

An Overview of Smart Grid Standards



Grant Gilchrist
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Why Use Standards?

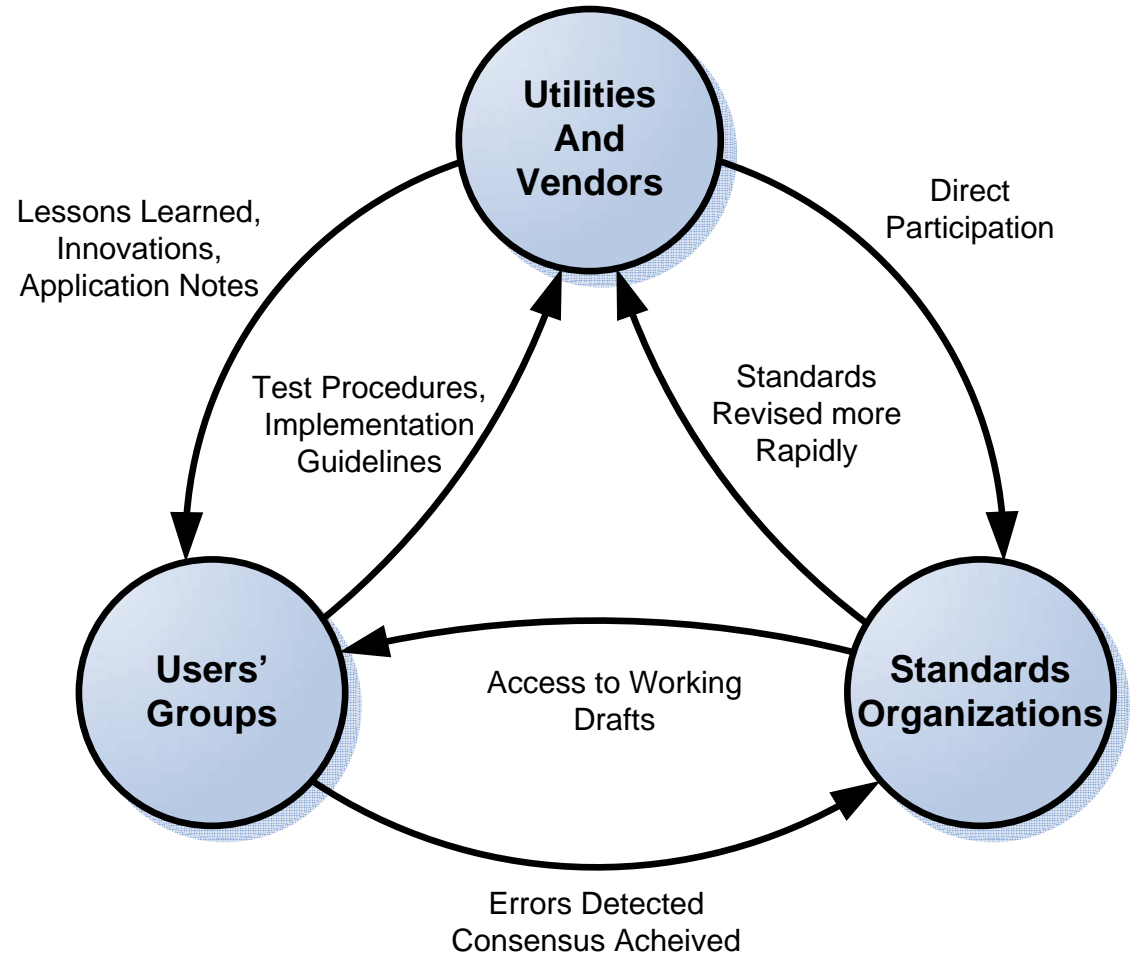
- Avoid re-inventing the wheel
- Learn from industry best practices
- Specify requirements more easily
- Reduce integration costs
- Prevent single vendor “lock-in”
- Vendors share a much larger market



Making Standards Work

Items critical to a successful standard:

- Mature spec
- Involved user group
- Certification process
- Revision process
- Marketing, labeling
- Implementations
- Tool sets

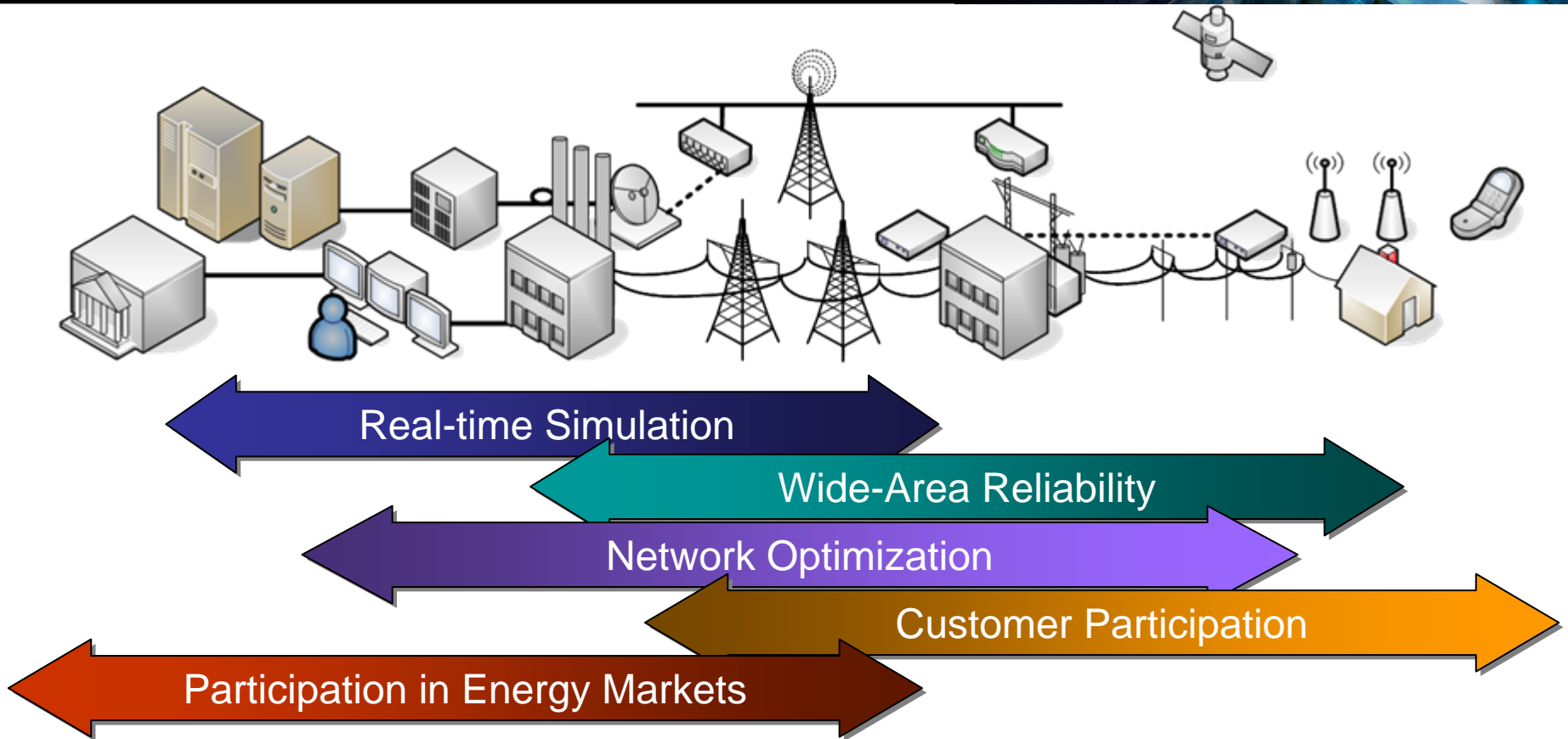


Why International Standards?

- Several Advantages
 - Time-tested process
 - Proven fair and open
 - Can be accelerated if needed
- Other alternatives:
 - “de Facto” needs a market-maker
 - Industry consortia can work well
 - Work even better if endorsed by a standards org

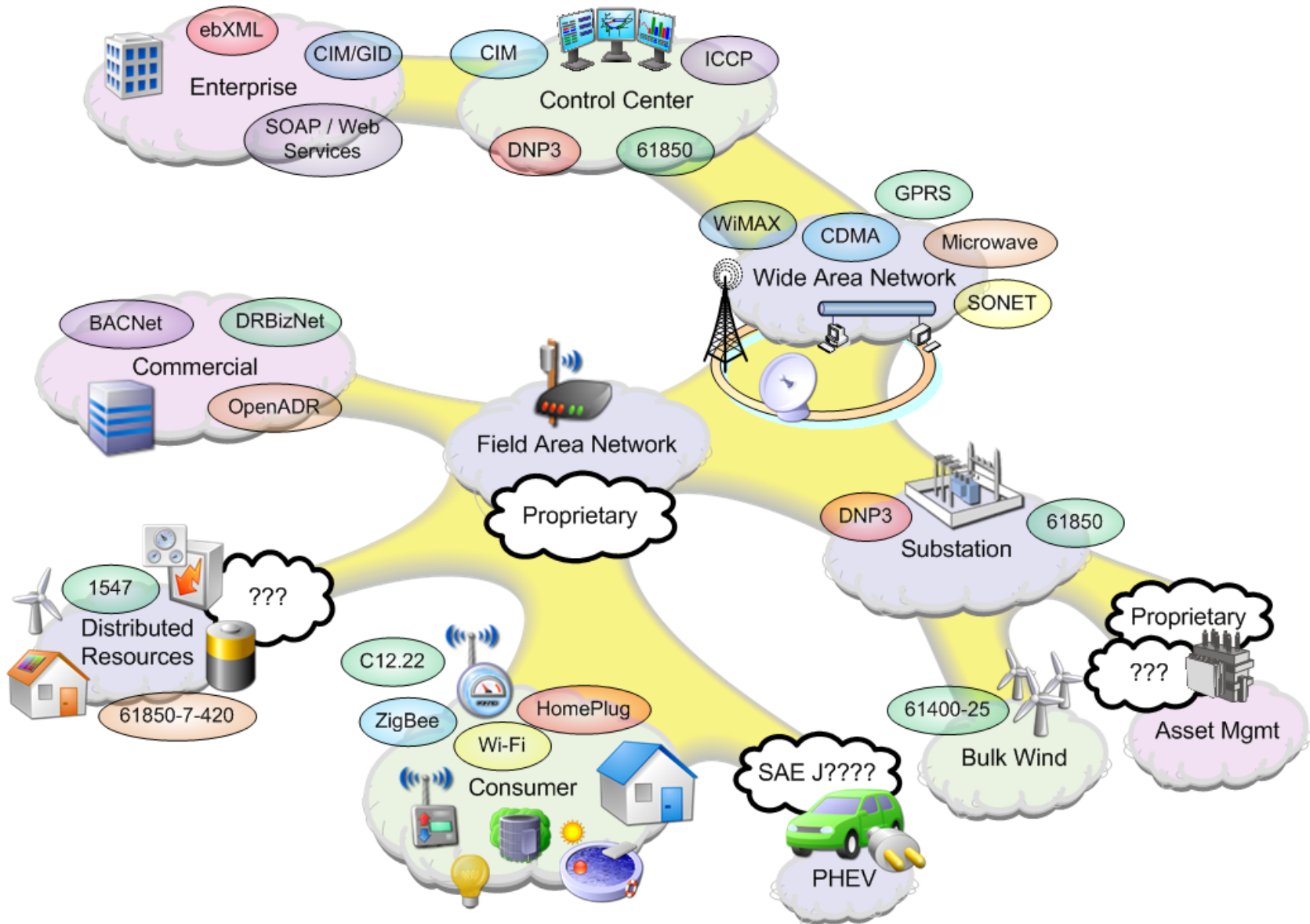


Standards in the Smart Grid



- EPRI IntelliGrid Architecture, <http://www.intelligrid.info>
- Catalog of Use Cases, Standards, Technologies

Smart Grid Comm Standards Domains



Enterprise and Control Center

| Name / No. | Description | Status |
|-------------|--|---------------------------------|
| IEC 60870-6 | Inter-Control Center Protocol | Widespread |
| IEC 62325 | ebXML for Power Systems | In development |
| IEC 61970 | Common Information Model / Generic Interface Definitions (CIM/GID) | In use; mostly single-vendor |
| IEC 61968 | Interfaces for Distribution Management | Mostly still in development |
| Multispeak | NRECA Enterprise web services | In use; not flexible |

- There is a culture of manual integration
- Very labour-intensive and costly
- Object models and services defined, but...
- A variety of underlying technologies: UML, XML, OWL, XSD, RDF, OPC
- Working on agreement on a design framework



T&D Wide-Area Networks

| Name | Notes |
|------------------------|---|
| Frame Relay | Packet-switched, no reliability guarantee |
| SONET | Campus or city backbones |
| WDM | Wavelength Division Multiplexing – follows SONET |
| <i>Microwave</i> | Proprietary, used in geographically difficult areas |
| <i>Satellite</i> | Various proprietary technologies, costly |
| <i>Trunked Radio</i> | Licensed, one broadcast channel, one return |
| <i>Spread-Spectrum</i> | Unlicensed frequencies, more efficient |
| <i>IP Radio</i> | Like trunked radio but with IP addressing |

- Many of these are considered obsolete or aging in the general IT world
- Still in common use in the power system



T&D Substations

| Name / No. | Description | Status |
|------------|--|--------------------------------------|
| IEC 61850 | Object models, self-describing, high-speed relaying, process bus | Widespread in Europe, beginning here |
| DNP3 | Distributed Network Protocol | Most popular in NA |
| Modbus | Evolved from process automation | Close second |
| COMTRADE | Fault Capture file format | Widespread |
| PQDIF | Power Quality file format | In use |
| IEC 62351 | Security for power systems | Recently released |

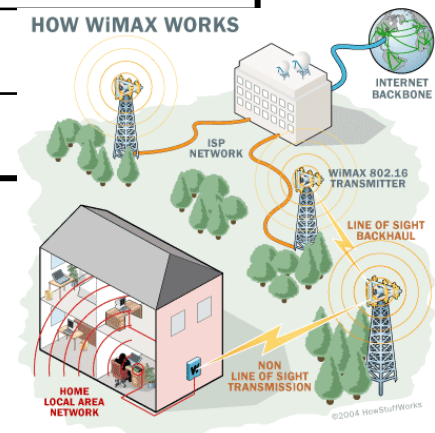
- Automation common in transmission
- Business case tough in distribution
- Well-known problems and solutions
- Moving to the next level



Access Wide-Area Networks

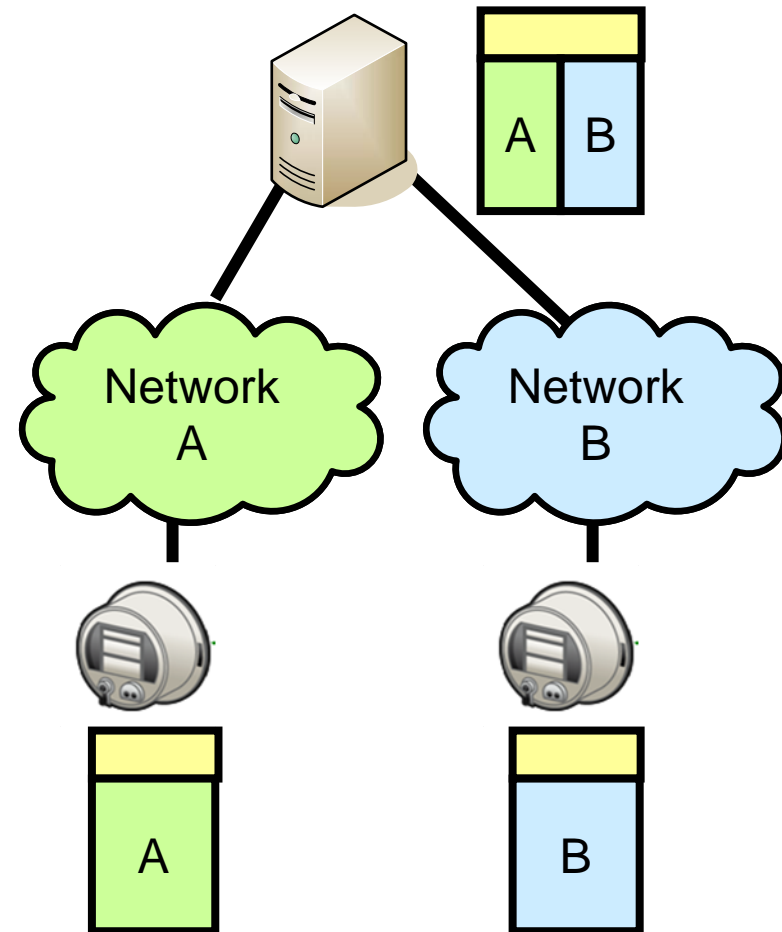
| Name | Notes |
|------------|---|
| PSTN | Public Switched Telephone Network – dial-up, leased lines |
| DSL | Digital Subscriber Line - Telco IP-based home access |
| Cable | DOCSIS standard for coax IP-based home access |
| WiMAX | WiFi with a backbone, cellular-type coverage |
| Cellular | Various technologies e.g. GSM/GPRS or CDMA/EVDO |
| FTTH | Fiber to the Home. Passive Optical Networks (PONs) |
| PLC | Narrowband Power Line Carrier – the “old stuff” |
| Access BPL | Broadband over power line to the home |
| Paging | Various proprietary systems, POCSAG |

- Used to reach the Collector or Substation
- Too expensive, too unreliable or too slow for actual access to home



Field Area Networks – Distribution and AMI

- Offerings mostly proprietary
 - Wireless mesh, licensed or unlicensed
 - Power line carrier, narrowband or broadband
- Open standards not useful yet
 - Cellular, WiMAX, ADSL, Cable, FITL
 - Not economical or not reliable or both
 - Mostly only reach the Collector level
- Interop solution: common upper layer
 - Network layer preferred: IP suite
 - Most don't have bandwidth
- Application layer instead: ANSI C12.22
 - Too flexible, not enough interoperability
 - Need guidelines, profile from users
- More bandwidth the main solution!



Home Area Networks

| Name | Number | Notes |
|----------|---------------|--|
| Ethernet | IEEE 802.3 | Substation LANs, usually fiber optic |
| WiFi | IEEE 802.11 | Access by field tool, neighborhood AMI net |
| ZigBee | IEEE 802.15.4 | Customer premises automation network |
| HomePlug | 1.0, AV, BPL | Powerline comms, in and outside premises |
| 6LowPAN | IEEE 802.15.4 | The “approved” IPv6 wireless interface |
| OpenHAN | | Power Industry requirements definition! |

- ZigBee and HomePlug alliance
- LONWorks, Insteon, Z-Wave, X10 – popular proprietary networks
- Challenges coming in Electric Vehicles



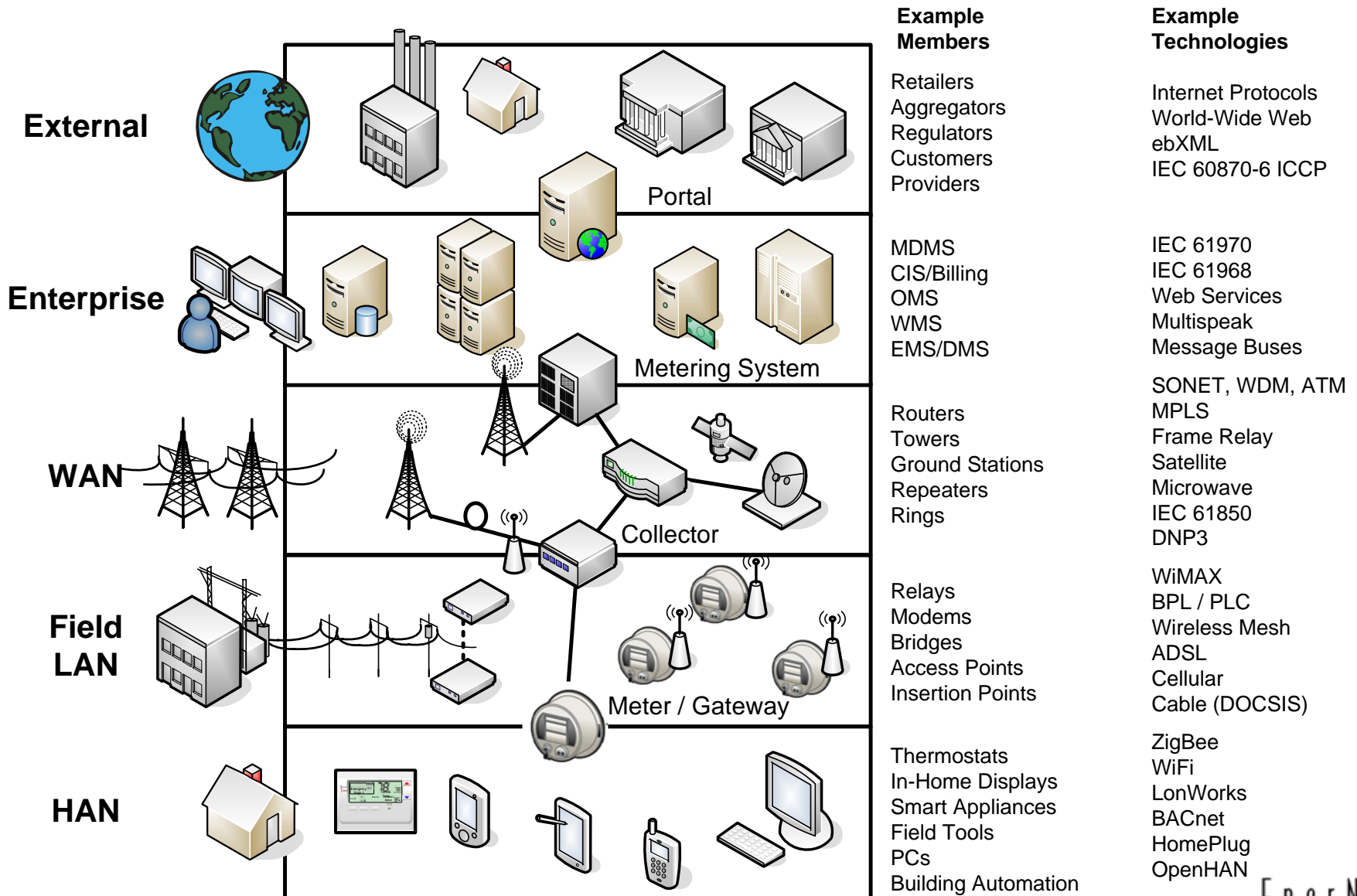
Distributed Resources and Commercial

| Name / No. | Description | Status |
|-----------------|----------------------------|------------------------|
| OPC | Application interface | Widespread in industry |
| IEC 61400-25 | Wind Power | In use; turf war |
| DRBizNet | California initiative | In development |
| BACNet | Building automation | In use; many profiles |
| OpenADR | Automated Demand Response | In development |
| IEEE 1547 | Basic principles of DER | In use |
| IEC 61850-7-420 | Information models for DER | Just released |

- Rapidly growing, but tend to be “islands of automation”
- Concerns over integration with power utilities
- Need to get people talking

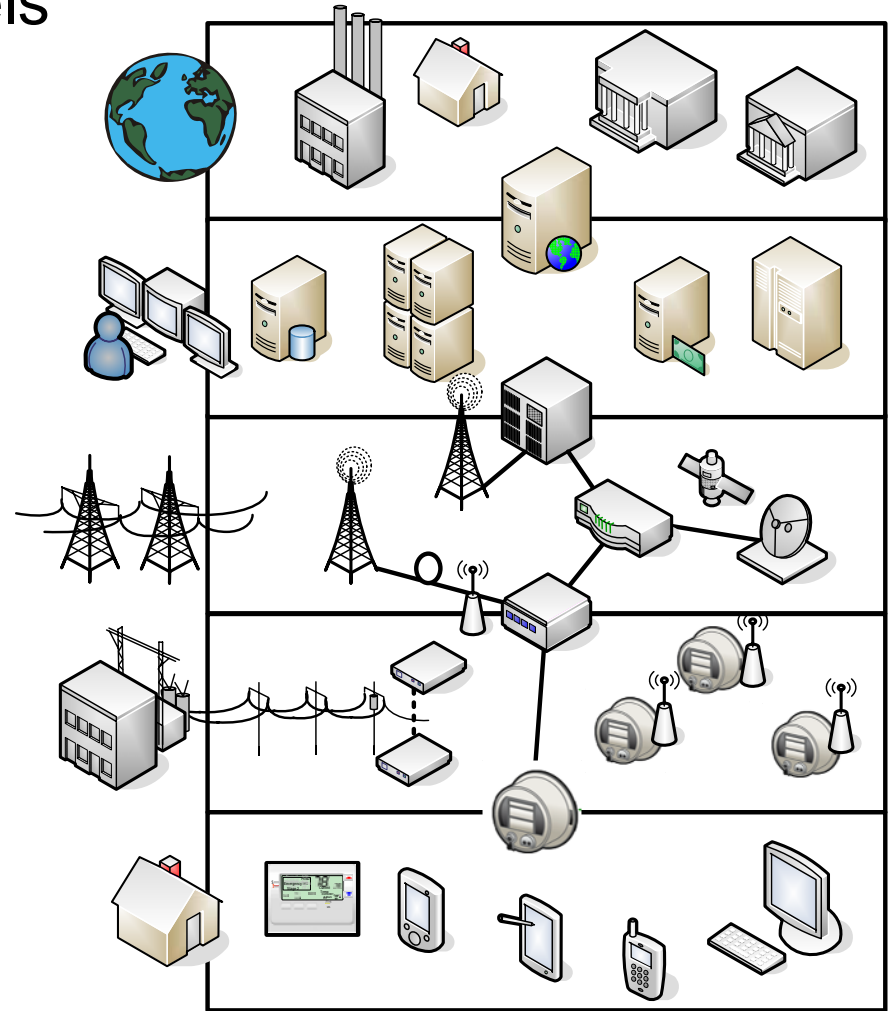


Another Look at Smart Grid Standards



Standards Challenges for Smart Grids

- Need Common Object Models
- Wishy-washy standards
- More bandwidth in the field
- Proprietary field networks
- Too many stds in the home
- Merging power and industry
- Merging meters and distribution automation
- Merging IT and operations
- Holistic security



Summary

| Essential | Promising | Needed |
|------------------------|-------------------|--------------------------|
| IP-based networks! | WiMAX | Standard Field LANs |
| IEC 61970 CIM/GID | ZigBee / HomePlug | Modems for Field LANs |
| IEC 61968 Distribution | OpenADR | More field bandwidth! |
| IEC 61850 Substations | 6LowPAN | CIM Design Framework |
| IEC 62351 Security | BACNet | CIM Application Security |
| DNP3 | OPC/UA | CIM/61850 Harmonization |
| ANSI C12.19, C12.22 | NERC CIPs | IEC 61850 Outside Sub |
| AMI-SEC | | ANSI C12 Guidelines |
| OpenHAN | | Finish AMI-SEC |
| | | Asset Mgmt, DER, PHEV |

We have the technology.

We have the lessons learned.

We just have to apply it!

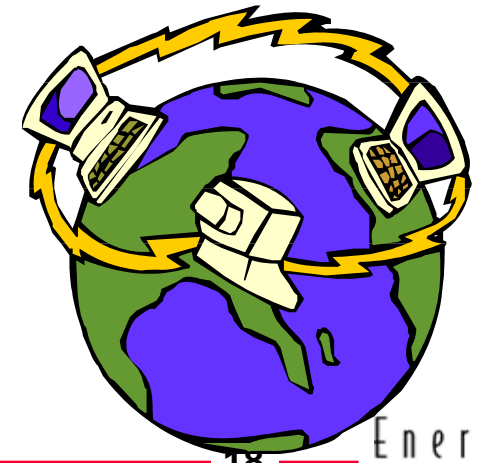
Appendix: Networking Standards



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Core Networking Technologies

| Name | Notes |
|------|--|
| IPv4 | What everyone uses |
| IPv6 | More addresses, better security, standard for China, DoD |
| TCP | Provides a connection, reliability, flow control |
| UDP | When you don't want any of those |
| HTTP | Basis of the world-wide web |
| MPLS | Latest of many to try to provide guaranteed bandwidth |



Security Technologies

| Name | Notes |
|--------------|--|
| TLS | Transport Layer Security – device-to-device |
| IPSec | Security for IP – site-to-site |
| HTTPS | Secure web traffic – application layer |
| Secure Shell | SSH, SCP, SFTP – secure login and file transfer |
| X.509 | Key and certificate management |
| RADIUS | Centralized password management |
| Kerberos | Centralized key management |
| WPA2 | IEEE 802.11i – wireless security (don't use WEP) |
| IEC 62351 | Security for Electric Utility Protocols |



Network Management Technologies

| Name | Notes |
|-----------|--|
| ARP | Address Resolution Protocol |
| DNS | Domain Name Service |
| DHCP | Dynamic Host Configuration Protocol |
| SNMP | Simple Network Management Protocol |
| CMIP | Common Management Information Protocol |
| SNTP, NTP | (Simple) Network Time Protocol |
| IEEE 1588 | Precision Time Protocol |