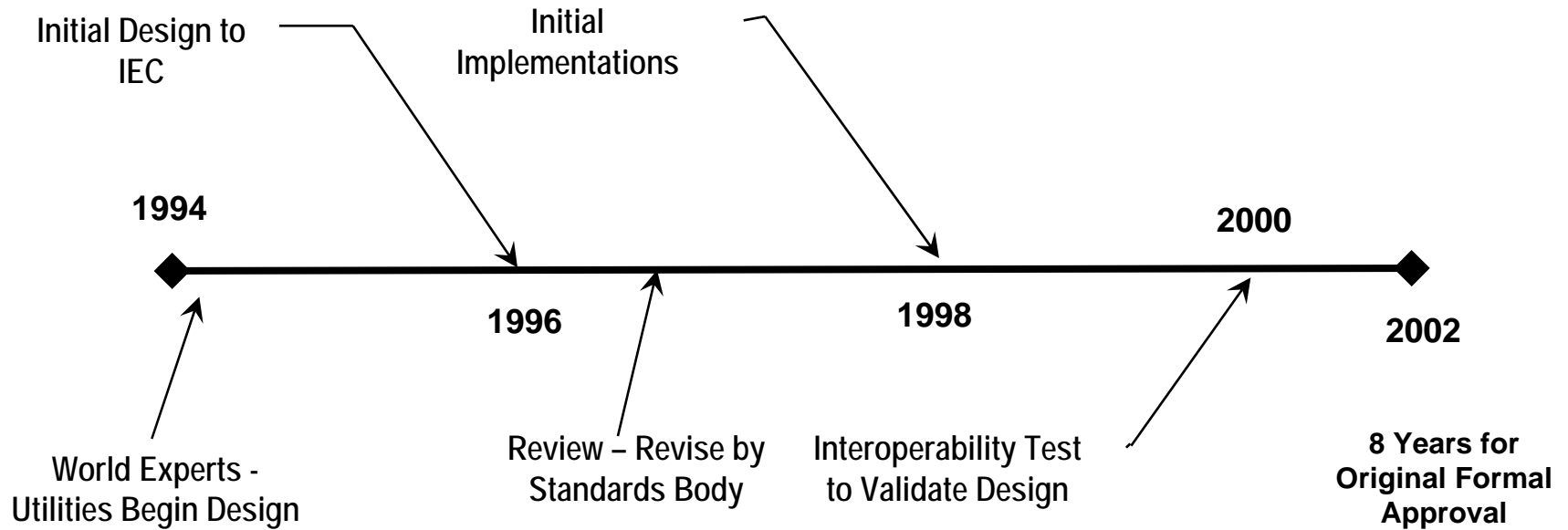


It Takes Time to Develop and Adopt Standards.....

Example of Utility Energy Management System (EMS) Standard



EPRI's IntelliGrid Research Results Can Significantly Accelerate the Development of Standards for Exchanging Information with DR Ready Appliances

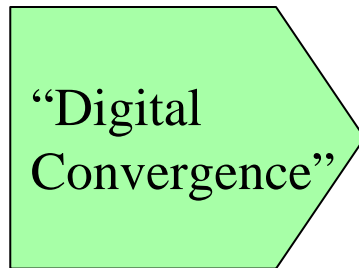
Home “Automation” Standards...

1985



2007

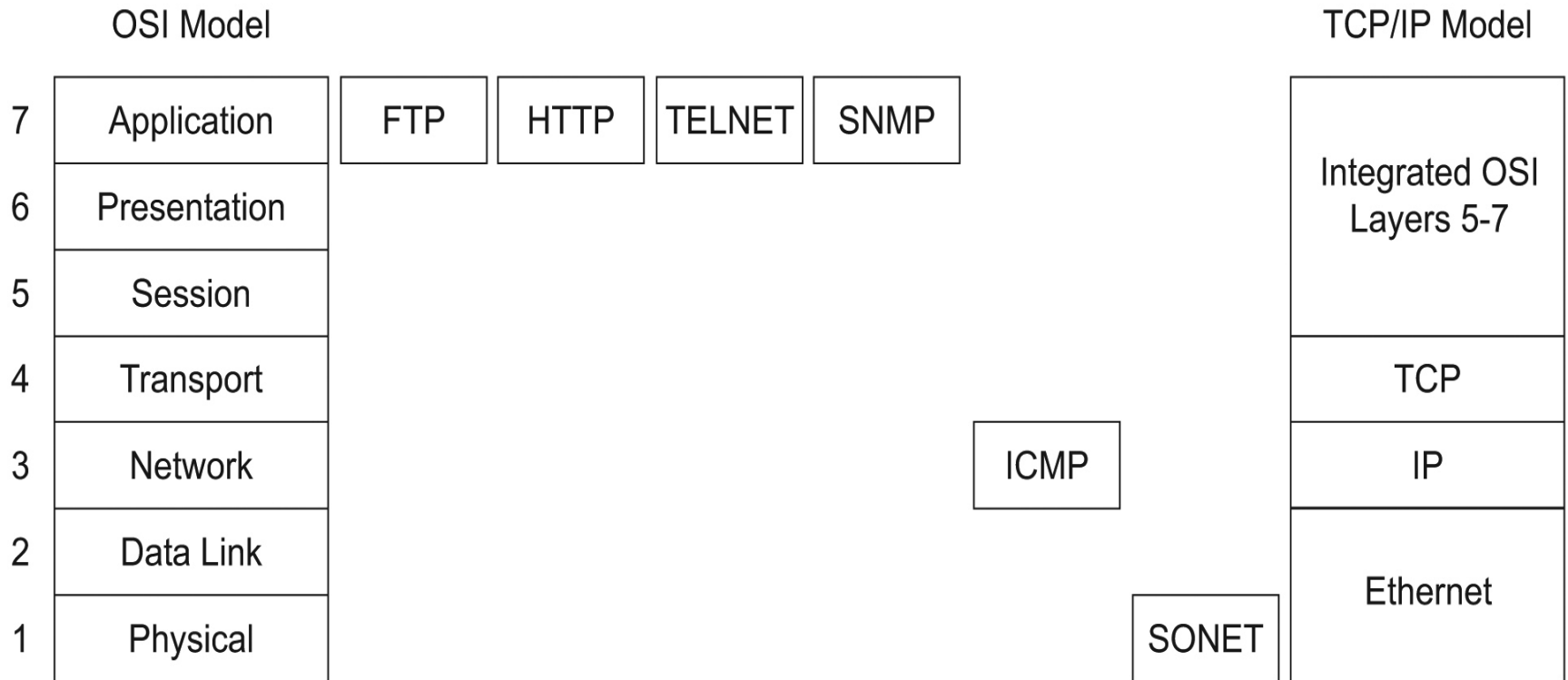
X-10™
CEBus©
LonWorks™
Smarthouse™



“Digital
Convergence”

- X-10™
- CEBus©
- Lonworks™
- Smarthouse
- Firewire
- CAL/HPnP
- Home RF
- Bluetooth
- SWAP
- WLIF
- Home PNA
- Home API
- HES
- SNAP
- HOP
- UPnP
- ATM RBB
- Jini/Java
- HAVi
- OSGi
- IRDA
- VESA
- WLIF
- SOAP
- HomePlug
- ZigBee
- UWB
- AHAM CHA
- Ethernet
- IPvX
- WSDL
- UDDI
- XML
- EIB
- Konnex
- BACnet
- HomeGate

7-Layer Communication Protocol Architecture



Home Area Network Communication Protocol Stack View

	OSI Model	HomePlug	Insteon	Z-wave	Zigbee	TCP/IP Model
7	Application	7	Integrated OSI Layers 1-7	Integrated OSI Layers 5-7	7	Integrated OSI Layers 5-7
6	Presentation	Integrated OSI Layers 4-6			4	
5	Session			5		
4	Transport	3		4	4	TCP
3	Network	2		3	3	IP
2	Data Link	1		2	2	Ethernet
1	Physical			1	1	

- Z-wave & Insteon are the two major players in this market (70% of current market)
- HomePlug and ZigBee are gaining market share in HAN automation & control through utility-based DR program offering

What are the features of the ZigBee protocol?

- Low power low bandwidth wireless protocol
- Operates at 2.4 GHz ISM Band in the US
- Uses an RF Mesh topology
- Publicly available spec
- Physical and Data Link Layer is governed by the IEEE 802.15.4 standard
- Stack in Layers 3-7 has not been approved by any Standards Development Organization (SDO)
- Pro Stack has the Smart Energy Application Profile at the Application Layer



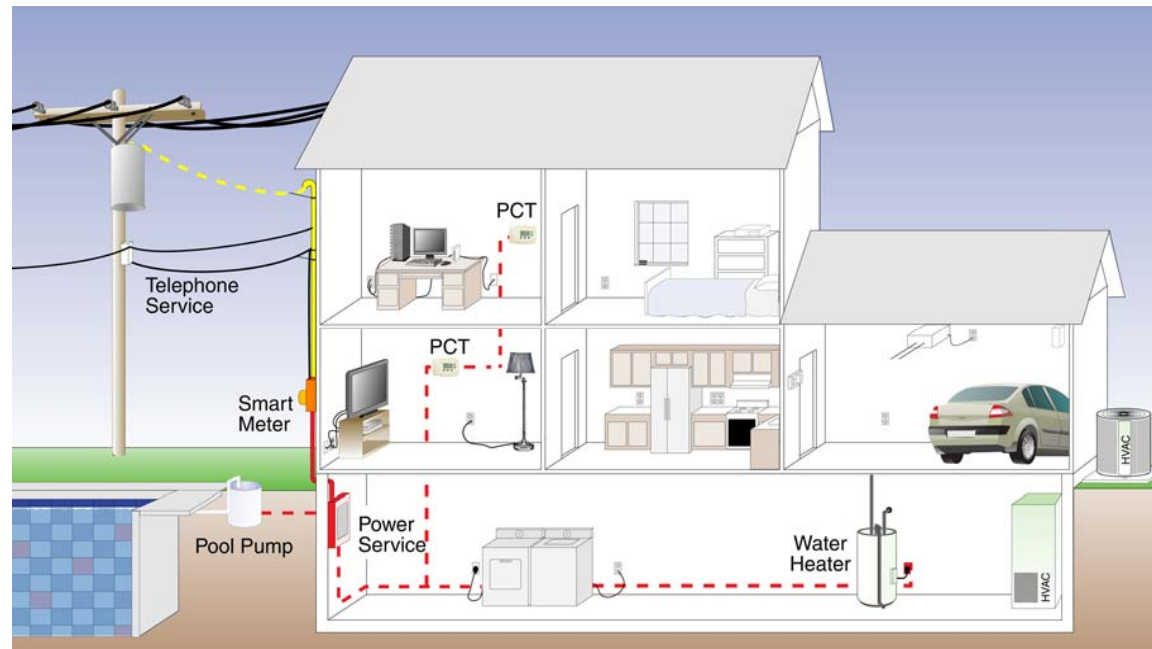
What are the features of the HomePlug protocol?

- A power line carrier (PLC) based communication protocol
- Primarily defined at Layers 1-2 of the protocol stack
- Can use TCP/IP for Layers 3-7 of the protocol stack
- Specification defines 3 types of transport:
 - AV (up to 200 Mb/s)
 - 1.0 (14 Mb/s half duplex)
 - Command & Control (7.5 Kb/s at Layer 1)



Current HAN Automation and Control Protocol Landscape for Utility Applications

- HomePlug
- Insteon
- WiFi
- ZigBee
- Z-Wave



- Air Conditioner
- Pool Pump
- Water Heater

What is the state-of-the-art of automation, smart end-use devices, and interoperability?

- Very small market currently
- Limited interoperability between HAN protocols (Require Application Layer gateways to interoperate)
- Limited commercial availability of ZigBee Smart Energy Application Profile (SEP) compliant devices
- Very limited set of suppliers for ZigBee chips
- Z-wave compliant products present in the market for over 3 years
- 15+ year history of Insteon/X-10 compliant devices

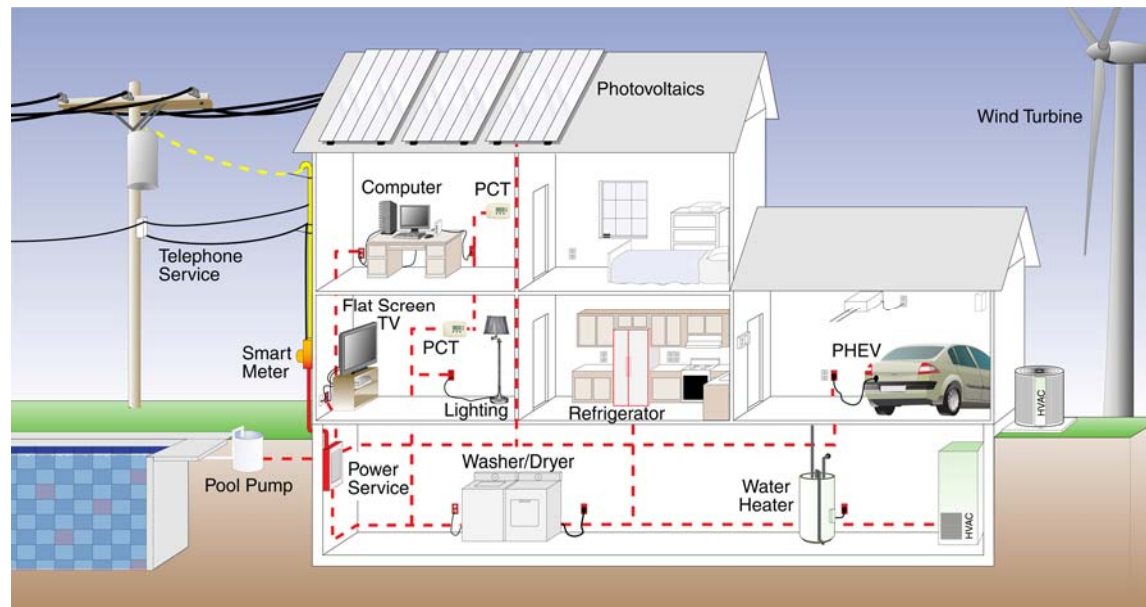
Future Direction of HAN Interoperability

- HomePlug and Zigbee are working together to develop a Smart Energy Application Profile 2.0 that will work over both communication protocols (Tentative Release Date – May 2010)
- HomePlug+Zigbee Joint Alliance includes 6-8 major utilities, product vendors and technical experts from the industry that are helping to accelerate the development and acceptance of this standard in HAN automation and control market (Possible mapping to IEC CIM)
- Should Wi-Fi Alliance join the ZigBee+HomePlug Joint Alliance's efforts, a truly interoperable Application Layer HAN profile could be established for enabling Demand Response & Energy Efficiency Programs in the residential sector

Future HAN Automation & Control Protocol Landscape for Utility Applications

Smart Energy Application Profile 2.0

Zigbee
HomePlug
Wi Fi



Air Conditioner
Computer/Laptop
Plug-in Hybrid Electric Vehicle

Pool Pump

Water Heater

Flat Screen TV

Wind Turbine

Refrigerator

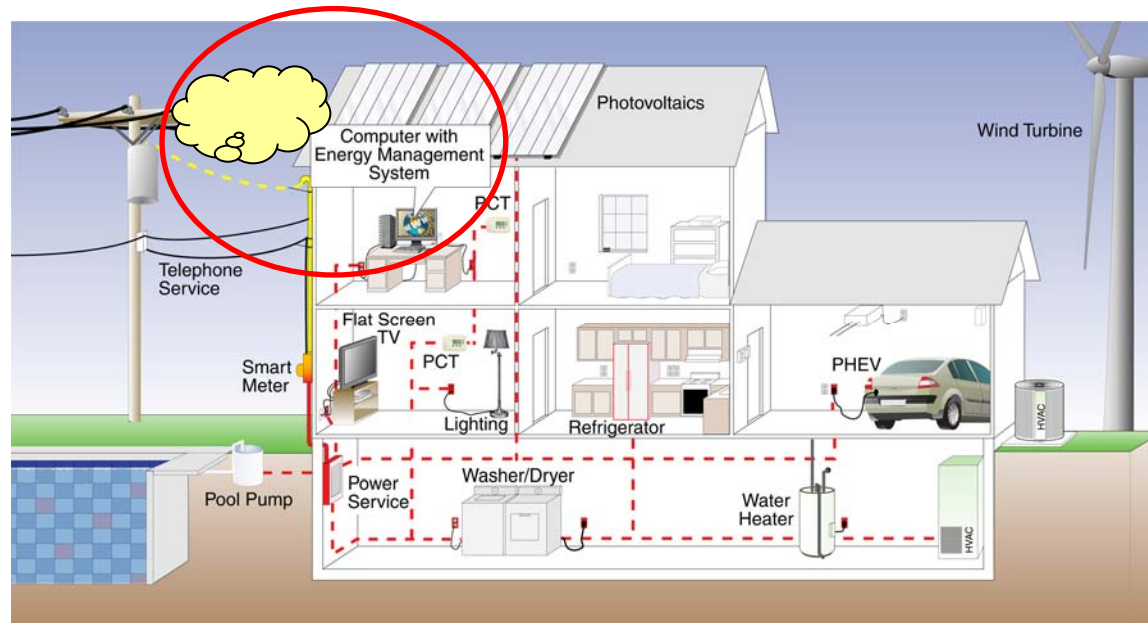
Washer/Dryer

Solar Panels

Alternative Home DR Program Through Internet Gateway

Smart Energy Application Profile 2.0

Zigbee
HomePlug
Wi Fi



Air Conditioner
Computer/Laptop
Plug-in Hybrid Electric Vehicle

Pool Pump

Water Heater

Refrigerator

Flat Screen TV

Washer/Dryer

Wind Turbine

Solar Panels

PS 161D

2008 Project Deliverables

2008 Project Deliverables

- ANSI C12.22 White paper
 - Status: Completed & Distributed to Members
 - EPRI Project Manager: Brian Seal bseal@epri.com
- AMI Security Acceleration Project (ASAP) Report
 - Status: Final Review Stage (Report Release Date 4/15/09)
 - Technical PM: Darren Highfill darren@enernex.com
 - EPRI Project Manager: Erfan Ibrahim eibrahim@epri.com
- IEEE 802.15.4 (PHY & MAC Layer) Test Procedure Report
 - Status: Final Review Stage (Report Release Date 4/15/09)
 - EPRI Project Manager: Erfan Ibrahim
 - Report reviewed by 5 funding utilities

2008 Deliverables (Contd.)

- ZigBee Smart Pro Stack & Smart Energy Profile Overview
 - Status: 1st Draft of Report Available for Review (4/1/09)
 - EPRI Project Manager – Erfan Ibrahim
 - Report Release Date 5/1/09
- IEEE 802.15.4 (PHY & MAC Layer) Lab Test Results
 - Status: RF Lab Testing Underway
 - 1st Draft of Report Available for Review (4/15/09)
 - EPRI Project Manager – Erfan Ibrahim
 - Report Release Date 5/1/09
- Whitepaper on Internet Protocol use in Smart Grids
 - 1st Draft Under Development
 - EPRI Project Manager – Joseph Hughes jhughes@epri.com
 - Report Release Date 5/1/09

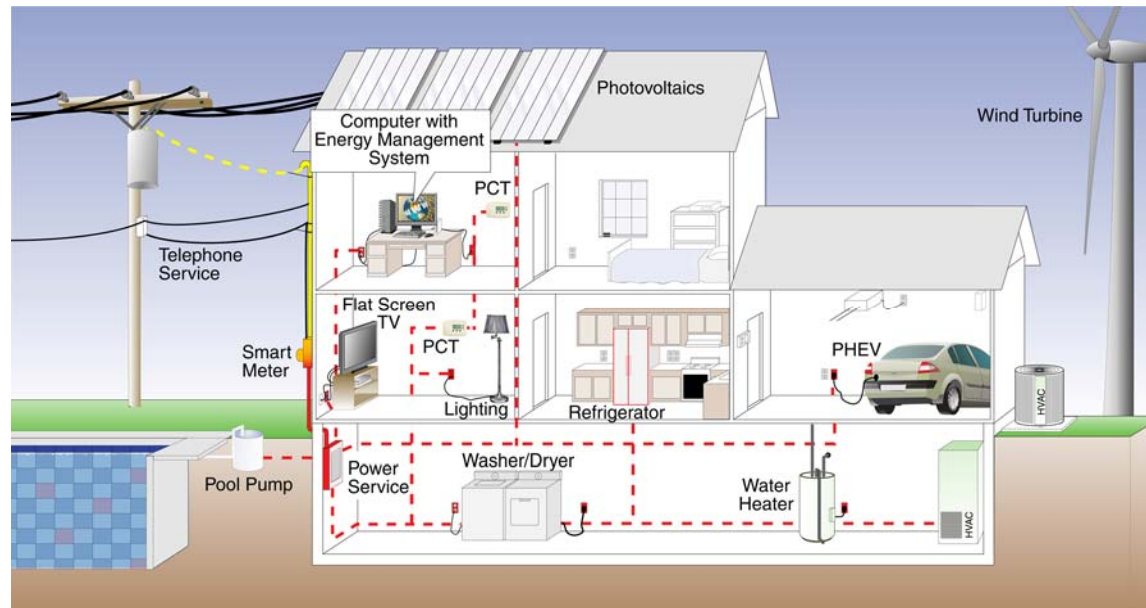
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2009 Project Descriptions

Alternative Home DR Program Through Internet Gateway

Smart Energy Application Profile 2.0

Zigbee
HomePlug
Wi Fi



Air Conditioner	Pool Pump	Water Heater	Refrigerator
Computer/Laptop		Flat Screen TV	Washer/Dryer
Plug-in Hybrid Electric Vehicle		Wind Turbine	Solar Panels

Lab Testing of Internet Based HAN Gateways (Technical Update) – P 161.006

Vendor Products to be tested over the Internet:

- ComVerge HAN Gateway (ZigBee with SEP 1.0)
- Tendril HAN Gateway (ZigBee with SEP 1.0)
- PlugSmart HAN Gateway (HomePlug 1.0)

End-use devices to be tested for DR Signal Response

- Programmable Communicating Thermostat
- AC Motor
- Light (via ZigBee enabled Digital Control Units)

Types of Testing:

- Range
- RF Interference (2.4 GHz sources)
- Power line Interference Testing (Plugged Loads)
- Reliability
- Availability

Analysis of HomePlug Communication Protocol Suite (Technical Update) – P 161.007

- Detailed Spec Overview for:
 - HomePlug 1.0
 - HomePlug AV
 - HomePlug Command & Control
- Easy to Use Reference for PHY and MAC Layer Services Defined in Each HomePlug Specification
- Identification of Gaps in HomePlug Specifications
- Recommendations for Future Development of HomePlug Standards to Meet DR and DER Requirements

Benefits of Integrating Metering Data with Distribution Automation Protocols (Whitepaper) – P 161.008

Benefits of Delivering Customer Load Data to Distribution Assets

- Integration of Distributed Energy Resources
- Mitigating Risk from Loss of Connectivity to Utility NOC
- Microgrid (Islanding)
- Disaster Recovery (Phased Restoration of Power)

AMI/HAN Economic Benefits Analysis for Utilities (Technical Update) – P 161.009

- Development of Standard Methodology to Quantify AMI Economic Benefits for Utilities
- Model to include economic savings from use case data (Peak Clipping, Distributed Energy Resource Integration, Energy Efficiency, etc.)
- Recommendations for applying methodology to Utility Pilot Projects & EPRI Smart Grid Demo Project
- Documentation of Model & Report Writing

Lab Testing of AMI/HAN Vendor Technologies (Technical Update) – P 161.010

Development of Test Plans for Leading AMI/HAN Vendor Technologies Specs from:

- Grid-Net (WiMax) + GE Meter + HomePlug (AV)
- Elster (EnergyAxis System with ZigBee SEP 1.0 v15)
- Silver Spring Networks with ZigBee SEP 1.0 v15 (Metering Company TBD)

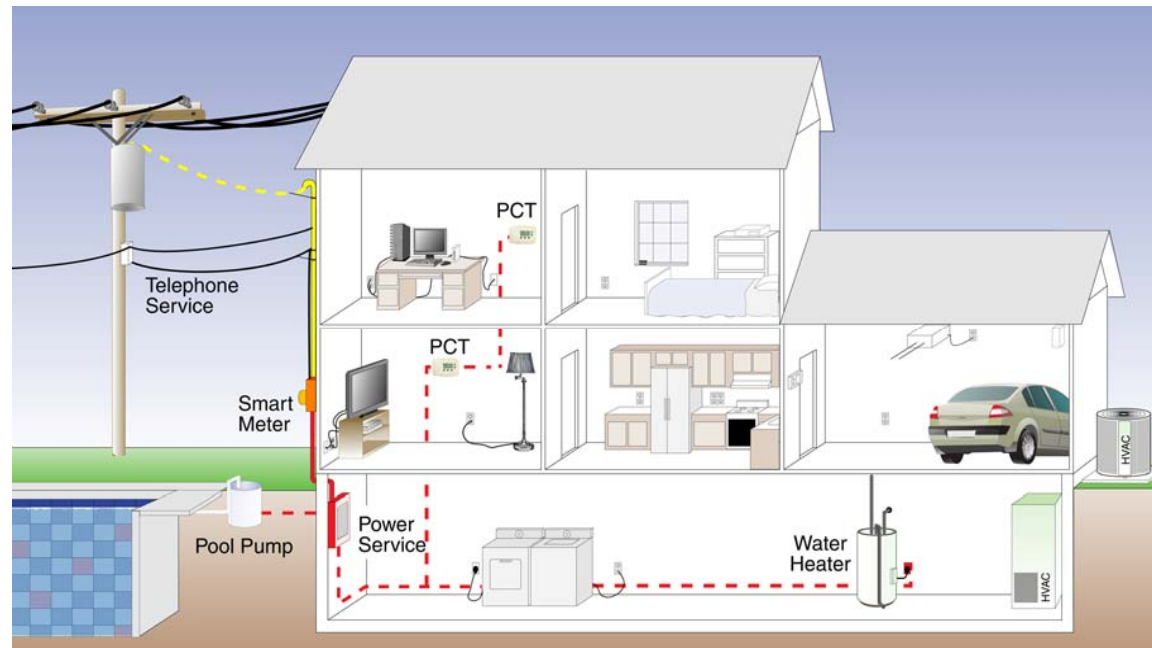
Types of Testing

- Reliability
- Availability
- RF Interference
- RF Mesh Routing
- ANSI C12.19 Metering Data Parsing & Communication

2009 Supplemental Project

Current HAN Automation and Control Protocol Landscape for Utility Applications

- HomePlug
- Insteon
- WiFi
- Zigbee
- Z-Wave



- Air Conditioner
- Pool Pump
- Water Heater

Field Trial of HAN Automation & Control Communication Protocols – Supplemental Project

Testing of HAN Communication Protocols in Homes

- RF and Power Line Based Protocols Integrated in Advanced Meters (ZigBee, HomePlug, ERT)
- Testing Between Advanced Meters Outside the House and End-Use Devices in the House for:
 - Probability of Successful Transmission in Different Topologies
 - Sustained Availability (days, weeks, months)
 - Throughput Under RF & Electric Load Interference
 - Maximum Range in Homes of Different Types
 - Data Error Rates

Field Trial of HAN Automation & Control Communication Protocols – Supplemental Project

- Advanced Meters from Leading Manufacturers (E.g. Itron, Elster, Landis+Gyr, GE, Sensus, & Echelon)
- Number of Homes to be Tested per Service Territory: 10-50
- Number of Service Territories for Testing: 10+
- Participation Fee (\$60K per utility, \$30K TC + \$30K Match)
- Fee Covers EPRI Cost for Overall Project Management, Test Plan Development, Data Analysis & Report Writing)

Field Trial of HAN Automation & Control Communication Protocols – Supplemental Project

- Project Kickoff Date – April 15th 2009 (UCA Meeting at FPL)
- EPRI Project Manager – Erfan Ibrahim
- Project Conclusion Date - 12/31/2009
- Project Report Writing – Q1 2010
- Report Availability – 3/31/2010

PS 161D Project Set Plan for 2010 & Beyond

Evaluation of Communications Technologies for Demand Response & DER Integration

Types of Technologies to be Evaluated:

- AMI/HAN & Broadband Based Gateways
- Renewable Sources for Homes (PV & Solar Thermal)
- Energy Storage (Electric & Thermal)
- Plug-In Electric Vehicles

Types of Activities

- Lab & Field Trials of Leading Vendor Systems
- Testing & Evaluation of Communication Interfaces
- Testing Integration Capability with Smart Grid
- Demonstration of Demand Response Capability

Smart Grid Communications Architecture for Demand Response & DER Integration

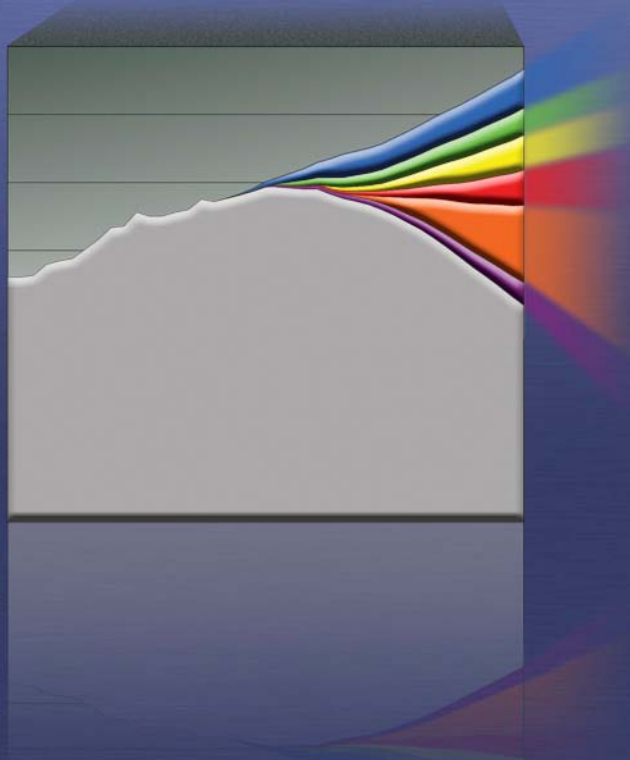
Development of a Standards Based 7-Layer Communication Architecture for Smart Grids Including (Continuation of NIST Interoperability Framework Research):

- Building Automation Systems
- Distribution Systems
- Distributed Energy Resources
- Plug-In Electric Vehicles
- Advanced Meters
- Metering Data Management System

Life Cycle Management of Technologies for Demand Response & DER Integration

Full Product Life Cycle Support Including:

- Use Case Analysis
- Product Requirements Document Preparation
- Vendor Product Testing, Evaluation & Certification
- Product Selection & Procurement
- Implementation Guidance & Best Practices
- Configuration & Functional Testing
- Operations & Management (FCAPS)
- Data Collection, Transmission, Storage, & Usage
- End of Product Life Preparation
- Transition to Next Generation Technologies



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