ZigBee Smart Energy: Home to Grid

Wireless Glue Networks, Inc.

John Lin, PhD

john@wirelessglue.com
jwlo@pge.com

2009 May 27
Wireless Glue Networks, Inc.:
> ZigBee Smart Energy Logo Certification Test Harness (validated), SE Device Simulator (5/19/08)
> ZigBee Smart Energy RF Module (ZCC-2520-M)
> ZigBee Gateway/Server middleware GSF
> Various development kits and modules
> Java and Javascript for Smart Energy
> Helped launch ZigBee Smart Energy 1.0

Myself:
> Founder/CTO of Wireless Glue Networks, Inc.
> Consultant to PG&E on Smart Energy / ZigBee / Wireless Interop Technology Innovation Center (TIC) wireless lab
> ZigBee Qualification Working Group; specification work
> ZigBee / HomePlug Certification Working Group Tech Editor
Focus on household devices: utility owned HAN network

IOU: Investor Owned Utility-- UtilityAMI

openHAN requirements published in 2007
(2009 – OpenHAN, OpenSG - UCA)

openHAN requirements became basis of ZigBee “Smart Energy” (SE) Application Profile

ZigBee Alliance completes the Smart Energy certification program
May 19, 2008

Energy Service Portals, Meters, PCT, In Home Display

Itron, Landis-Gyr, Trilliant, Comverge, PRI, LSR, WGN, Tendril, Computime, etc. receive first Smart Energy Logo Certification
It's official!! ZigBee Smart Energy is part of Smart Grid Grid2Home

<table>
<thead>
<tr>
<th>Standard</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI-SEC System Security Requirements</td>
<td>Advanced metering infrastructure (AMI) and Smart Grid end-to-end security</td>
</tr>
<tr>
<td>ANSI C12.19/MC1219</td>
<td>Revenue metering information model</td>
</tr>
<tr>
<td>BACnet ANSI ASHRAE 135-2008/ISO 16484-5</td>
<td>Building automation</td>
</tr>
<tr>
<td>DNP3</td>
<td>Substation and feeder device automation</td>
</tr>
<tr>
<td>IEC 60870-6 / TASE.2</td>
<td>Inter-control center communications</td>
</tr>
<tr>
<td>IEC 61850</td>
<td>Substation automation and protection</td>
</tr>
<tr>
<td>IEC 61968/61970</td>
<td>Application level energy management system interfaces</td>
</tr>
<tr>
<td>IEC 62351 Parts 1-8</td>
<td>Information security for power system control operations</td>
</tr>
<tr>
<td>IEEE C37.118</td>
<td>Phasor measurement unit (PMU) communications</td>
</tr>
<tr>
<td>IEEE 1547</td>
<td>Physical and electrical interconnections between utility and distributed generation (DG)</td>
</tr>
<tr>
<td>IEEE 1686-2007</td>
<td>Security for intelligent electronic devices (IEDs)</td>
</tr>
<tr>
<td>NERC CIP 002-009</td>
<td>Cyber security standards for the bulk power system</td>
</tr>
<tr>
<td>NIST Special Publication (SP) 800-53, NIST SP 800-82</td>
<td>Cyber security standards and guidelines for federal information systems, including those for the bulk power system</td>
</tr>
<tr>
<td>Open Automation</td>
<td>Home Area Network device communication, measurement, and control</td>
</tr>
<tr>
<td>OpenHAN</td>
<td>Home Area Network (HAN) Device Communications and Information Model</td>
</tr>
<tr>
<td>ZigBee/HomePlug Smart Energy Profile</td>
<td></td>
</tr>
</tbody>
</table>
System Overview of Grid

- Generation
- ISO
- Distribution Grid
- Consumer: ZSEP 2.0
- Control Demand & Control Load
- Advanced Meter Infrastructure (AMI)
- Substation Automation
- SCADA and Phasor Measurements
- Transmission & Sub-transmission
- Distribution Automation
- Smart Metering, Demand Response, Energy Conservation and Distributed Resources
Direct Grid to Home: G2H services through the meter as ESI

Silverspring Networks system being deployed by PG&E as Energy Service Interface (ESI)

5.3 m ZigBee radios at ESI
Indirect Grid to Home: G2H AMI services through meter as ESI and higher level HAN services through GW

Bandwidth Limitation

Data Push/Pull

Internet
Basic System centered on Demand Response/Load Control

SMART ENERGY 1.0: ZigBee Technology

It's a start; implementation is still fragmented across the US
Wider range of devices

SMART ENERGY 2.0: ZigBee + HomePlug

This is the intent: widespread adoption as method for Smart Grid into homes
Smart Energy 2.0

Utility Installation | Consumer Install

**P1** – Utility deploys

**P2** – Utility distributes, Consumer installs

**P3** – Consumer buys, Technician installs

**P4** – Consumer buys and installs

Large scale HAN SE must be just a few percent of service calls will make large scale HAN SE impossible
To Achieve Smart Energy 2.0: Creation of a device ecosystem enabling end-to-end Smart Grid
To Achieve Smart Energy 2.0: Creation of a device ecosystem enabling end-to-end Smart Grid

Harmonize standards

Time is NOW to standardize

ZigBee Smart Energy is the focal point
ZigBee Smart Energy 1.x

ESI Device

IEEE 802.15.4
ZigBee

Local Transport
C12.22 Application Protocol

Public IP
Web Services

Private IP
## ZigBee SE Clusters

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Expected Mode</th>
<th>Application Level Security Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Response</td>
<td>Command</td>
<td>Yes</td>
</tr>
<tr>
<td>Price</td>
<td>Informational</td>
<td>No</td>
</tr>
<tr>
<td>Simple Metering</td>
<td>Informational</td>
<td>No</td>
</tr>
<tr>
<td>Complex Metering</td>
<td>Both</td>
<td>Yes</td>
</tr>
<tr>
<td>Prepayment</td>
<td>Both</td>
<td>Yes</td>
</tr>
<tr>
<td>Message</td>
<td>Informational</td>
<td>No</td>
</tr>
</tbody>
</table>
ZigBee Smart Energy 1.x

<cluster id="0x0701" apsEncryptionRequired="true">
  <description>
    AMI Cluster Library -- Demand Response and Load Control Cluster
  </description>

  <server>
    <command id="0x00" name="LoadControlEvent" mandatory="true">
      <uint32 name="IssuerEventId"/>
      <uint16 name="DeviceClass">
        <bitfield name="HvacOrFurnace" width="1" position="0"/>
        <bitfield name="StripOrBaseboardHeater" width="1" position="1"/>
        <bitfield name="WaterHeater" width="1" position="2"/>
        <bitfield name="PoolPumpOrSpaOrJacuzzi" width="1" position="3"/>
        <bitfield name="SmartAppliance" width="1" position="4"/>
        <bitfield name="IrrigationPump" width="1" position="5"/>
        <bitfield name="ManagedCommercialAndIndustrial" width="1" position="6"/>
        <bitfield name="ResidentialOnOff" width="1" position="7"/>
        <bitfield name="ExteriorLighting" width="1" position="8"/>
        <bitfield name="InteriorLighting" width="1" position="9"/>
        <bitfield name="ElectricVehicle" width="1" position="10"/>
        <bitfield name="GenerationSystem" width="1" position="11"/>
      </uint16>
      <uint8 name="UtilityEnrollmentGroup"/>
      <uint32 name="StartTime"/>
      <uint16 name="Duration"/>
      <uint8 name="CriticalityLevel"/>
      <uint8 name="CoolingTemperatureOffset"/>
      <uint8 name="HeatingTemperatureOffset"/>
      <int16 name="CoolingTemperatureSetPoint"/>
      <int16 name="HeatingTemperatureSetPoint"/>
      <int8 name="AverageLoadAdjustment"/>
      <uint8 name="DutyCycle"/>
      <uint8 name="EventControl">
        <bitfield name="RandomizeStartTime" width="1" position="0"/>
        <bitfield name="RandomizeEndTime" width="1" position="1"/>
      </uint8>
    </command>
  </server>
</cluster>
LCE: Load Control Event
Issued by ESP

RES: Report Event Status: Received
HAN device side

RES: Report Event Status: Started
HAN device side

RES: Report Event Status: Complete
HAN device side
Price Signals

- Publish Current Price to HAN device side (can be InterPAN)
- Get Current Price from HAN device side
- Get Scheduled Price from HAN device side
Messaging

Display Message
to HAN device side (can be InterPAN)

Get Message
from HAN device side

Display Message
to HAN device side
Meter Read

Get Profile
from HAN device side

Get Profile Response
to HAN device side
Initial openHAN / Smart Energy network implementation

Implementation of various devices via owner controlled network and utility owned network

In Home Display

Energy Management System: Bridges SE to other networks
Final Form of SE and HAN

PCT, IHD, EMS, Smart Appliance, LCD, Submetering
PHEV/PEV, PHHC, Energy Storage/Generators, Home Automation
So, what's ZigBee Smart Energy 2.0?

Expanded Feature Set
- Plug In Electric
- More Pricing Signals
- PrePay
- More Demand Response
- More sophisticated Metering

Common Information Model
Based on ZSEP 1.0

WHO's going to write it???
Serverside Javascript and Java Framework for ZigBee and Internet Smart Objects

Architecture of Wireless Glues’ ZigBee Glueware System

Scripts:
- Device.gsh
- SendFile.gsh
- SendLine.gsh

GSF Core 0.9.11

Hardware Drivers for:
- ZCC-2420-U “Indian Rock”
- ZCC-2520-M “Castle Rock”
- Daintree SNA Active Mode

ZigBee Hardware:
- ZCC-2420-U “Indian Rock”
- ZCC-2520-S “Castle Rock”
- Daintree 2400E
GSF Server System Diagram

Rich Internet Application (RIA)

REpresentational State Transfer: REST Gateway
Q & A