Development of Advanced Metering Infrastructure (AMI) for Metering and Customer Communications

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Infrastructure Excitement!

CIGRE European Conference: UCA International Users Group Interoperability Display
Multi-vendor Display for Utility Automation Equipment Interoperability…
Presentation Structure

• AMI Communications Overview

• Communications Technologies: A Status Report

• Interoperability and Standards

• Moving Forward
What is an Industry Level Architecture?

**Architecture:** The Structure of Components, their relationships, and the principles and guidelines governing their design and evolution over time*.

*DoD Integrated Architecture Panel, based on IEEE Std 610.12*
Drivers For Open Standards and Architecture Development

- Open Systems and Standards Development
  - Capital Cost Reductions
  - Life Cycle Cost Reductions
  - Decrease Costs

- Systems Engineering Methods
  - Robust Designs Enabling Infrastructures
  - Increase Value

- Communications Asset Utilization
  - Shared Infrastructures
  - Bundled and New Applications

Increase Value
Energy efficiency and demand response *if architected correctly* could assist the development of a smart grid.
Architecture Vision

• Uses Consistent Policies Across Operating Domains
• Integrates a Wide Variety of Networks
• Integrates a Wide Variety of Physical Media
• Enables Interoperability among Intelligent equipment
• Uses a Carefully Integrated Set of Standards from Different Industries
• Standards are Supported by Effective User Groups
• Industry Requirements are Shared across the industry
• Interoperable Equipment is available Across the Industry
• Conformance and Interoperability Testing widely adopted
• Standardized Notation and Systems Engineering is Widely Used to Specify and Manage Systems
“Smart Grid” Today...

- Some Standards in use… but not enough use
- Limited Visibility across the system
- Little integration between IT and Field Automation
- Islands of automation
- Older difficult to maintain protocols
- Patchwork of “legacy” Systems
- No Customer Integration

Where’s the Architecture?
Presentation Structure

• AMI Communications Overview
• Communications Technologies
• Interoperability, and Standards
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Customer Communications (AMI) Scope: Integrated Wide Area and Local Area Networks

Energy Industry Networked Applications

- ISO’s
- RTO’s
- PX’s
- ESP’s
- ESCO’s
- ETC’s
- UDC’s
- Disco’s
- LDC’s
- Genco’s
- Transco’s
- Regulators
- Oversight
- CIP, others

Wide-Area Communications and Distributed Computing

- RTP Composition
- RTP Implementations, Settlement, Billing
- Measurement, Data and Meter Management
- Distribution Operations Integration
- Public/Private Communication Services... copper, fiber, powerline, carrier, wireless (terrestrial, satellite), other...

Customer Systems: In-building networks and networked equipment

- Revenue Meter
- Customer Interface
- Comm Power
- Lighting Subsystems
- Misc. Loads
- Customer Generation/Storage
- HVAC and Thermal Storage Subsystems

RTP System Architecture
Introduction to Communications, Interoperability and Distributed Computing

Data Packet

C12.22 Device

Network Communications Information
Address 135.35.5.2

End Device (Meter)

0 - Identification
...
2 - Registers
...
6 - LoadProfile
...
7 - Events
...

ANSI Standard Communications
“Envelope”

Meter Data Message
“Letter”

Revenue Meter

C12.2 Device

Address 135.35.5.2

End Device (Meter)

0 - Identification
...
2 - Registers
...
6 - LoadProfile
...
7 - Events
...
What is A Common Language?

“Master Station”
Computer

Communications
Interfaces

Intelligent-
Communicating
Remote Device
(Meter)

1. Physical
Communications
Media...

2. Communications
“Envelope”

3. Communications
Message “Object”
Simplified View on Layered Communications...

“Master Station”
Computer

“Wireless”

“Fiber Optic”

“Wired”

Brand X

Brand Y

Brand Z

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Security Architecture Must Encompass Varied Systems and Security Domains

“Consistent Implementation of Security Policies”

- “Wireless”
  - Data
  - Encryption
  - Intrusion Detection, Forensics, Other...

- “Fiber Optic”
  - Data
  - Monitoring, Other
  - Access Controls

- “Wired”
  - Data
  - Encryption
  - Intrusion Detection, Forensics, Other...

Brands:
- Brand X
- Brand Y
- Brand Z
Integration necessary across multiple communications and network “environments”
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A Sample of “Smart Grid” Infrastructure work that needs to be built upon…

IEC 61970/61968 for Enterprise “IT” Integration

IEC 61850 for Real-Time Field Automation, DER and Customer

IEEE P37.118 for Phasor Measurement Units

SAE For PHEVs

ANSI C12 Revenue Metering

ASHRAE/ANSI 135 for Building Automation

ISA for Industrial

IEEE P37.118

SAE For PHEVs

ANSI C12 Revenue Metering

ASHRAE/ANSI 135 for Building Automation

ISA for Industrial
Networking Infrastructure Layering Strategies

Application (Central)

7: Application
6: Presentation
5: Session
4: Transport
3: Network
2: Data Link
1: Physical

Application (Remote)

7: Application
6: Presentation
5: Session
4: Transport
3: Network
2: Data Link
1: Physical

Adopt a Common Language

Develop Common Approaches and collapse

Investigate Issues and Adopt as Appropriate

Understand Physical Media... Use as Appropriate
Situation: Home “Automation” Standards...

1985

• X-10™
• CEBus©
• Lonworks™
• Smarthouse
• Firewire
• CAL/HPnP
• Home RF
• Bluetooth
• SWAP
• WLIF
• Home PNA
• Home API

“Digital Convergence”

2008

• 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
Other

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Key Standards Organizations Involved in the Development of “Smart Grid” Infrastructure

International standards-developing organizations:
- ISO
- ITU
- JTC 1
- JTC 1 WG 25
- IEC
- CENELEC

National Organizations:
- ISA
- ANSI (US)
- EIA/CEMA
- ASHRAE
- IEEE
- SAE
- ANSI C12 Series
- AHAM
- ASHRAE SSPC 135 U1WG
- NIST

Trade, technical, and government:
- EPRI IWG
- AEIC Meter Group
- UCA International
- BACnet™ Users
- BACnet™ Mfrs
- Zigbee Alliance

Consortia and user groups:
- IETF
- IEC 61850 Users
- IEC 61970/68 CIM Users
- Open AMI
- Utility AMI
- Open HAN

RD&D Projects:
- CEC Projects
- EPRI Projects
- DOE Projects
- DOD Projects
- Other Projects

*Representative Sample
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A Standards Development Model

Universe of networking and distributed computing options

Standards Developed by Formal Standards Development Organizations (SDO’s)


Technical Interoperability Agreements

AEIC, Open AMI, Development and Initial Implementation Projects

Conformance Testing

End-Users Desired Interoperability (Plug and Work)
Three Necessary Ingredients for Successful Interoperable Systems Development

Three Legged Stool: For Interoperable Products

1) Mature Open standards: Protocols, test schemas, object models
   - IEC TC57, ANSI C12, ASHRAE SPC135, Other

2) Involved User Group: Interoperability Agreements, Labeling, Testing, Marketing
   - UCA International, BACnet Mfgs. Assoc. Assoc. of Edison Illuminating Cos, Other

3) Reference implementations and Designs: Developer Tools, Standards Implementations and test implementations
   - AMRTools, openAMI, ...
Applications/Equipment Development Processes: Work with Standards Communities

*Don’t Skip Steps in this Process!

Standards Based Technology

Requirements
Analyses
Designs
Implement Bench/Develop

Energy Specific Standards
User Groups

Interoperable Equipment

Utilities

Manufacturer

Field Test Small/Develop
Field Test Large/Demo

Commercial Rollout
Methods: Use Systems Engineering and Architecture Development... Requirements Elicitation First

- Initial Ideas and Concepts
- Reference Requirements Sources
- Project Team Develop Initial Drafts
- Reviews
- Stakeholders Review
- Draft Requirements and "Use Cases"
- Scenarios of vision and future operations functions
Architectural Gaps

• Policies for management and security need to be further developed and consistently applied
• Network and Systems Management Infrastructures need to be further specified, evaluated and adopted/developed
• Security Architecture Needs to be Developed/Adopted for Advanced Automation and Customer Communications
• Physical Media Options Need to be Better Understood for Specific Functions, Designs Developed Implemented and Tested
• Networking Infrastructure Options Need to be Better Understood and Designs Developed, Implemented and Tested
Architectural Gaps Continued

- Requirements and Reference Designs for Advanced Automation and Customer Communications need to be fleshed out for Specific Functions:
  - Distributed Energy Resource Integration
  - Advanced T&D Automation Integration
  - Customer Communications and Metering
  - In-Building Equipment Integration for Energy Functions
  - EV/PHEV Integration for Advanced Operations
- Common Application Level Communication Objects need to be developed for key applications that cut across traditional Operations
Customer Communications Situation Analysis: R&D Needs

- Common requirements that are sufficient for common equipment designs for the industry is an urgent need.
- Need to integrate/distill libraries of requirements from Utility User Groups and Standards Organizations.
- Network and Systems Management (including security) on the scales needed by the industry still needs to be resolved.
- Development of the key integration technology needs to be developed before the technology is “demonstrated”.
- Standards efforts are fragmented across different initiatives and now need to be coordinated.
Develop/Harmonize Common Meter Data Models for Integration of MDMS with Field Operations

R&D Needed: Integrate Across Standards=> Common Meter Data Model

IEC 61970/61968 Common Information Model (CIM) Enterprise Application Integration

"Service Oriented Architecture"

ANSI/IEC Metering “Field Operations”

Meter Master Station
Moving Forward: A Ten Step Program

1. Work toward consistent industry level policies for customer communications infrastructure
2. Use Systems Engineering and Architecture Development Methods and Tools
3. Use a “Requirements Driven” approach to technology adoption and development
4. Work toward an industry level strategic architecture model and development pathway in key areas such as customer interface
5. Do not do “one off” or custom projects that are not on a strategic open systems architecture pathway
6. Do not “wait” for standards: Use, adopt, further develop, contribute to and procure to key industry level standards
7. Understand where the technology “gaps” and “overlaps” are and work on collaborative solutions
8. Adopt technology from other industries only as appropriate making sure it meets energy/power industry requirements
9. Develop energy specific standards where needed: i.e. applications level language
10. Recognize where collaborative R&D is needed and actively participate
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