Infrastructure, Standards and Architecture Development for the “Smart Grid”

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A portion of success from focused work…

IEC 61850
Interoperability
Booth

Laufenburg Substation,
Switzerland…61850 in
Use

CIGRE 2004
“Smart Grid” Scope is End to End
Drivers For Open Standards and Architecture Development

- Open Systems and Standards Development
- Systems Engineering Methods
- Communications Asset Utilization
  - Capital Cost Reductions
  - Life Cycle Cost Reductions
  - Robust Designs Enabling Infrastructures
  - Shared Infrastructures
  - Bundled and New Applications

Decrease Costs → Increase Value
Interoperability Key Concept: Use a Common Language for Communications

Data Packet

C12.22 Device

Network Communications Information
Address 135.35.5.2

End Device (Meter)

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

Revenue Meter

End Device (Meter)

Network Communications Information
Address 135.35.5.2

ANSI Standard Communications “Envelope”

Meter Data Message “Letter”

Meter Inc. Model 12b
2 Phase, 120VAC, 200A

55 000 801

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What is A Common Language?

1. Physical Communications Media...
2. Communications “Envelope”
3. Communications Message “Object”

“Master Station” Computer

Intelligent-Communicating Remote Device (Meter)
Recommendation: Develop Designs that Make Use of Layered Communications…

“Master Station”

Computer

“Wireless”

“Fiber Optic”

“Wired”

Brand X

Brand Y

Brand Z
Develop Technology to Enable Consistent Security Policies Implementation

“Security Policies”

“Wireless”

“Fiber Optic”

“Wired”

Intrusion Detection

Encryption

Access Controls

Monitoring

Brand X

Brand Y

Brand Z
Energy efficiency and demand response *if architected correctly* could assist the development of a smart grid.
Power Industry Uses a Variety of Distributed Computing “Environments”
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

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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 UIWG
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
DOC Projects
Other Projects

*Representative Sample
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
Integration Across Both Information Technology and Field Equipment is Required
Emerging Requirements for Advanced and Mission Critical Applications

- Mission Critical Power System Automation and Protection
- Real-Time Application Support
- High Reliability
- Full Set of Cyber Security Functions
- Full Set of Systems Management Capabilities
  - Fault, Configuration, Accounting, Performance, Security, Application, Other
- Quality of Service Management
- Scaling and Addressing on Large Scales
- Consistent Policy Based Management over Networks of Networks
- Mobility
OSI Basic Reference Model

Application (Central)

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

Application Level Language => Harmonize

“Middle Stack”
=> Investigate Issues with Management & Maturity Develop Common Approaches Adopt as Appropriate

“Physical Media”
=> Understand and Use as Appropriate

Application (Remote)

7: Application
6: Presentation
5: Session
4: Transport
3: Network
2: Data Link
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Application Level Language => Harmonize

“Middle Stack”
=> Investigate Issues with Management & Maturity Develop Common Approaches Adopt as Appropriate

“Physical Media”
=> Understand and Use as Appropriate
“Smart Grid” Today…

- Little or no enterprise level integration
- Limited Visibility across the system
- Little integration between IT and Field Automation
- Some Standards in use… but not enough use
- Older difficult to maintain protocols
- Patchwork of “legacy” Systems
- Islands of automation
- Proprietary “Solutions”
- Limited Visibility

Where’s the Architecture?
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
A Sample of “Smart Grid” Infrastructure work that has taken place and needs to be built upon...

- **IEC 61970/61968** for Enterprise “IT” Integration
- **IEC 61850** for Real-Time Field Automation, DER and Wind
- **IEEE P37.118** for Phasor Measurement Units
- **SAE** for PHEVs
- **ANSI C12** Revenue Metering
- **ASHRAE/ANSI 135** for Building Automation
- **ISA** for Industrial

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Applications and Infrastructure Development Needs to Occur in Parallel: Designs are Critical to Architecture

- Requirements
- Analyses
- Designs
- Implement Bench/Develop
- Refinement
- Field Test Small/Develop
- Field Test Large/Demo
- Commercial Rollout
- Manufacturer
- Interoperable Equipment
- Standards Based Technology
- Adoption
- Architecture Development
- Individual Project work
- User Groups
- Energy Specific Standards
- Energy Specific Standards Based Technology
- Adoption
- Architecture Development
Ingredients for Successful Industry Level Interoperable and Managed Systems Development

Three Legged Stool: For Interoperable Products

1) Open Mature 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

3) Reference implementations and Designs: Developer Tools, Standards Implementations and test implementations
Customer Communications (AMI) Scope: Integrated Wide Area and Local Area Networks

RTP System Architecture
Standards alone are not enough for interoperable product development...

Universe of networking and distributed computing options

Standards Developed by Formal Standards Organizations (SDO’s)

- IEC 61850, 61970
- ANSI C12

Interoperability Agreements from Consortia

Users Agreements

End-Users Desired Interoperability (Plug and Work)

Management and Security (Future)
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
- SG Profile
- Other

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Application Language Strategy for Working with Industry: Mutual Respect For Domain Knowledge

Meters
- ANSI C12 Series

Power Industry
- IEEE PES
- IEC TC 57

Customer Comm
- LBL DRAS
- Zigbee
- Open HAN
- Utility AMI
- AMI SEC

Focused R&D

Electric

Composite
- SAE
- DMTF
- ASHRAE
- AHAM
- ISA

SAE
- Automotive Industry

DMTF
- Computers

ASHRAE SSPC 135
- Buildings & HVAC

AHAM
- Appliances

ISA
- Industrial

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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 California 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 California Specific Functions:
  – Distributed Energy Resource Integration
  – Advanced T&D Automation
  – 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
Architectural Development Recommendations

• Develop and Use Systems Engineering Tools to Collaboratively develop requirements that support the key California Applications
• Document requirements in standardized notation and industry models
• Evaluate Requirements and Develop standards based equipment Designs based on the requirements
• Use these designs to evaluate the supporting standards.
• Contribute results to appropriate Standards and User Groups
• Assist the integration of key standards necessary to support next generation applications for California
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 |
|-------------------------------|-------------------------|---------------------|------------------|
| CIS                           | AM/FM/GIS               | OMS                 | Distribution Automation |
| **“Service Oriented Architecture”** |
| Proprietary Metering B        | Proprietary Metering A  | Meter Data Management |

ANSI/IEC Metering “Field Operations”

Customer Communications

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
Industry Architecture Development Puts a Technical Framework around Key Relationships…

- Regulators
- Government Agencies
- Standards Communities
- Product Vendors
- Utilities and Energy Companies
- Energy Consumers
- EPRI and Industry R&D Projects and Development

Industry Architecture Foundation Work