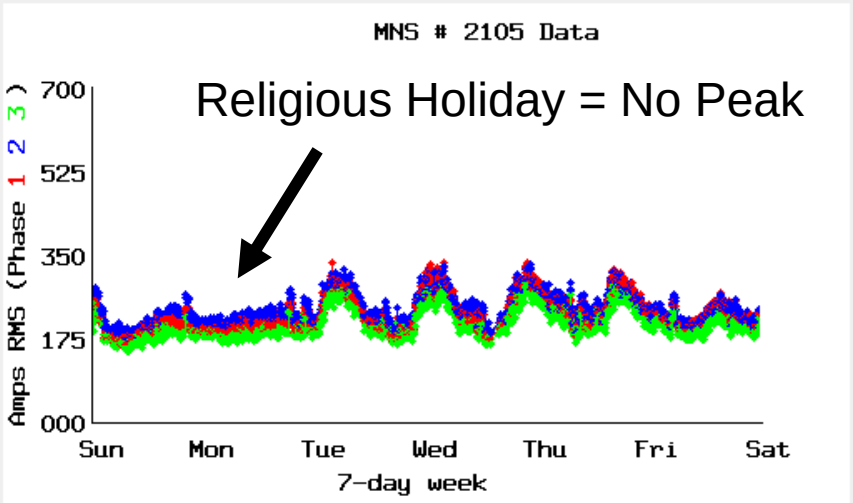
Polyphase Currents
Communication Signal Info
Communications Path Map
Phase 1 Details
Phase 2 Details
Phase 3 Details

Secondary Network Monitoring "History View"

Daily Load profiles are captured and can be used for various purposes: Like Day Ahead Load Forecasting

Detailed Information	Back to Map Selection Screen	Back to Text Summary Screen
Manhole MAN0110151 (MH 151)	Transformer PO1307, 750 kVA	Unit Serial Number 2105
Graph List	Text View	History View

Graph Data Times:
Start data point: Sat 23 Dec 23:03:12 EST
Ending data point: Sat 30 Dec 22:57:06 EST
Download this graph's data in CSV format.



Graph Display Control

Select a different historical graph:

Polyphase Currents
Phase 1 Details
Phase 2 Details
Phase 3 Details

Select a different graph timeframe:

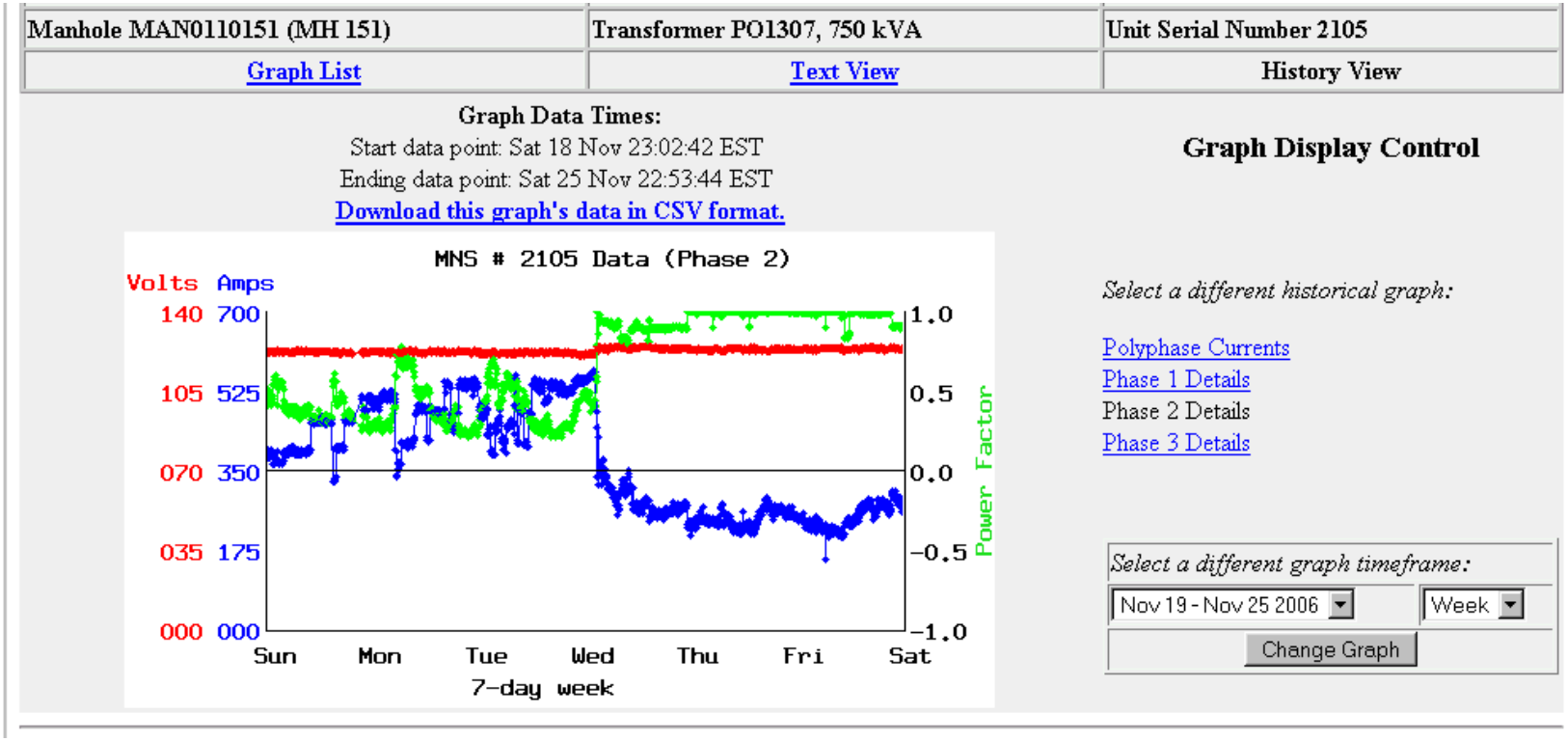
Dec 24 - Dec 30 2006 | Week

Change Graph

Power Companies Can See LV Network Changes

”Important LV Network Diagnostics Can Be Used”

A small voltage imbalance between the PO and (PK,PU) Primary Feeders caused significant circulating currents on the LV side. PSI’s PF Monitoring discovered the field deviation and captured the CHU corrective action.



Field Experience

This equipment has been installed on Secondary Networks

- Consolidated Edison 2005/2006 in Queens, NY over 5 city blocks
- Central Hudson Gas & Electric 2006/2007 throughout the LV Network in Poughkeepsie, NY

CHU is currently monitoring the Secondary Network on most the Network Transformers in Poughkeepsie, NY. The installed system will measure and report the 3 phase currents; voltages and 4 quadrant phase angles at all network transformers over the Meshed PLC Communications System.

CHU will use a single GUI/Server to simultaneously monitor the Secondary Network systems in 3 cities.

What Can Be Reported

From the Powerline sensors

- Individual cables currents
- Voltages at specific points
- Cable limiter status
- AOB “alive on back feed”

From Compatible Relay Controls

- Network protector relay controls
- Network protector relay status

From the meters and sensors

Customer power consumption

Secondary Network Monitoring System

- Low cost and easy to install
- Intelligence is at the Smart Sensor Nodes
- Data processing and analysis of line conditions at the Smart Nodes
- Communications are incorporated in the Network Sensor Nodes
- Smart Nodes are direct line powered

Meshed PLC Networks

A fully meshed communication architecture has been developed for use with Spread Spectrum Power Line Carrier (PLC). The resulting Local Area Network (LAN) system was specifically designed for use in electric power delivery grids. In this system architecture the individual nodes can participate as routers for other nodes in the network.

• Conventional PLC systems are concerned with circuit obstacles and must install additional gateways in central locations to overcome these obstacles. Typically, these systems are not well suited for utility automation applications.

• In a mesh network, the system architecture is designed with the expectation that obstacles will be encountered. Each end device, sensor or meter in the network can act as a repeater. This eliminates the need for numerous gateways, and provides increased flexibility in gateway sighting.

• In other words the gateway itself does not have to directly reach all end points.

• Meshed PLC is less expensive to implement and operate than conventional PLC networks involving radial branches and centralized gateways.

Meshed PLC Advantages

Historically, PLC communications for sensing and control in utility applications, although desirable, was impractical because of communication range and reliability limitations of the radial network architectures.

- Meshed PLC networks use flexible, multi-hop networking to optimize communications for maximum efficiency and reliability.

- Each network node is in direct communication with its immediate neighbors, and if a single node fails or a branch of the power grid fails message packages are automatically re-routed through another path.

- Meshed PLC networks combine the benefits of radial and mesh PLC topologies to provide the optimal communication efficiency, flexibility and reliability required for utility applications in sensing and control.

Conclusions

- The Secondary Network Monitoring System has demonstrated excellent communications reliability.
- CDMA communications from below grade in transformer vaults is easy to install and provides excellent communications reliability.
- Meshed PLC communications has proved itself as a viable communications backbone for generalized measurements in Secondary Networks.
- A scaleable system that is Field Proven

Thank you for the opportunity to present a Secondary Network Monitoring System at the Fall 2007 ICC.