Smart Grid Information Management

Applying Advanced Communication and Distributed System Technologies

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Outline

- Introduction
- BBN
- Application of advanced communication and distributed systems technology in smart grids
- Conclusion

Introduction

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At the core of the Smart Grid vision is development and adoption of technology to collect, transport, store and analyze information about electricity condition and usage….. GridWise 2006 Panel on Smart Grid

Example features of a smart grid: Advanced metering, Demand Response, Energy intelligence, Advanced control, Asset management/business optimization…. (EnerNOC documentation)

Modern smart grid must be able to heal itself, motivate consumers to actively participate in operations of the grid, resist attack, provide higher quality power that will save money wasted from outages, accommodate all generation and storage options, enable electricity markets to flourish, run more efficiently.. (NETL, DoE 2007)

- Information system characteristics
  - Resilient (tolerant, survivable): failures and attacks
  - Trustworthy and collaborative:
  - Adaptive: autonomic and proactive

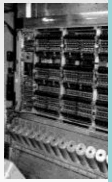
Smart Grids need Smart Information Systems

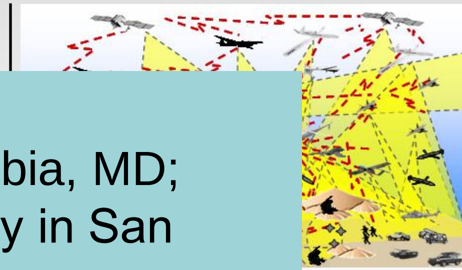
We've seen this before: network centric systems, information centricity…

BBN and Evolution of Distributed Systems

BBN TECHNOLOGIES

1950s 1960s 1970s 1980s 1990s 2000s





- Over 700 employees
- HQ in Cambridge, MA with offices in Arlington, VA; Columbia, MD; Minneapolis, MN; Middletown, RI; O'Fallon, IL & a subsidiary in San Diego, CA
- 2/3 of BBN employees have advanced degrees
- Interest spans from computing and information technology to physical sciences
- Specializes in
  - Developing technology enablers (R&D)
  - Advanced technology concept demonstrations
  - Custom solutions to hard problems

Applica

Operating System

Programming Languages

Database Systems

Database Systems

System Development Environments

Emb. App

W vcs

LW Middle-ware

Embedded OS

Information Management Systems

BBN is continuing to contribute key networking and distributed systems technologies

Network protocols, distributed OS, middleware & middleware services, DRE, survivable systems, semantic web…

An Information Centric View

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- (Grid) Information management
  - Collection: what needs to be collected
  - Transportation: where to, how fast
  - Storage: where, how much, how long
- (Grid) Information services
  - Business logic: how to process, what to produce
  - Building the new services
- QoS and Security
  - Information transport
  - Information processing

There are a number of unique challenges that the information system architecture must address

- Separation of concern
  - Electrical/Business domain experts generate requirements for computer scientists, network and security engineers
- Requirements and Technology both are evolving
  - Ad-hoc approaches will lead to a messy, brittle and costly solution

(Information) Technology Centric View

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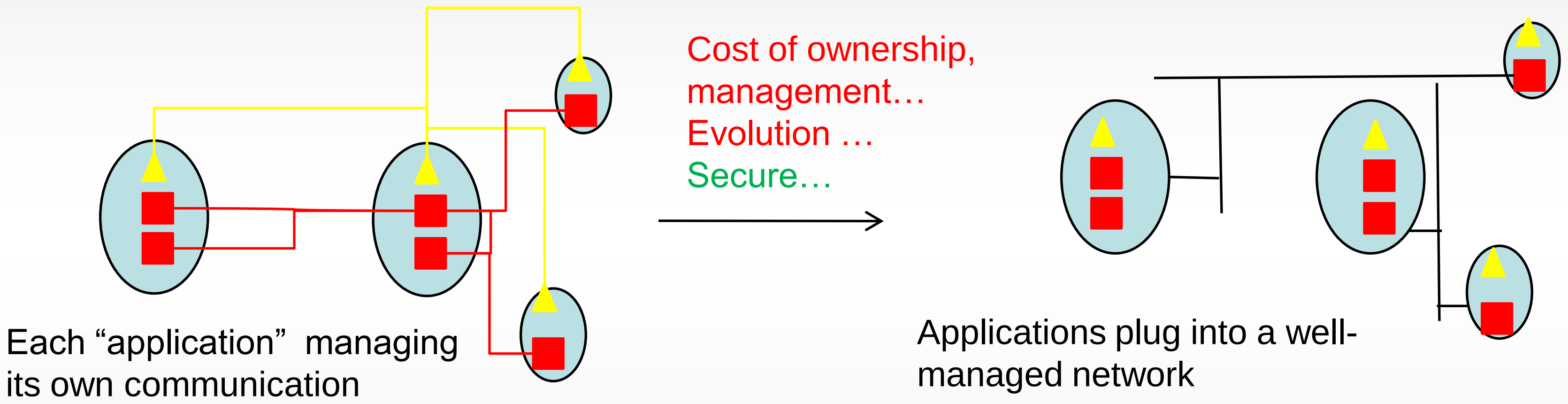
- Information Transport
  - Topology/network architecture
  - IP, GigE, Optical networks
  - Encoding, protocols vs. services (and legacy protocols)
- Information Storage
  - Cloud
  - Identifiers and other metadata
  - Relational databases, digital objects, semantic storage
- Information processing
  - Objects, Components, Services
  - Persistence vs. streams/events
  - Adaptive and adaptation control
  - Multi-core vs. cell, virtualization
- QoS and Security
  - Mission/application oriented adaptive QoS
  - Survive in addition to prevent or detect

Will focus on advanced transport and survivability only in this talk

Advanced Transport Services

- Envisioned Smart Grid information internetwork will have
  - Multiple types of services with specific QoS (loss rate, latency, capacity..) and security
  - Multiple types of transport (packets, circuits, various types of multiplexing),
  - Multiple modes (wireless, leased, fibers, tunneling through the public Internet)



The current situation has many ingredients that may cause the grid information system of the future to look like the current Internet: applications that are locally adapted to communicate over the network, patchwork of interconnections without a holistic view of the entire system– an integrated architecture combining electrical as well as information system aspects–and how it may evolve in the future …..

Advanced Transport (contd.)

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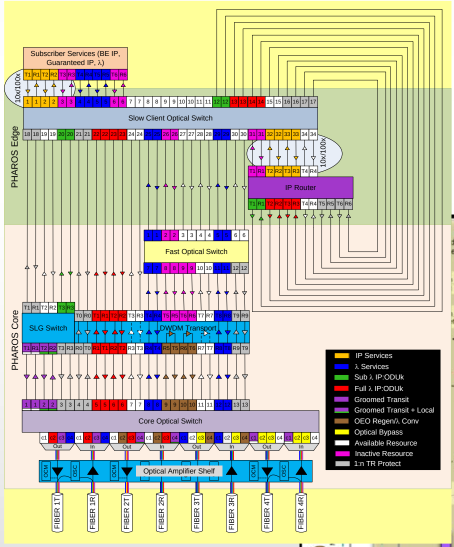
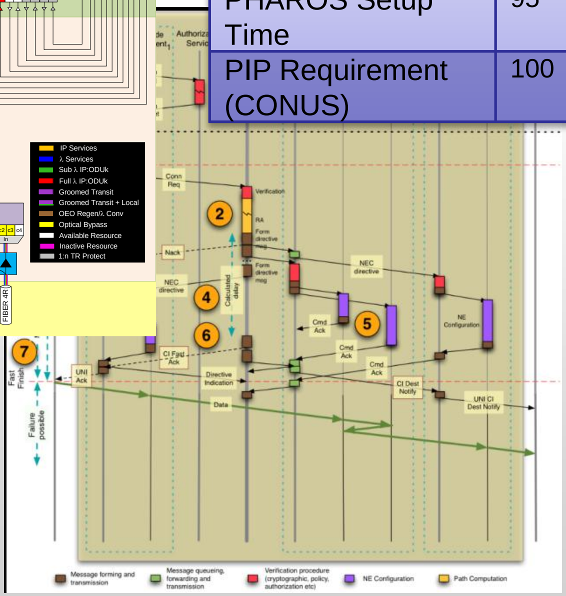
Emerging technologies provide new transport capabilities; we should be aware of, and be prepared to take advantage of these

- Network architecture:
  - Adapters (a necessity for interoperation and relatively routine)
  - Topology Abstractions: innovative view of the network based on adjacencies at various levels
  - Resource allocation algorithms: use the abstractions to decide how to set up a path or route
  - Fast signaling to enable mesh routing and dynamic reconfigurations
  - Authentication/authorization /encryption: security association at the network level

We are implementing these capabilities in the context of a high speed, high capacity optical network (PHAROS)



	VFSS (ms)
Path Computation	10
Signaling	35
Network Element Configuration	<50
PHAROS Setup Time	95
PIP Requirement (CONUS)	100



Leveraging the Network

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- Creation of abstractions appropriate for the application and its context
  - Programming
  - Services

- Availability of high speed, high capacity, security-enabled, robust and dynamically provisioned network makes it easy to construct value-added middleware
  - multicast, probabilistic multicast, pub-sub, distributed queues, federations
  - High assurance dissemination
  - Timeliness and QoS adaptive

- Availability of value-added middleware in turn is required for cost-effective and rapid implementation of the desired business logic
  - The application does not need to worry about transport issues
  - Simpler implementation
  - Faster time to marked
  - “evolution ready”

Survivable Information Systems

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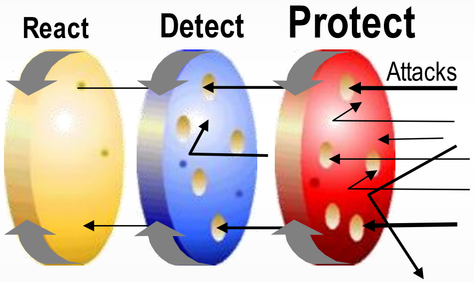
- Intrusion Tolerant Systems:
  - Resiliency against failures in the information domain
    - Natural (fault tolerance) as well as attack-induced

Nature of attacks

- Access– enabler of further actions
  - Exfiltration, Corruption
- Denial by consumption
  - Requires minimal access..
- Crash
  - Can be caused by physical attacks
- Corruption
  - Can be caused by insiders

Defense mechanisms:

- Security tools and mechanisms to prevent, detect and recover from specific attacks or attack classes
  - Firewalls, crypto, redundancy



Survivability architecture:

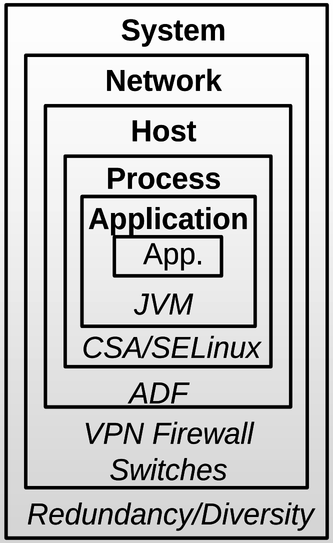
- Organizing multiple layers of defense chosen based on the need

Management of defenses:

- Control loops connecting the defense mechanisms

Validation/certification/accreditation

- Invariants and “trusted” enforcement



BBN developed (and validated) defense mechanisms, survivability architecture and cognitive management in various DARPA projects

Conclusion

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- Smart Grid without a smart Information System is untenable
  - Electrical/power and business domain will generate requirements for the information system
- The Information System must be “future proof” and “evolution ready”
  - New technologies
  - New requirements, usages
- Current technology and business environment is conducive to incremental and patchwork solutions
  - That will be a BIG mistake
- BBN’s past experience in networking and distributed systems innovation prompts us to recognize the need of a big picture
  - Integrated electrical and information system architecture
  - Evolving technologies and requirements
  - Over space, over time, not just grids, but inter-grid, possibly across national boundaries

BBN brings the information system perspective and expertise, need collaborative interactions with the community to develop and articulate a smooth transition to the big picture view