Smart Objects and Smart Grids

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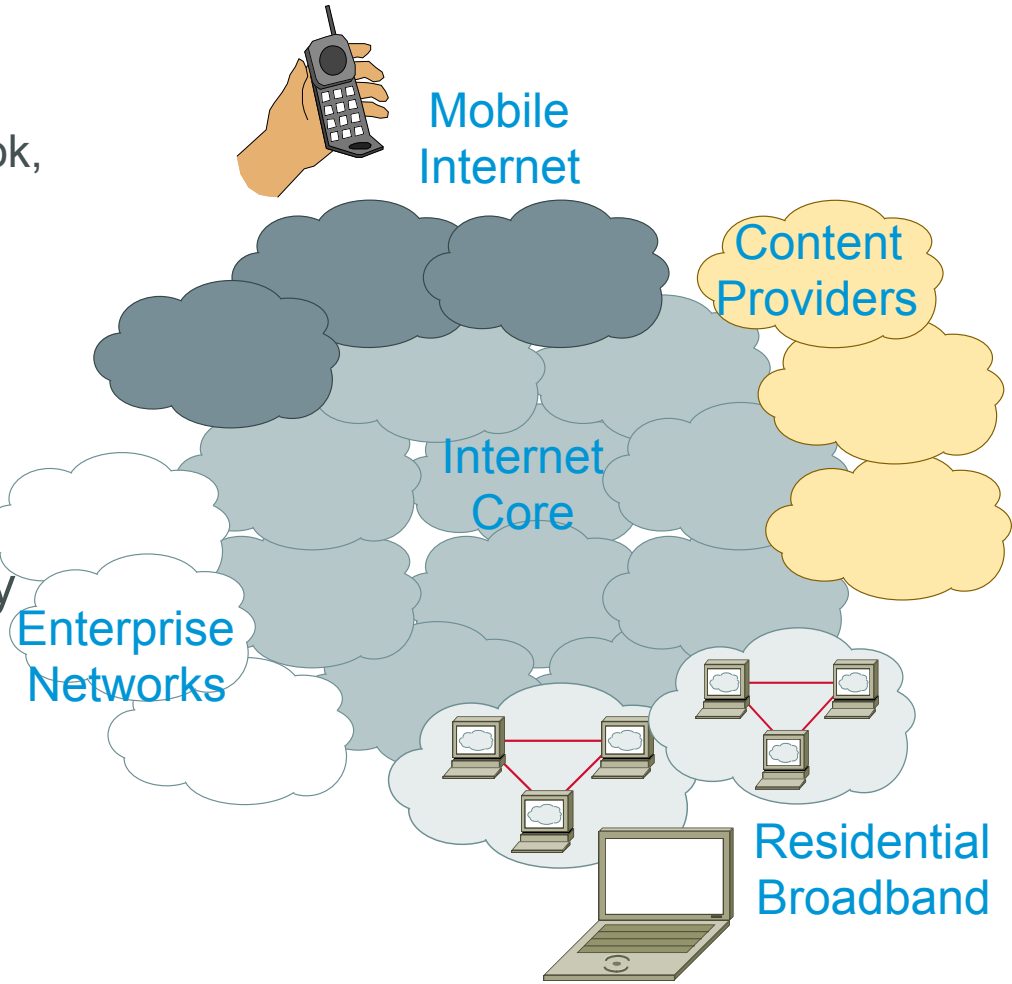
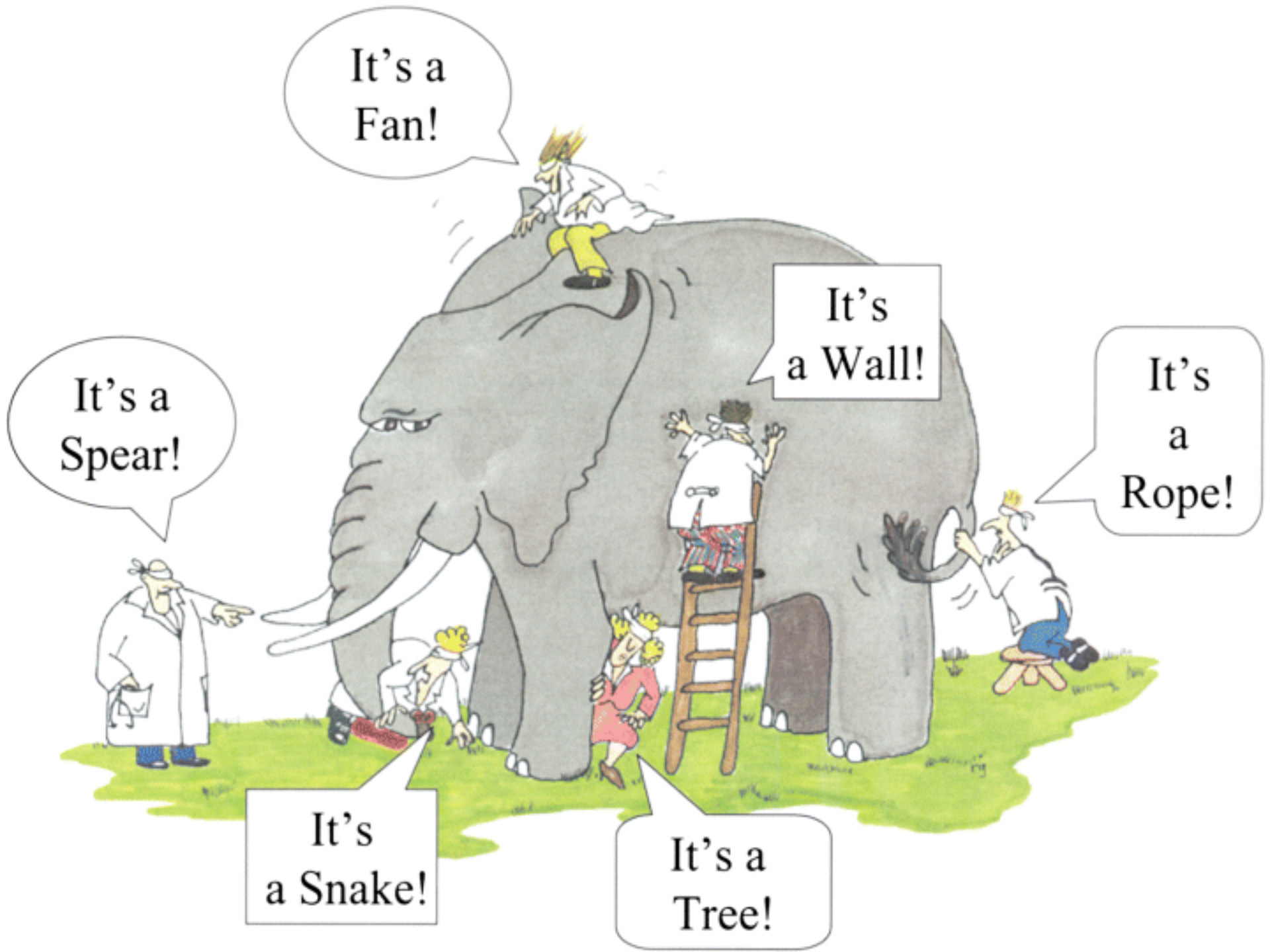
What is the Internet Today?
Network and business

A truly simplistic model of the Internet from a business perspective

- Many components
  - *Internet Core* – transit providers
  - *Content Providers* – Google, Facebook, YouTube
  - *Enterprise Networks*
  - *Residential Broadband*
  - *Mobile Internet/Telephone*
- People and companies are motivated to deploy a technology when it solves a problem that they believe they have
- Most portions of the network
  - Use services from other parts of the network
  - Use multiple communication technologies



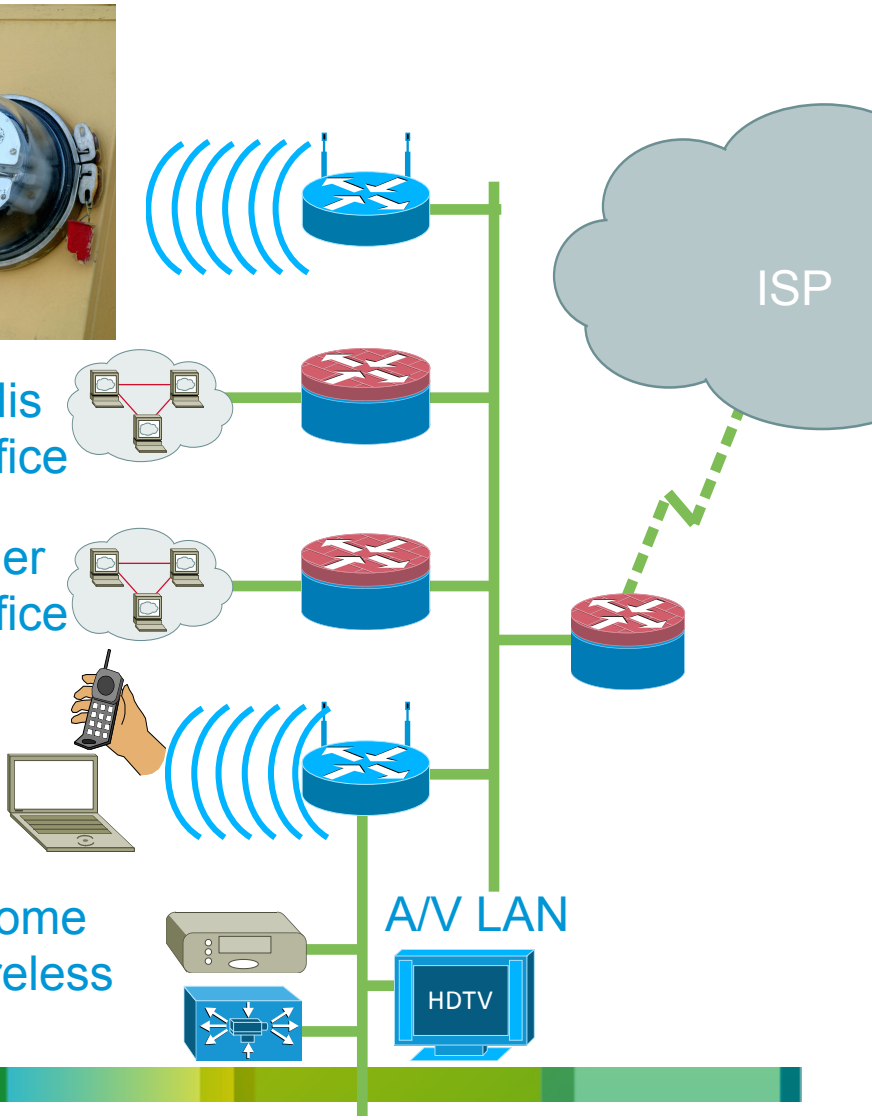

It's a Fan!
It's a Spear!
It's a Wall!
It's a Rope!
It's a Snake!
It's a Tree!

Changing applications

- Every 3-5 years, the Internet fundamentally changes in the payload it carries
  - 1990: FTP, Network News, telnet
  - 1992: World Wide Web, SMTP, multicast, experimental voice/video
  - 1995: WWW with multiple sessions in parallel, Voice on IP
  - 2000: Peer to Peer file sharing in various forms
  - 2003: Web 2.0 applications like MySpace, Facebook, BitTorrent File Sharing
  - 2008: Cyberlockers replacing file sharing
  - 1990-present: Rise of video in various forms
  - Lately: Map/Reduce and Hadoop – data center distributed applications
  - Next…
- On the commercial backbone, video is becoming dominant, primarily from ICPs that colocate with some or all of an ISP's POPs
- In private networks (Smart Grid, Health Care, Public and Private Safety) we see distributed telemetry and distributed control.

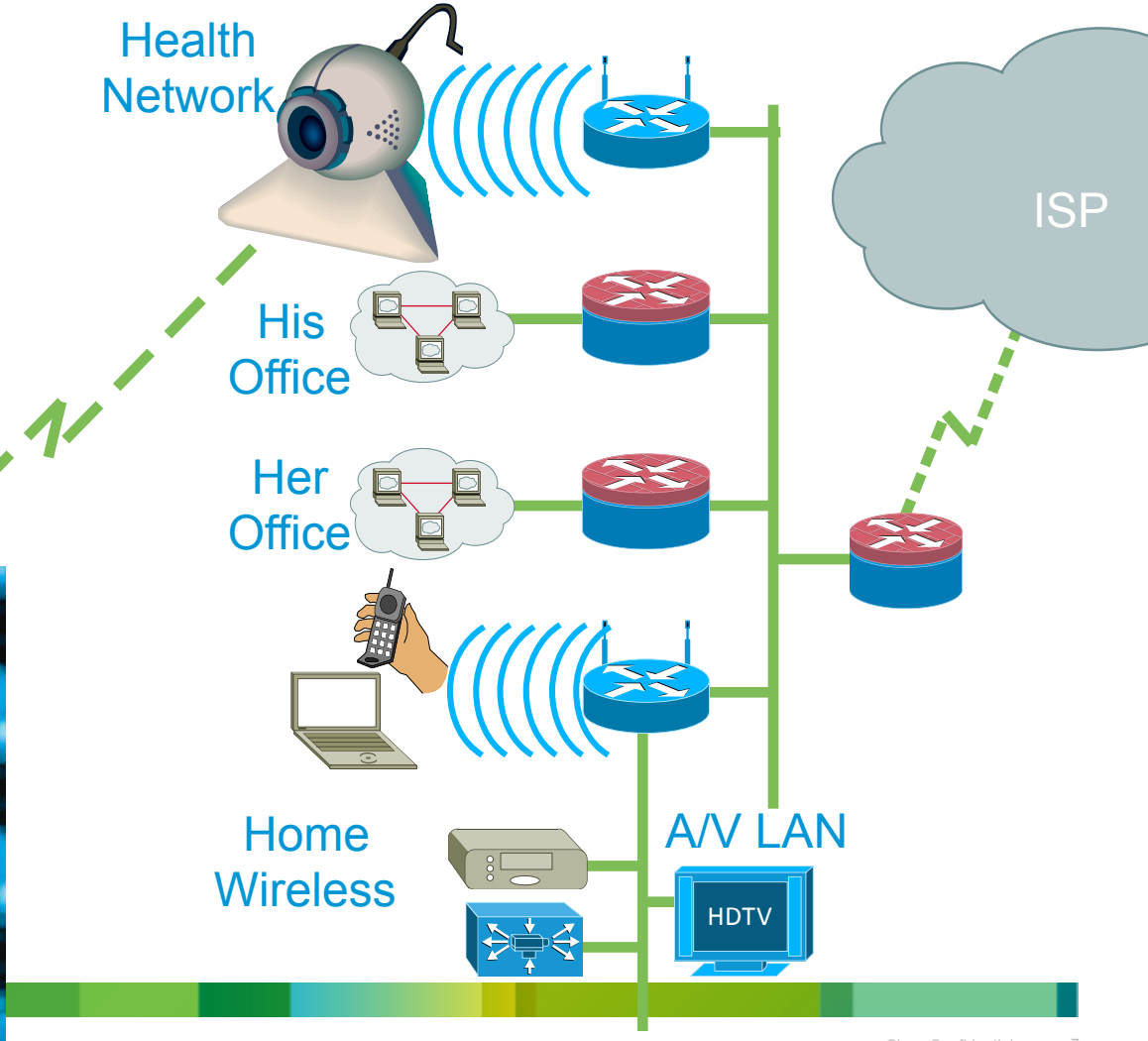
The changing home network

- Imagine a high end home network:
  - Audio/Video
  - Wireless
  - Telecommuting
  - Home Area Network
- What is the HAN?
  - Network connecting sensors in the home
  - Communications with utilities
  - Services to residents



Related to sensor networks for health…

- Infrared
- Motion sensors
- Heart Monitors
- Pedometers
- …



The Smart Grid:
Networks and business

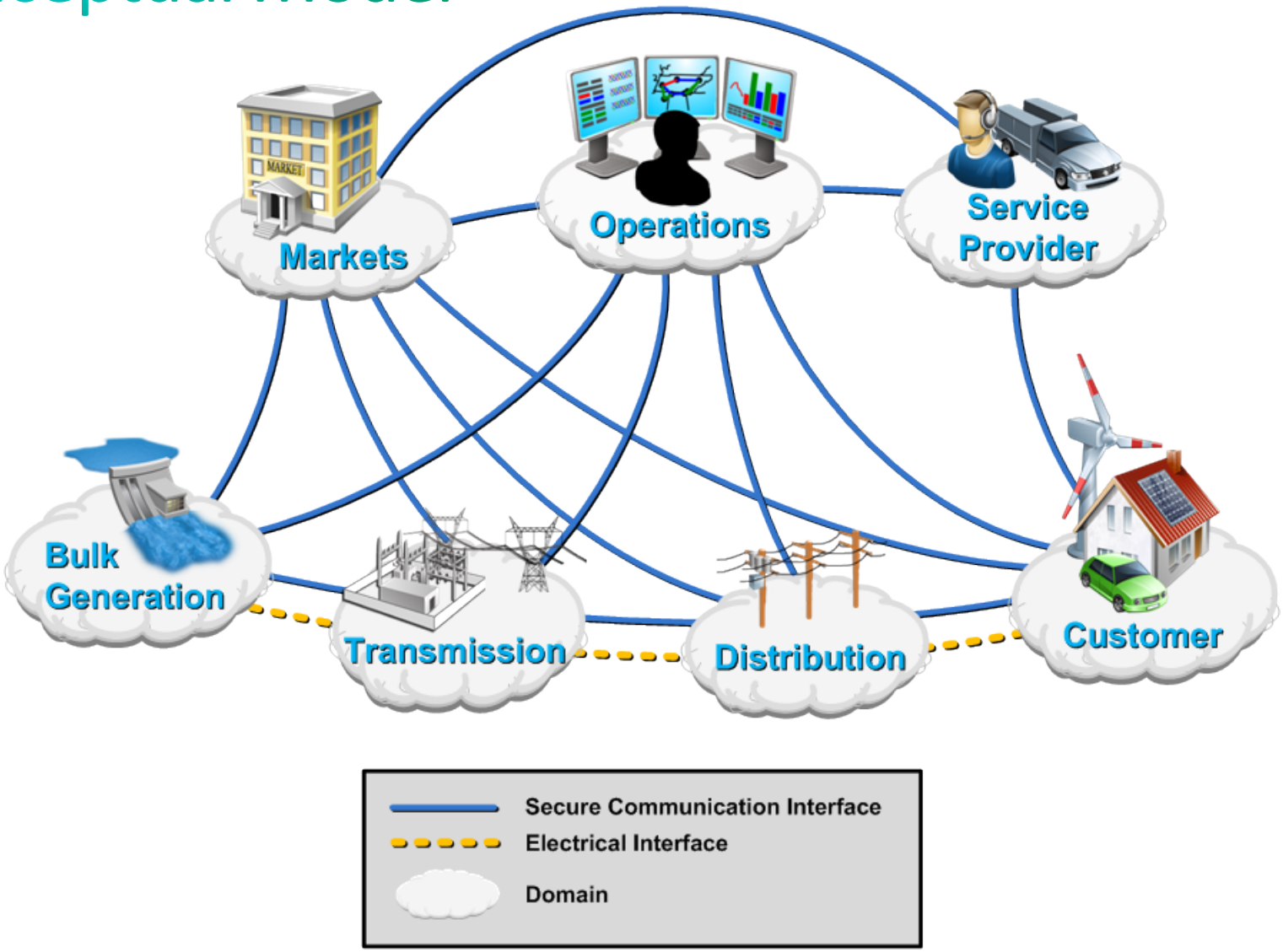
A brief overview of the Smart Grid

Figure 4: Domain Decomposition

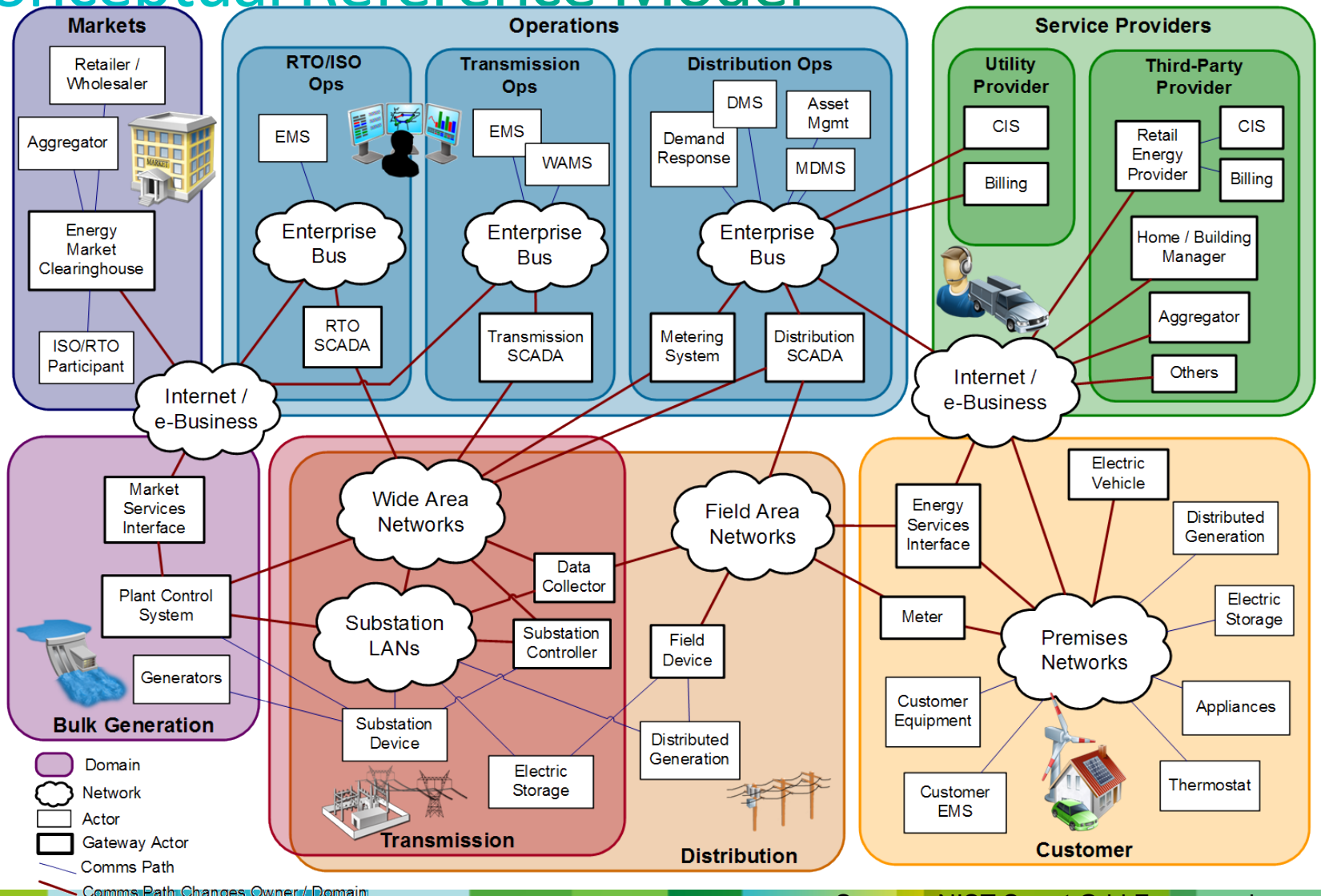
What Is A Power Grid?

- No single national power grid in North America
  - Thousand of distribution grids connected to…
  - Up to hundreds of transmission lines…
  - powered by thousands of generators
  - organized in to 4 large interconnects in N.A. (5 in Europe)
- North America has about 3,100 electric utilities (IOU's, muni's, co-ops)
- Now, in the US, overlay on all that…
  - About 150 control areas; 110 Balancing Authorities
  - Reliability Coordinating Councils and NERC regions
  - ISO's and RTO's

Conceptual Model

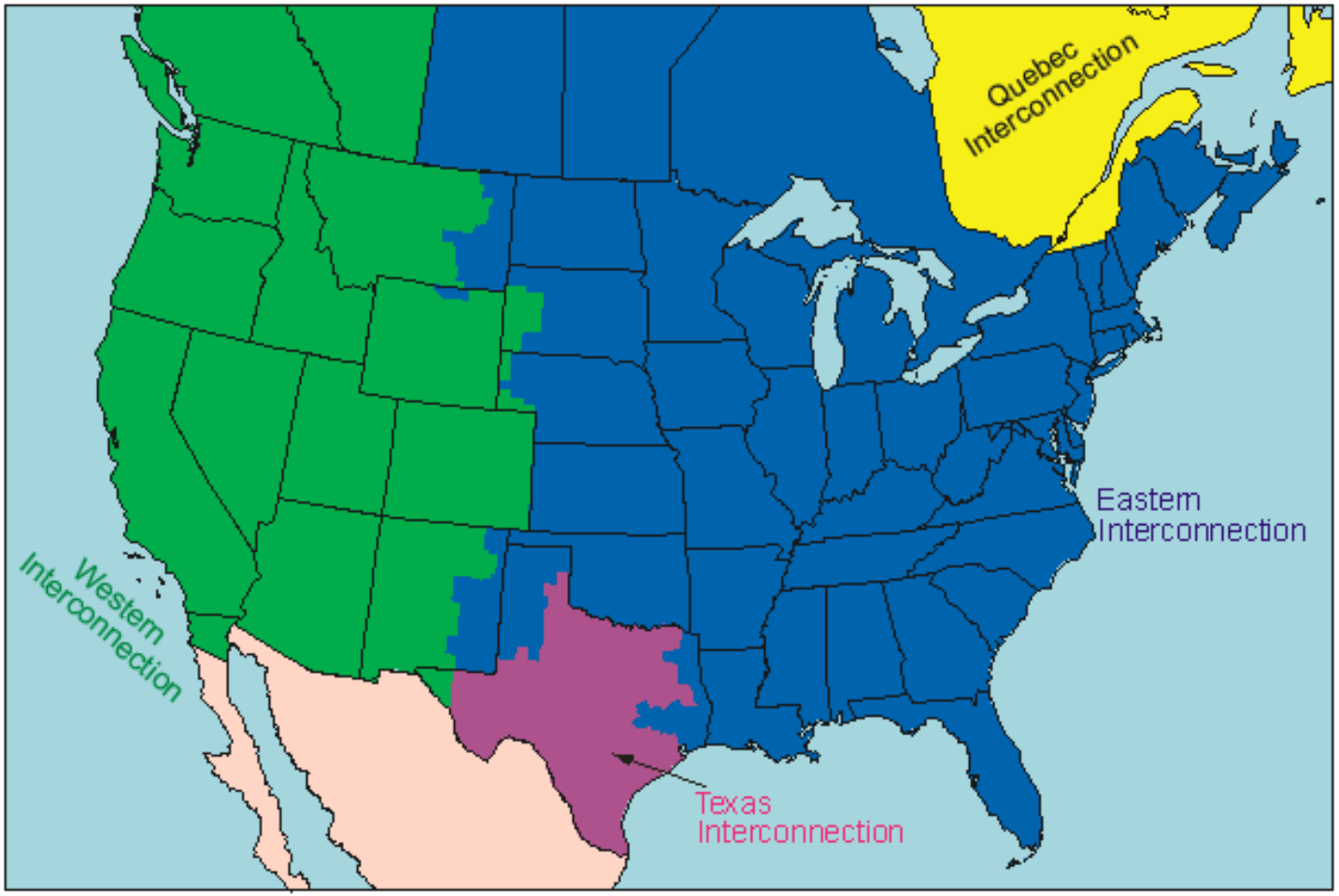


Conceptual Reference Model

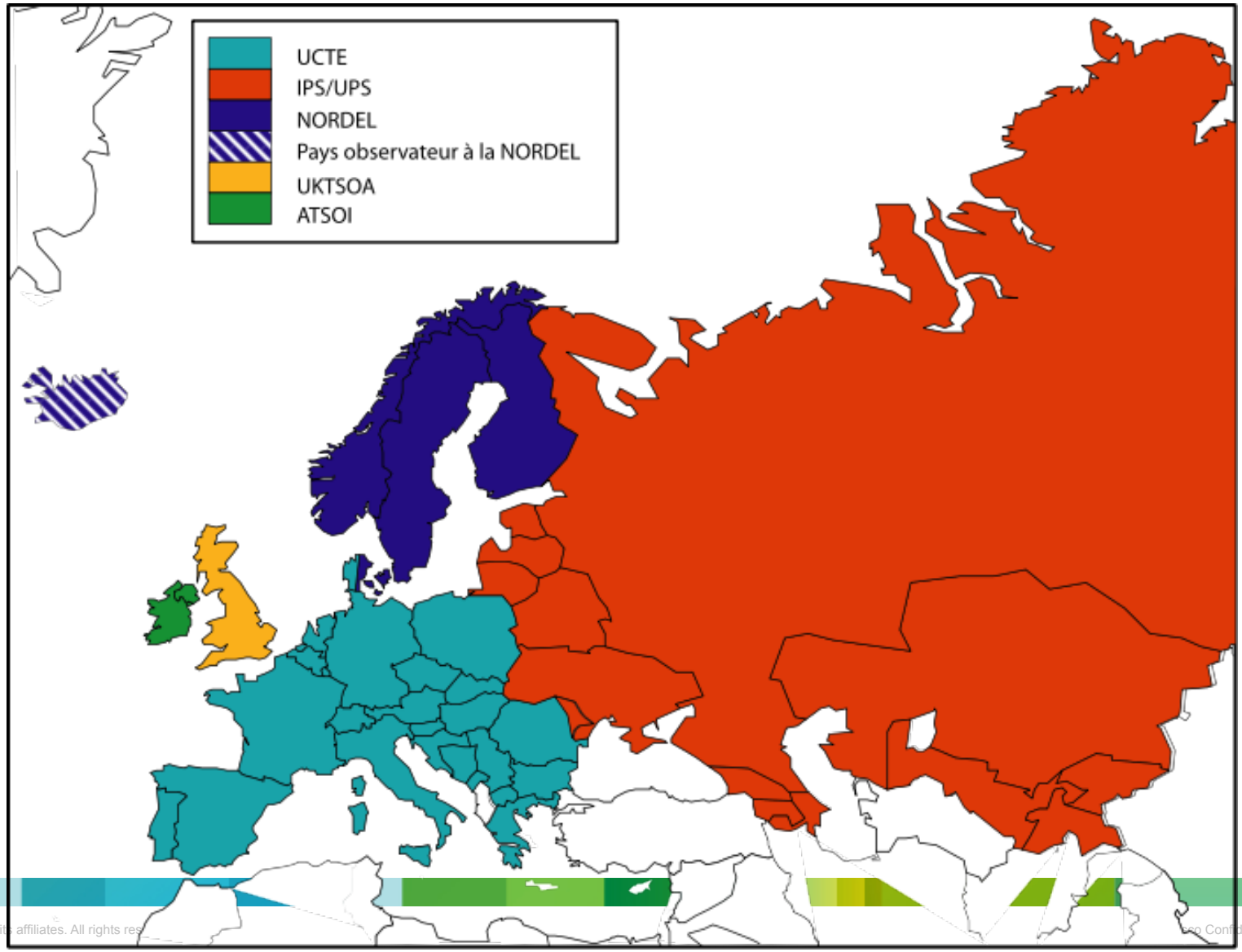


Source: NIST Smart Grid Framework

Interconnections of the North American Electric Reliability Council in the Contiguous United States, 1998



European Synchronous Grids



The Move Toward IP in Utilities

This is where the utilities have come from – but they are making much progress

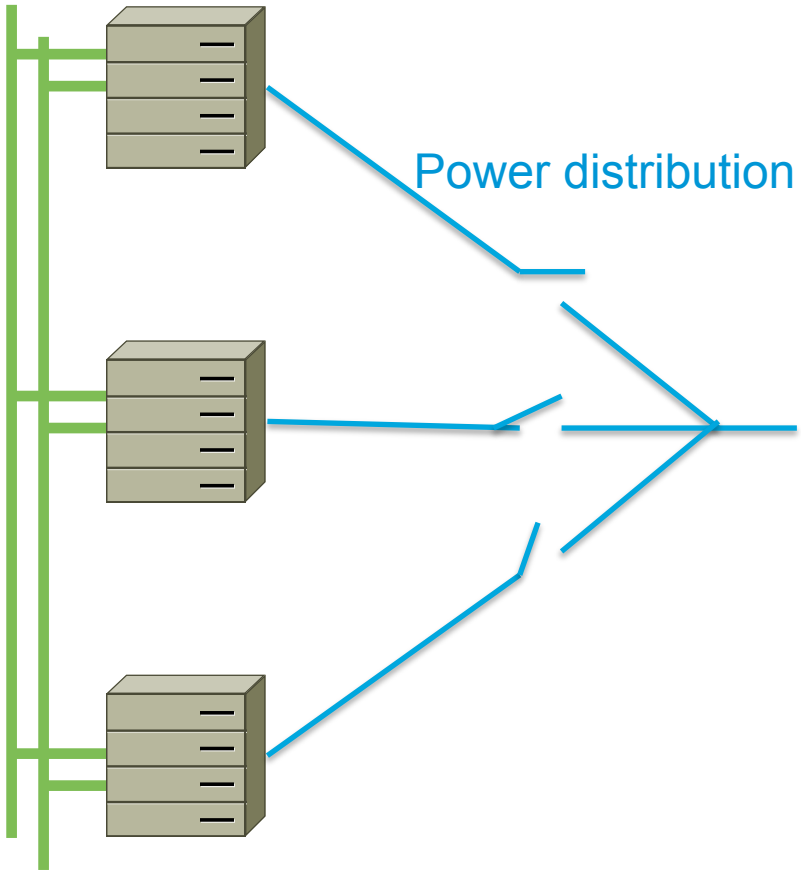
Smart Objects: What marketing people call the "Internet of Things"

Numerous categories

- Essentially a question of distributed telemetry and control
- *Many communication technologies, usually not directly attached to the Internet*
  - Powerline Communications: Primarily within/between buildings
    - IEC 14908, Homeplug IEEE 1901/ ITU
  - Low power radio
    - IEEE 802.15.1 Bluetooth, 802.15.4/4g Zigbee, 802.11
  - ANSI C12 meter management
    - OSI on powerline, twisted pair, or TCP/IP
  - Ethernet
  - Proprietary
- Many system architectures, not necessarily traditional
  - Internet architecture + Centralized Control
    - Similar to SNMP management
  - Internet architecture + Distributed Control
    - Set of controllers managing state of network application
  - Proprietary architecture based on standard communication technologies
    - Examples: IEC 61850 GOOSE, Ethernet-based Industrial robotics
  - Named data networks
    - Summarizing sensors
    - Content centric networking

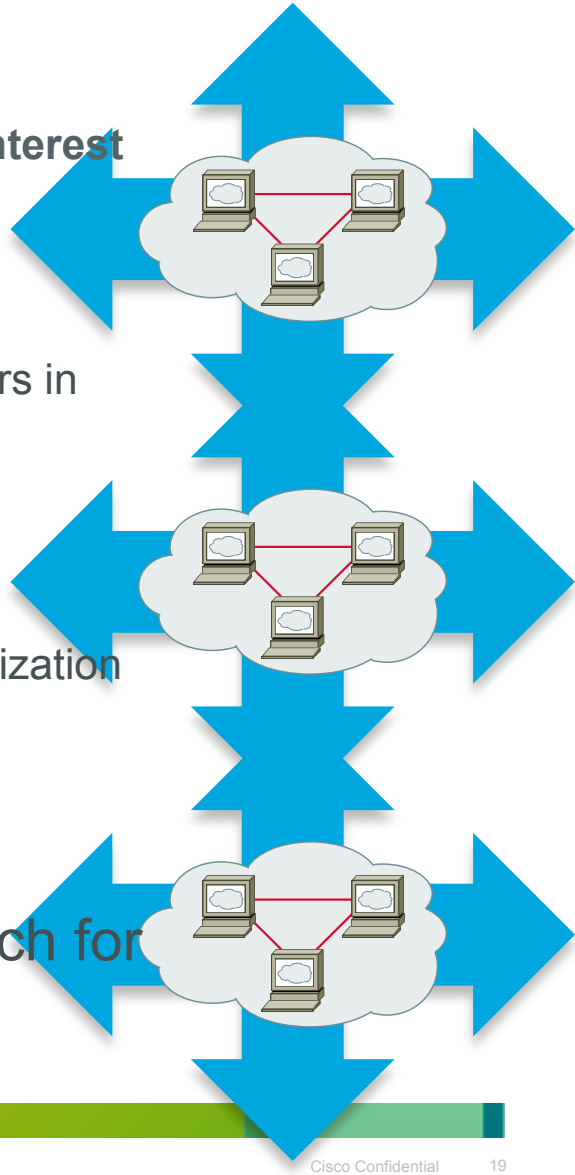
Generic Object Oriented Substation Event (GOOSE)

- What is GOOSE?
  - Ethernet multicast protocol exchanging state among systems in an IEC 68150 Power Substation
  - Redundant optical 100/1000 MBPS Ethernets
  - Equipment out of phase by ¼ Hz (4 ms) taken out of service
- Assumptions:
  - Even in a substation, communication is not impeded by physics
  - Propagation delays less than 1 ms
- Extensions to IP proposed
  - Targeting more distributed stations



Assumptions in Named Data Networking

- Essentially a data distribution network built on publish/subscribe principles
  - Data distributed from **producers** to **consumers** that express **interest**
  - "Interested" systems may include intermediate repositories
- Example of named data:
  - GPS location of isobars in temperature, humidity, or other factors in forests or farms
  - Fault data in power distribution networks
- Assumptions:
  1. Network layer privacy issues plus application layer summarization manage application layer privacy issues
  2. Consumers are interchangeable
  3. Producers are interchangeable
- If assumptions don't hold, application not a match for the technology



Automated surveillance

- The title makes this sound awful. Examples include health care, building management, and other very ordinary activities
- In essence, watch and capture state, and raise an alarm if something advances beyond limits
  - Motion that looks like a person in places or at times a person should not be there
  - Temperature outside a stated range
  - Lack of motion when motion is expected
- In this context, “Real time” may be in tens of seconds or minutes

Conclusions

- Smart objects are not general purpose application hosts; they embody an embedded application of some form.
  - In essence, yet another market, often in a specialized network
- *Cisco sees several reasonable implementation approaches*, including IP networks, specialized Ethernet-based networks, Name-based networks, and others, depending on the specifics of the application.
- I haven't spoken much about this in this presentation, but we see IPv6 as key to IP-based networks, as there are not addresses for IPv4, and large subnets have value in certain use cases

Thank you.