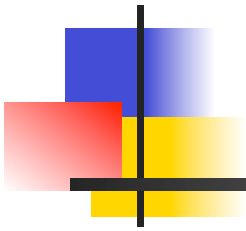


Network Architecture in the Smart Grid



**Architectural Requirements in
the NIST Framework and how to
meet them**





Architectural designs

Internet Architecture

Application	Application Protocol, encoding, AAA, identity, encryption
Transport	End to end reliability
Internet	End to end routing, VPN, Network AAA, identity, encryption
Data Link	Link encoding on physical layer
Physical	Physical Interconnect

“1-2-7” Architecture

Application	Application Protocol, encoding, AAA, identity, encryption, End to end reliability, end to end routing
Data Link	Link encoding on the physical layer
Physical	Physical Interconnect

Examples

Internet Architecture

- The Internet
 - IPv4 or IPv6
- The ISO OSI Reference Model
 - breaking the application into several layers
- Novell Netware
- AppleTalk
- DECNet
- XNS Internet Transport
- etc

*Designed to work in
Enterprise and general
networks*

“1-2-7” Architectures

- Microsoft NetBIOS
- IEC 14908 LonTalk
 - Implements 7 layers, but in the application protocol
- Zigbee 1.0
- Many others in the Grid

*Wire replacement, designed
to work in local networks*



Zones of Smart Grid Communications

- **Enterprise bus:**
 - **Connects control center applications to markets, generators, and each other**
- **Field Area Networks:**
 - **Devices that control circuit breakers and transformers**
- **Substation Networks**
 - **Premise networks in substations: special requirements**
- **Premises Networks:**
 - **Connections within customer and utility premises**
- **AMI Networks:**
 - **Connecting utilities to premises**



Functional Requirements for communication

- **“...the Network should enable an application in a particular domain to communicate with an application in any other domain in the information network, with proper management control over who and where applications can be interconnected.”**



Implication of functional requirements: *Link layer independence*

- **Many different link layer networks are used in the Smart Grid**
 - Ethernet, IEEE 802.11, IEEE 802.15.4g, Homeplug, ...
- **Therefore, either**
 - *Each link layer must be directly translatable to any other via a gateway, and addressable end to end, or*
 - *Network addressing and routing must be independent of the link layers in the Smart Grid*
- ***Link layers are not designed to be translatable and application-independent gateway technology is not defined***
 - **No “1-2-7” architectures**



Implication of functional requirements: *End to End Security*

- **Link layer network standards are not designed for application identity/authentication/authorization/confidentiality management**
 - **IEEE has defined many of these within local area networks, but not end-to-end**
 - **They are also used at the network layer via IETF specifications**
- **Therefore,**
 - ***Applications and network elements must implement interoperable AAA and encryption standards***



Implication of functional requirements: *Divisibility into manageable domains*

- **Design intent of specifications**
 - **Link layer standards, including link layer networks, are designed as wire replacements – they connect every system to every other within their domain**
 - **Network layer standards are designed to organize networks into separable and separately manageable domains**
- ***Use each for the purpose for which it was designed***



Implication of functional requirements: *End-to-end interoperability*

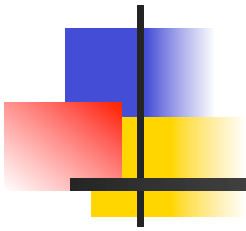
- **Multi-link-layer and Multi-network *interoperability* is proven in the Internet Architecture**
- **There is no other architecture in current use that has demonstrated world-wide, multilingual, general purpose *interoperability***



Internet Community to Smart Grid: adopt our working technologies; *make new mistakes*

- **Focus on security**
 - We have defined and partially implemented security solutions, but many don't use them
 - *Use them*
- **Addressing**
 - We have largely used up the IPv4 address space;
use the larger address space in IPv6
- **Focus on interoperable manageability**
 - We have solutions for this, but little market requirements; *use proven encodings like XML and application architectures like BEEP, ATOM, and XMPP*

Network Architecture in the Smart Grid



**Architectural Requirements in
the NIST Framework and how to
meet them**

