IEEE 802 for the Smart Grid

Authors: **Date:** 2009-11-16

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Executive Summary

- **The US Smart Grid efforts have been accelerated by economic and energy conservation incentives. NIST is validating standards on behalf of the Department of Energy at an unprecedented pace.**
- **IEEE 802 sets the bar. IEEE 802 and its affiliated interoperability organizations are the examples for NIST in defining SDOs. What is 802 doing?**
- **The Smart Grid opportunity will accelerate growth in IEEE 802 network nodes for sensing and control. *And* this is just the tip of the iceberg.**
- **Discussion: What is the appropriate role for IEEE 802 to play in the development of Smart Grid technologies and standards?**

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The Biggest of Pictures in the US

- 2007/8 – the price of Energy sky rocketed and the payments were being exported
- 2007/8 - Global Climate Change became topical and CO^2 emissions were being blamed in part
- 2008/9 – America became mired in the worst economic down turn since the great depression
- 2009 – a new President and majority party in congress and the senate took office
- 2009 - Under the Energy Independence and Security Act of 2007 NIST is assigned the primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems
- 2009 – NIST recommendations will be used as guidelines for Energy related stimulus projects. Will also drive requirements for utility industry for next 20 years.

‘A’ Smart Grid Problem Definition

- **The major driving forces to modernize current power grids can be divided in four, general categories:**
  - **Increasing reliability, efficiency and safety of the power grid**
    - prevent outages, lower CO2, reduce electricity bills
  - **Enabling decentralized power generation so clients can be both energy consumers and energy suppliers**
    - provide consumers with interactive tool to manage energy usage
  - **Provide a much more flexible Demand – Response Capability**
    - power consumption at the clients side, supplier selection on the response side
      - enables distributed generation, solar, wind, biomass
  - **Increase GDP by creating more new, green-collar energy jobs related to:**
    - renewable energy industry manufacturing
    - plug-in electric vehicles
    - solar panel and wind turbine generation
    - energy conserving construction
    - revamping of Electrical Grid infrastructure and Integrating water and gas grids

Critical Components of the SG Ecosystem

- **Evolutionary Devices**
- **Devices and Platforms**
- **Applications/Network Interface**
- **Design/Deployment**
- **Innovation**
- **Backhaul/Aggregation**
- **Spectrum**
- **Business Models**
- **Scale**

The Point: these are not unique to Smart Grid, but apply to the broader market of Wireless Sensor Networks in general.

NIST Activities to Date

PHASE 1
Engage stakeholders in a participatory public process to identify applicable standards, gaps in currently available standards and priorities for new standardization activities

PHASE 2
Establish a formal standards panel to drive longer-term progress. *

Framework: http://www.nist.gov/public_affairs/releases/smartgrid_interoperability.pdf
Cyber Security: http://csrc.nist.gov/publications/drafts/nistir-7628/draft-nistir-7628.pdf

Public review and comments

(Draft) Framework and Roadmap for Smart Grid Interoperability Standards (Release 1.0)

(Final) Framework and Roadmap for Smart Grid Interoperability Standards (Release 1.0)

PHASE 3
Develop and implement a framework for testing and certification

* - SGIP is concurrent with this meeting in Denver

March 2009 September 2010

NIST Update for Tutorial

- **See Document**
  - 15-09-767

NIST Priority Action Plan Topics

- Overview
- 1 Role of Internet Protocol (IP) in the Smart Grid (6.1.4)
- 2 Wireless Communications for the Smart Grid (6.1.5)
- 3 Common Pricing Model (6.1.1)
- 4 Common Scheduling Mechanism (6.1.3.2)
- 5 Standard Meter Data Profiles (6.2.5)
- 6 Data Tables Common Semantic Model for Meter Data Tables (6.2.5)
- 7 Electric Storage Interconnection Guidelines (6.2.3)
- 8 CIM for Distribution Grid Management (6.2.6, 11.6.1)
- 9 Standard DR Signals (6.2.1)
- 10 Standard Energy Usage Information (11.1.1)
- 11 Common Object Models for Electric Transportation (6.2.4)
- 12 IEC 61850 Objects/DNP3 Mapping (6.2.2)
- 13 Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization (6.1.2, 6.2.2)
- Transmission and Distribution Power Systems Model Mapping (11.2.1)
- Cyber Security Considerations for the Smart Grid (5)

http://www.nist.gov/smartgrid/Report%20to%20NISTlAugust10%20(2).pdf

Background information available at SmartGridInterimRoadmap Web

SGIP mainly an advisory group and see later slides – Charter under flux

22 Caterogies of Stakeholders identified

- **http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome**

Smart Grid Interoperability Knowledge Base

Priority Action Plan

- **PAP_Combined_WorkshopFinalV1_0_20090810.pdf: Composit Post Workshop PAPs**
- **http://collaborate.nist.gov/twiki-sggrid/bin/view/_SmartGridInterimRoadmap/PAP02Wireless**
- **Role of IP in the Smart Grid (5.10 Application of Internet-Based Networking Technology)**
- **Wireless Communications for the Smart Grid 5.11 Communications Interference in Unlicensed Radio Spectrums)**

SGIP Twiki Space

- **Smart Grid Community provides feedback**
  - TWiki: http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome (requires free registration for oversight and tracking purposes)
  - Email: smartgrid@nist.gov, "SGIP:" to start subject line

- **Smart Grid hold regular Webnair, One happening right now Mon 11/16 1-5 MST**

  SGIP General Meeting
  Grand Ballroom
  Webinar: www2.gotomeeting.com/register/157744955
  Conference Call-in: Phone: 866-613-0746 Pin: 8361

Latest on SGIP happening at Grid-Interop Conference

- ***Process, organisation, charter, ByLaws and Rules under flux***
- ***Review of Charter submitted so close to the vote on Saturday November 14, 2009.***
- **The draft charter for the SGIP is posted on the NIST Smart Grid Collaboration web site**
- **The draft charter describes the objectives, structure, membership, role and governance of the SGIP.**
- **The charter will be modified based on stakeholder feedback over the next 30 days.**
- **Some Potential members reviewing IPR and Charter.**
- **The resulting document will be discussed and voted on for ratification by the SGIP at its first formal meeting at the**
- **Grid-Interop conference, held on Nov 16-19 in Denver, Colorado**
- **Voting will take place this week Nov 16-19**

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802.11 Related Activities 2009

- **802.11/WFA**
  - Waikaloa 802 Interim Meeting: 2 hour session devoted to SG activities and status
  - WFA submitted a white paper on Wi-Fi for Smart Grid Sept
  - WFA formed a SG Task Group in October
  - WFA submitted comments on NIST Framework doc – Nov 6
  - WFA to submit comments on NIST Cyber Security doc – Dec 1

WFA White Paper

Key Attributes of Wi-Fi

- **Mature technology with more than a billion nodes already deployed (ABI Research, 2009)**
- **Mechanisms to deliver robust performance in shared-spectrum and noisy RF environments including Listen-before-talk protocol, RF noise awareness and reporting, and received signal strength**
- **Transports all IPv4 and IPv6-based protocols**
- **Extensive radio performance and network management mechanisms to provide radio link quality and history reports and channel selection optimization**
- **Low cost due to economies of scale: Wi-Fi chipset shipments now exceed one million units per day and will grow past one billion units per year by 2011 (ABI Research, 2009)**
- **One standard that allows implementation of several interoperable performance/power dissipation profiles**
  - Data rates ranging from 1 Mbps (802.11b) to 600 Mbps (802.11n)
- **Networks can scale from a single pair of devices to thousands of access points and clients**
- **Security protections: Link-, network-, and application-level security based on international standards which meet FIPS 140-2 certification[1]**
  - Rogue device and intrusion detection tools

(http://collaborate.nist.gov/twikisggrid/pub/Main/GregEnnis/Wi-Fi_for_the_Smart_Grid_September_2009.pdf)

802.15/ZigBee Developments

- **See Documents**
  - 15-09-0770
  - 15-09-0769

802.16/WiMAX Developments

- 802.16 Chair/WiMAX Forum representative participated in NIST Smart Grid SDO Workshop of 3-4 August (Wireless Breakout)
- •802.16 Working Group appointed Upkar Dhaliwal as “Smart Grid Liaison” in July; Dhaliwal is now a member of the NIST Smart Grid Interoperability Panel
- •The WiMAX industry has significant activity and deployments in Smart Grid networks
- •WiMAX Forum may join Smart Grid Interoperability Panel

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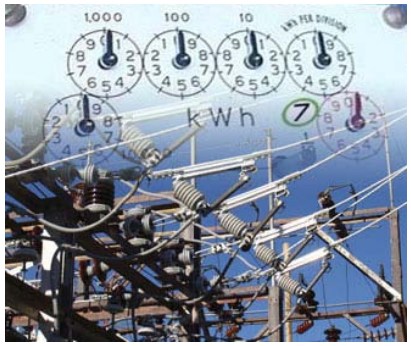
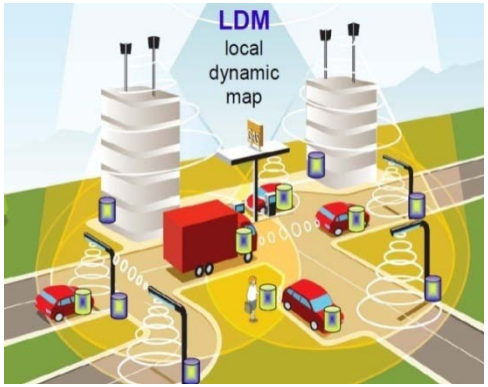
Smart Grid and Beyond

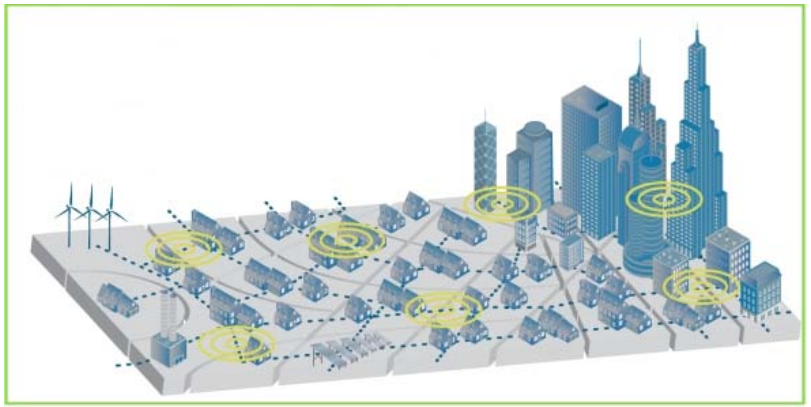


- **Smart Grid Sensor Network is visible and timely**
  - Potential funds for projects are driving immediate interest and participation
  - Proprietary is **out** – standardized and interoperable is **in**
  - IP everywhere
  - Standards are being set for the next 20 years
- **Not in the headlines, but also building momentum with similar technology standards**
  - Factory/Industrial Automation Sensors and Control
  - Building and Road Structural Sensors
  - Intelligent Transportation Systems
  - Heath Care and Body Area Networks

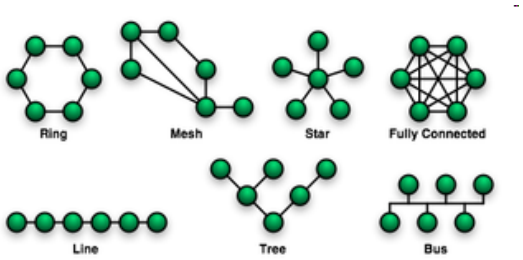


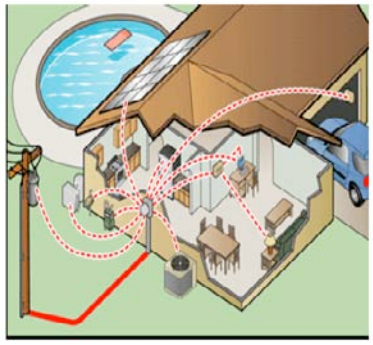
Exponential Growth Drivers

- **Ubiquitous overlapping networks based on common standards make growth *possible***
- **Declining device cost and advancing technology make growth *feasible***
- **Savings in energy and efficient resource management provide the *ROI* for growth**
- **Monitoring and reporting for safety makes growth *imperative***



Communication Technologies





- **IEEE 802.11 and 802.15 are open and global unlicensed.**
  - Dedicated spectrum for these standards awards will greatly enhance network reliability
- **ETSI initiatives are promoting UWB, DECT and GSM**
  - Machine to Machine and Femto technology adjustments offer alternatives
- **Powerline and wired connections**
  - Where appropriate and necessary
- **Interoperability conformance and certification is key to the success of any standard technology**

Ecosystem Opportunities

- Standardization and Interoperability of Sensors
- Security, Authentication and Privacy
- Network Management
- Data aggregation and storage
- Data analysis
- End user access and utility of output
- Inter-Network Data access and management

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Discussion: The Role of 802 in Smart Grid

- **IEEE 802 Wireless and its affiliated interoperability organizations are standards organizations that others are being compared to globally**
  - To maintain this leadership position, IEEE 802 must expand its scope to include smart grid technologies and solutions
- **What can IEEE 802 do to enable the Smart Grid and other sensor networks in the next 5-10 years?**
  - The existing 802 wireless standards (802.11, 802.15, 802.16…) have been developed to meet specific application requirements
  - The Smart Grid has its own requirements that are partially covered by the existing 802 wireless standards
  - Currently 802.11,802.15 and 802.16 are addressing Smart Grid in separate silos

IEEE 802 Smart Grid Opportunities

- **Radio Technologies:** Develop smart radio technology that can maximize the use of existing spectrum and new spectrum opportunities
- **Spectrum:** Seek spectrum allocations that meet the needs of smart grid applications
- **Interworking:** By proper definition of data formats (and semantics) interworking can be greatly facilitated. That VoIP over Bluetooth-Wi-Fi-WiMAX works is thanks to – in part – the use of the same encoding for voice signals, etc.
- **Security and Management:** A common security structure and management framework are needed across platforms
- **A New 802 Work Group?:** And we are talking about a new 802.xx WG that deals with all things Smart Grid – including charting changes/additions to existing MAC standards that are necessary to achieve that "multi-technology switching" goal for Smart Grid applications?

Next Steps?

BACKUP

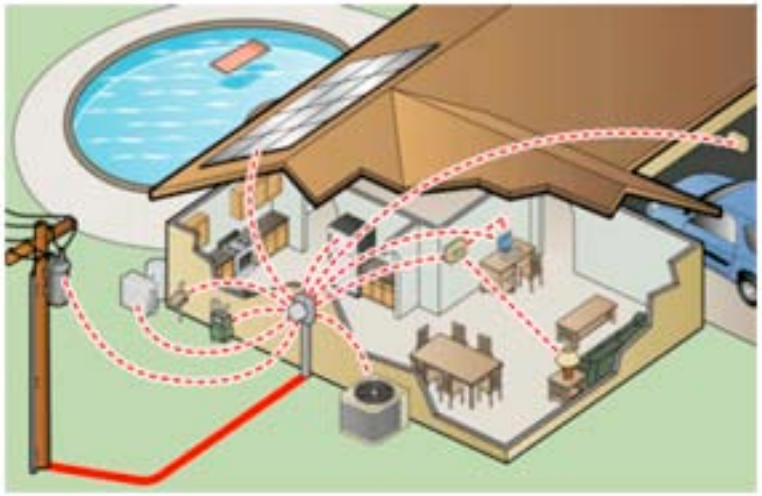
Background

- **The Dept of Energy says Smart Grid Standards must:**
  - Provide two-way communication among grid users, e.g. regional market operators, utilities, service providers and consumers
  - Allow power system operators to monitor their own systems as well as neighboring systems that affect them so as to facilitate more reliable energy distribution and delivery
  - Coordinate the integration into the power system of emerging technologies such as renewable resources, demand response resources, electricity storage facilities and electric transportation systems
  - Ensure the cyber security of the grid

  To enable interoperable systems and components

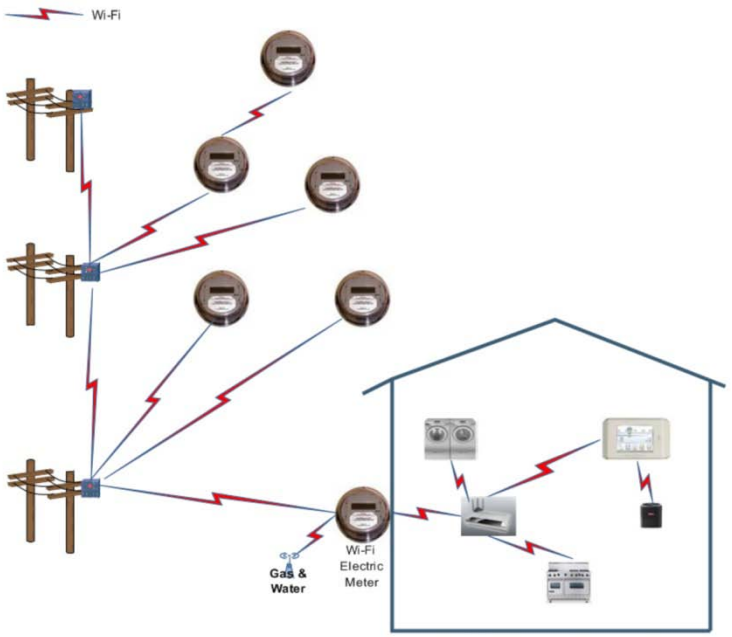
SG Communications Networks (1/5)

- **Home Area Network**



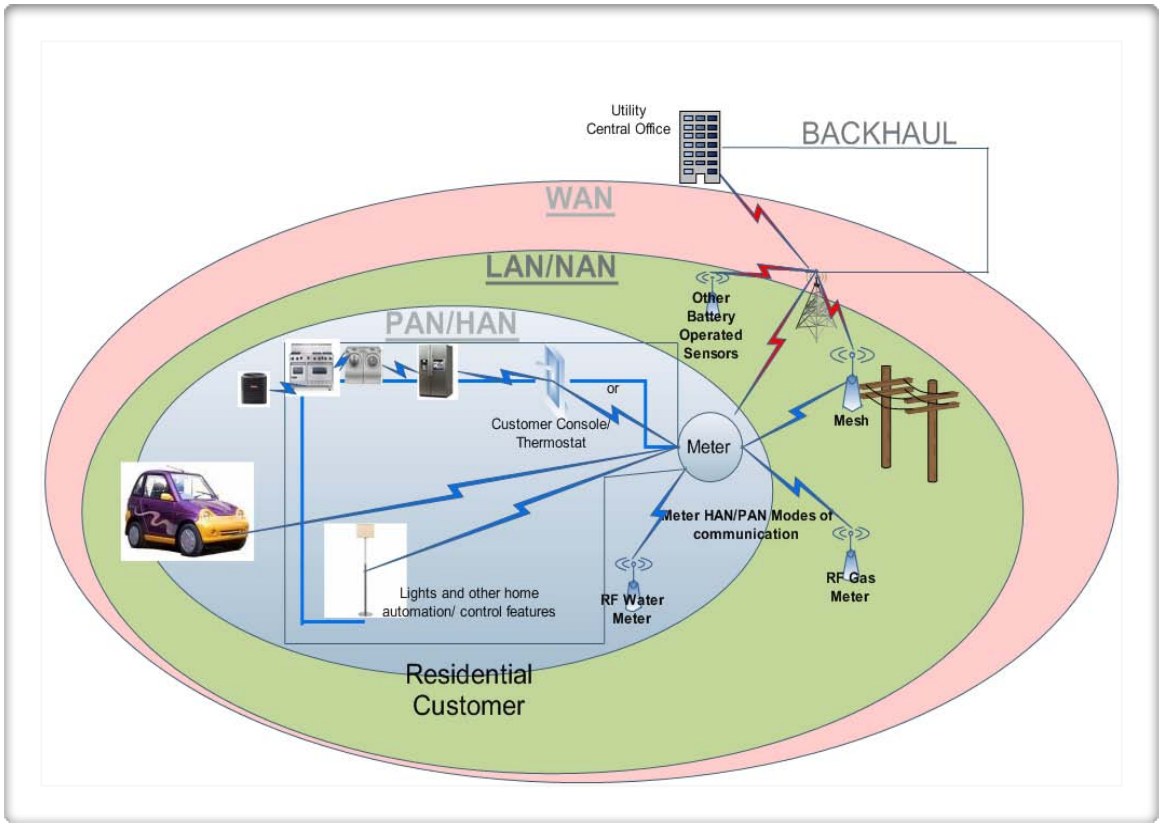
SG Communications Networks (2/5)

- **Neighborhood Area Network**



SG Communications Networks (3/5)

- **Wide Area Network and Backhaul**



Network Measurement and Management

- **Wi-Fi Network Management systems in place today provide:**
  - Visibility into device performance and usage
  - Historical trend reporting
  - Threshold-based alerts
  - Scheduled events and reports
  - Device configuration and reconfiguration, including multi-vendor management when networks are comprised of wireless devices from more than one manufacturer
  - Centralized software updates

Smart Grid Wireless Use Cases

- **Home Thermostats**
- **Advanced Metering Infrastructure (AMI)**
- **Grid Intelligence**
- **Gas and Water Metering**
- **Enterprise Mobility for Utility Companies**

AMI

- Advanced Metering Infrastructure (AMI) **refers to systems that measure, collect and analyse energy usage, from advanced devices such as electricity meters, gas meters, and/or water meters, through various communication media on request or on a pre-defined schedule. This infrastructure includes hardware, software, communications, customer associated systems and meter data management (MDM) software.**
- **The network between the measurement devices and business systems allows collection and distribution of information to customers, suppliers, utility companies and service providers. This enables these businesses to either participate in, or provide, demand response solutions, products and services. By providing information to customers, the system assists a change in energy usage from their normal consumption patterns, either in response to changes in price or as incentives designed to encourage lower energy usage use at times of peak-demand periods or higher wholesale prices or during periods of low operational systems reliability.**
- **AMI "raises the bar" with regard to traditional Automatic meter reading (AMR) in that it enables two-way communications with the meter. Traditional systems which were only capable of meter readings don't qualify as AMI systems.**

Advanced Electric Meter

- **An electric meter, new or appropriately retrofitted, which is: 1) capable of measuring and recording usage data in time differentiated registers, including hourly or such interval as is specified by regulatory authorities, 2) allows electric consumers, suppliers and service providers to participate in all types of price-based demand response programs, and 3) which provides other data and functionality that address power quality and other electricity service issues.**