EE392N

April 3, 2012

Dan O'Neill
Dimitry Gorinevsky

Outline

- Class logistics
- Introductory lecture on Intelligent Energy Systems

Instructors

- Daniel O'Neill, Consulting Professor in EE
  - Networks and Demand Response
  - Executive and venture capital experience
  - www.stanford.edu/~dconeill
- Dimitry Gorinevsky, Consulting Professor in EE
  - Information Decision and Control Applications
  - Broad industrial experience in advanced systems
  - www.stanford.edu/~gorin

Logistics for the Course

- 1 unit CR/NC
- Weekly on Tuesdays
  - The room and time might change!
  - Watch the class website announcements
- Two introductory lectures
  - Grid Overview – Dan
  - Monitoring Basics – Dimitry
- Eight lectures by industry leaders
- Final class

Current Speakers

- April 17, Grid Analytics - T&D power equipment diagnosis/prognosis thru Smart Grid technologies, Alex Rojas, GE
- April 24, Advanced Sensors and Monitoring & Diagnostics for Gas Turbines in GE, Vivek V. Badami and Scott Hoyte, GE Energy
- May 1, Data mining techniques to enhance sustainability of data centers, Manish Marwah - HP
- May 8, GridSpice , Amit Narayan
- May 15, Trevor Baily - UTC
- May 22, Communication Methods for Energy Management, John Parello - Cisco
- May 29, The Promise of Renewables, Rick Geiger - Cisco
- June 5, Datta Godbole - Honeywell

Course Requirements

- Requirements:
  - Attendance
- 1-2 page proposal for intelligent energy concept, research, or product, based on class presentations
  - Teams of up to three people, one person is acceptable
  - Due June 5
- Top three proposals will be presented at the scheduled final time
  - Will be considered by Stanford faculty and industrial presenters to receive research funding
  - The best proposal will be archived on class website including author info; expect PageRank 4 to 5.

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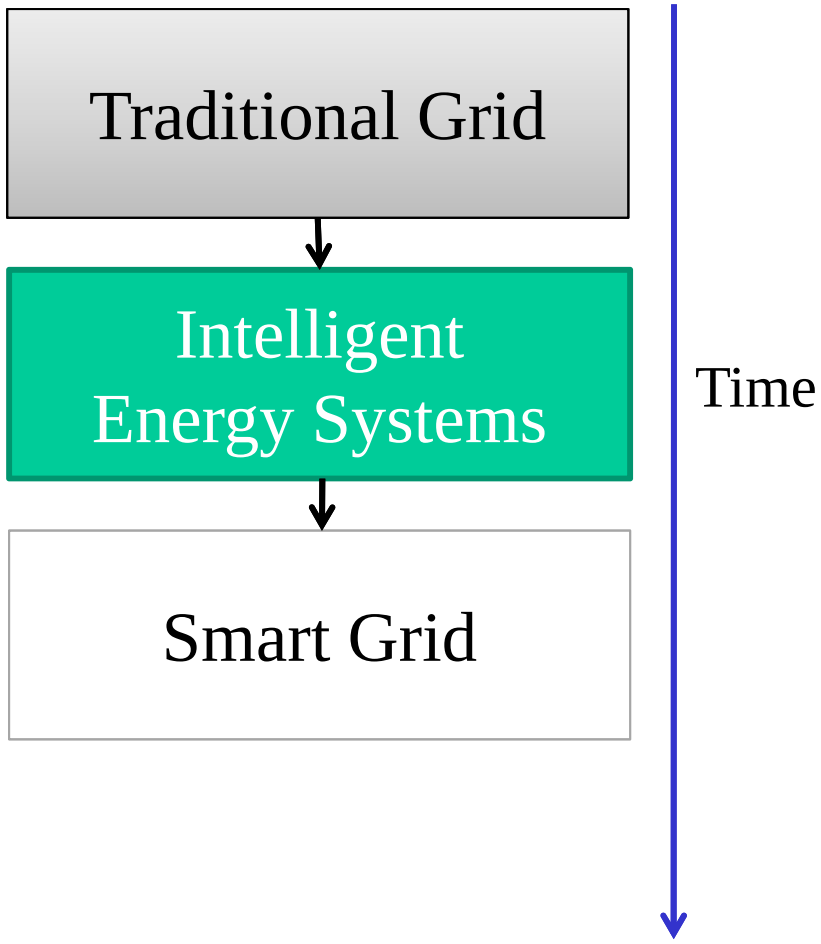
  - Definition
  - The Grid
  - Why its changing

Intelligent Energy Systems

- Look at intelligent energy systems from a systems point of view
- Nearer term evolution of the grid leading to the Smart Grid
- Focus monitoring



Why Intelligent Energy System Now?

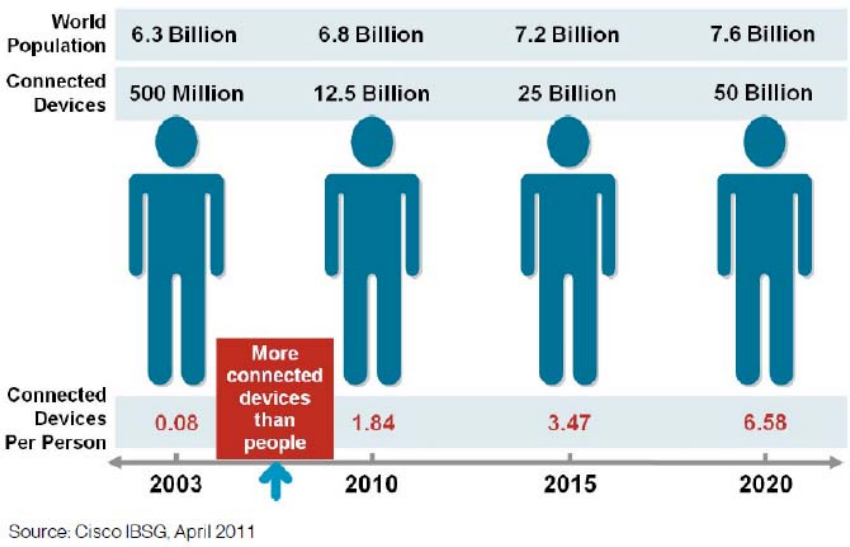
- Incorporating renewables – supply(t)
- Replacing old equipment, $1.5T
  - Electrical efficiency
  - Reliability
- Reducing costs – Energy Summit Comment…
  - TCO
  - CAPX
- Deregulating – markets for power
  - Consumer participation
  - De-commoditization
- New business models
  - Consumer behavior based
  - POS advertising

$850B - grid
$650B - users

Home EMS

Building EMS

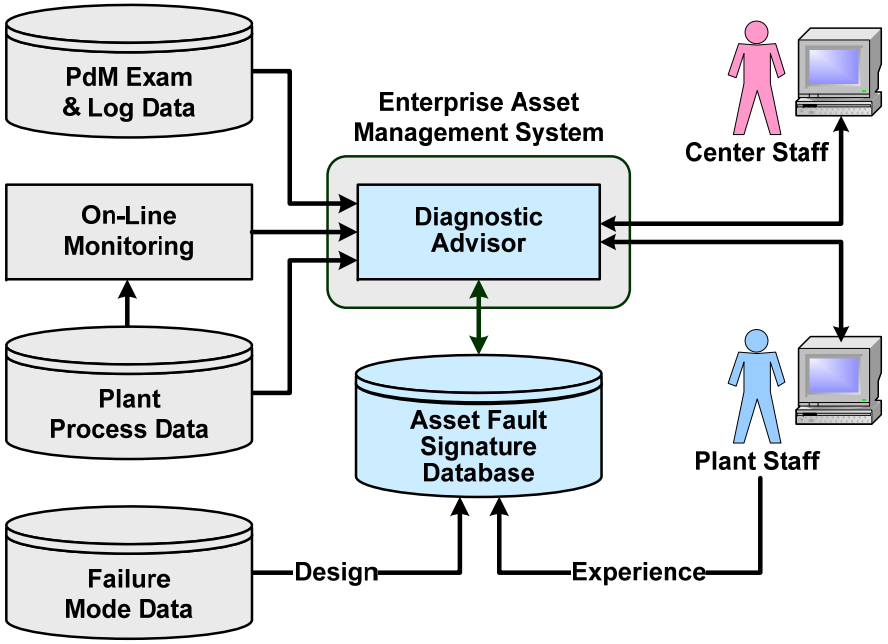
Intelligent Energy Systems



- What technology trends?
- Convergence
  - Internet of things (embedded internet)
  - Virtualization
    - Computation
    - Networking
    - Storage
- Economics of high performance computing (Moore's law)

Monitoring

- Monitoring vs. control
- Why monitoring?
  - ROA
  - Frequency and severity
- Types
  - Operational
  - Maintenance
- Industrial structure
  - Equipments, to
  - Services



Backup: Intelligent Energy Systems

- Definition: Connected, context aware adaptive systems that provide energy services.
- Includes all aspects of energy usage
  - Generation to commercial and residential EMS to
  - Individual devices
- New services (analytics)
  - Operational efficiency
  - Asset monitoring
  - Consumer behavior
- New infrastructure
  - Communications and IT
  - Big Data analytics

- Comment: Large scale IP connected embedded systems w/ emphasis on

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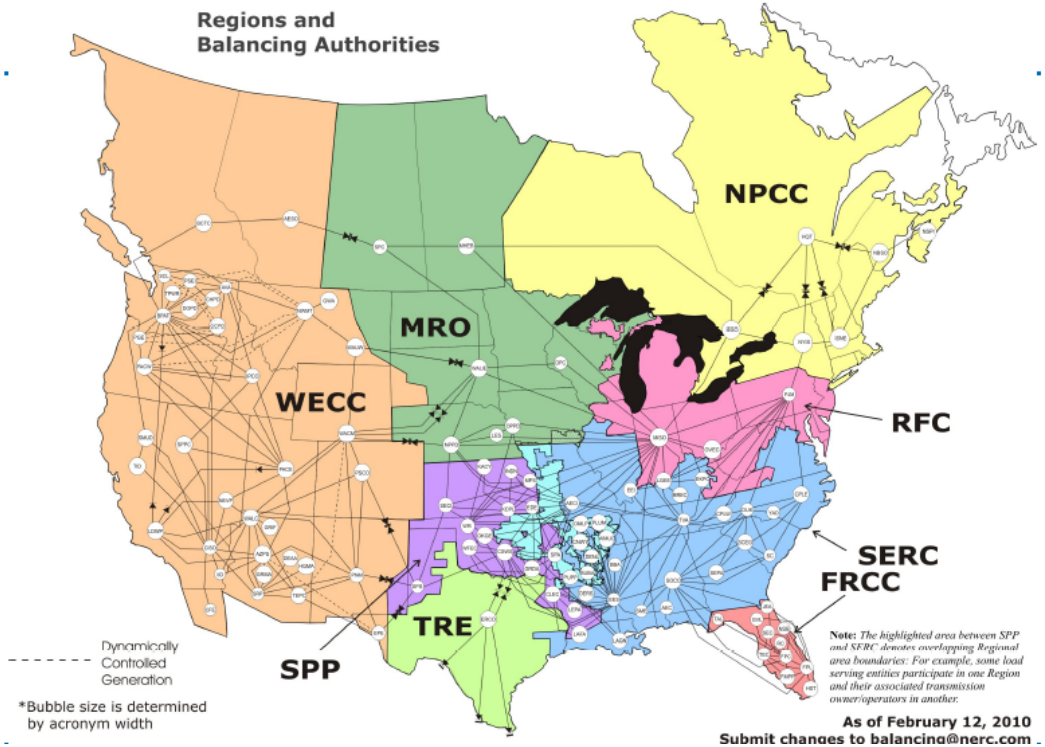
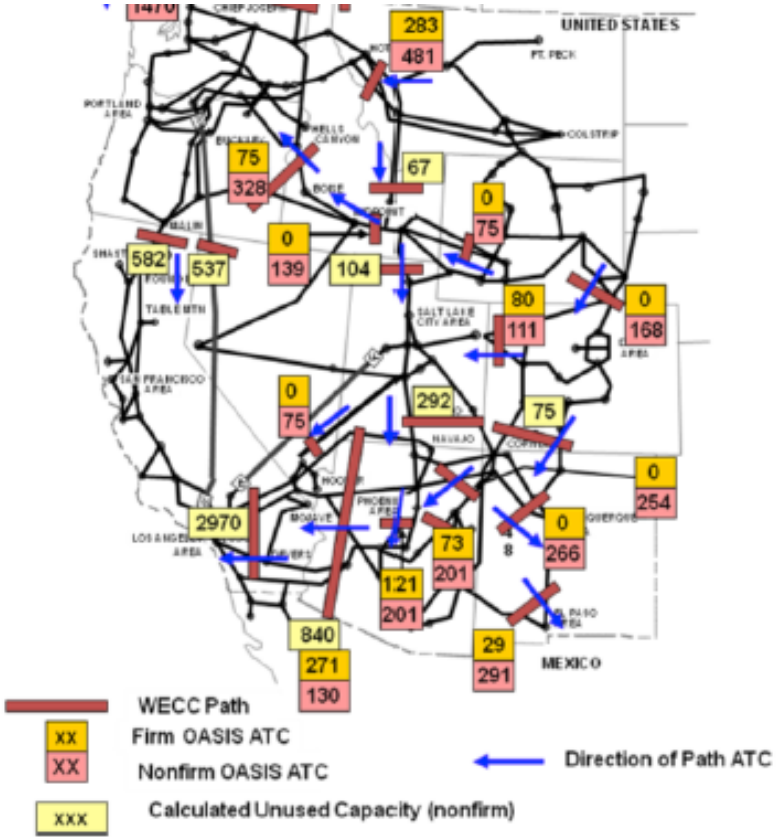
The Traditional Grid

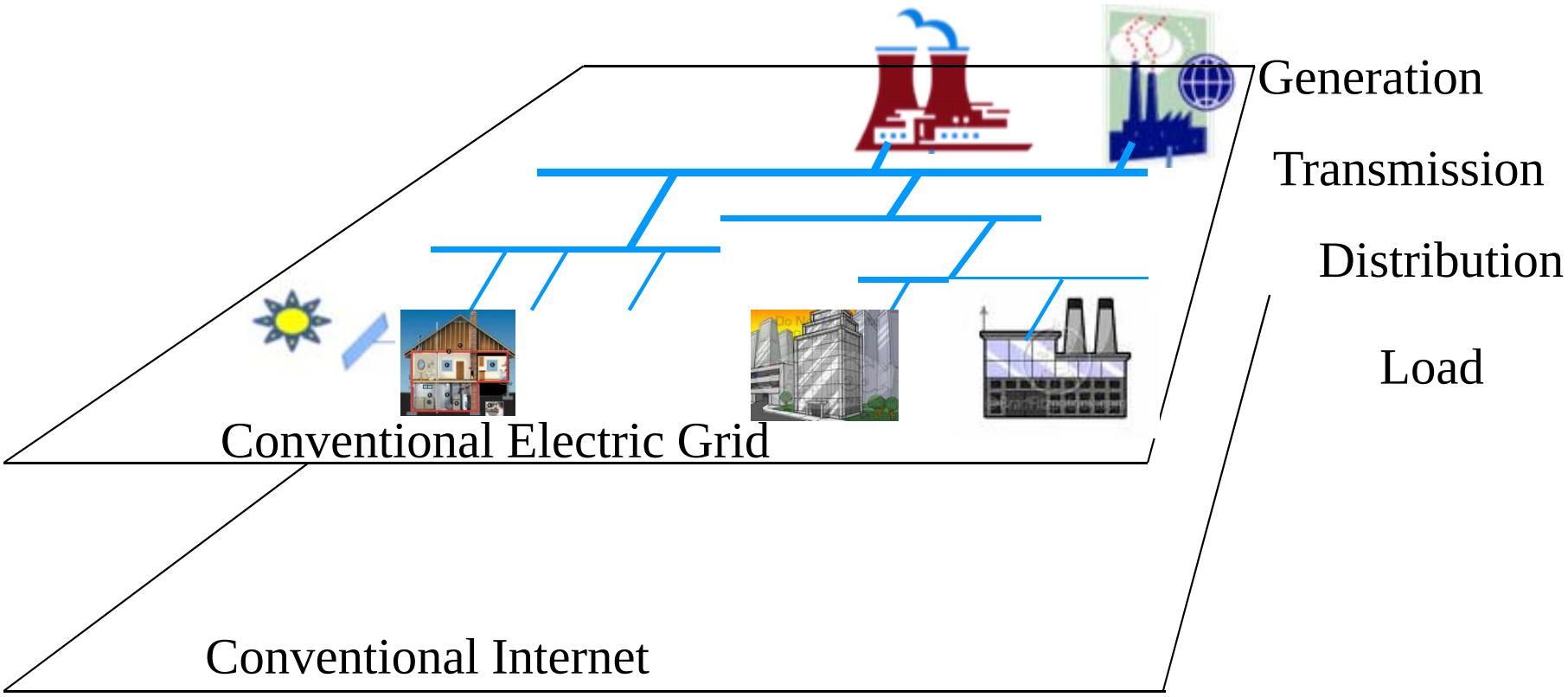
- Worlds Largest Machine!
  - 3300 utilities
  - 15,000 generators, 14,000 TX substations
  - 211,000 mi of HV lines (>230kV)
  - SCADA control
  - Mostly unidirectional
- Capacity constrained graph

Interconnect

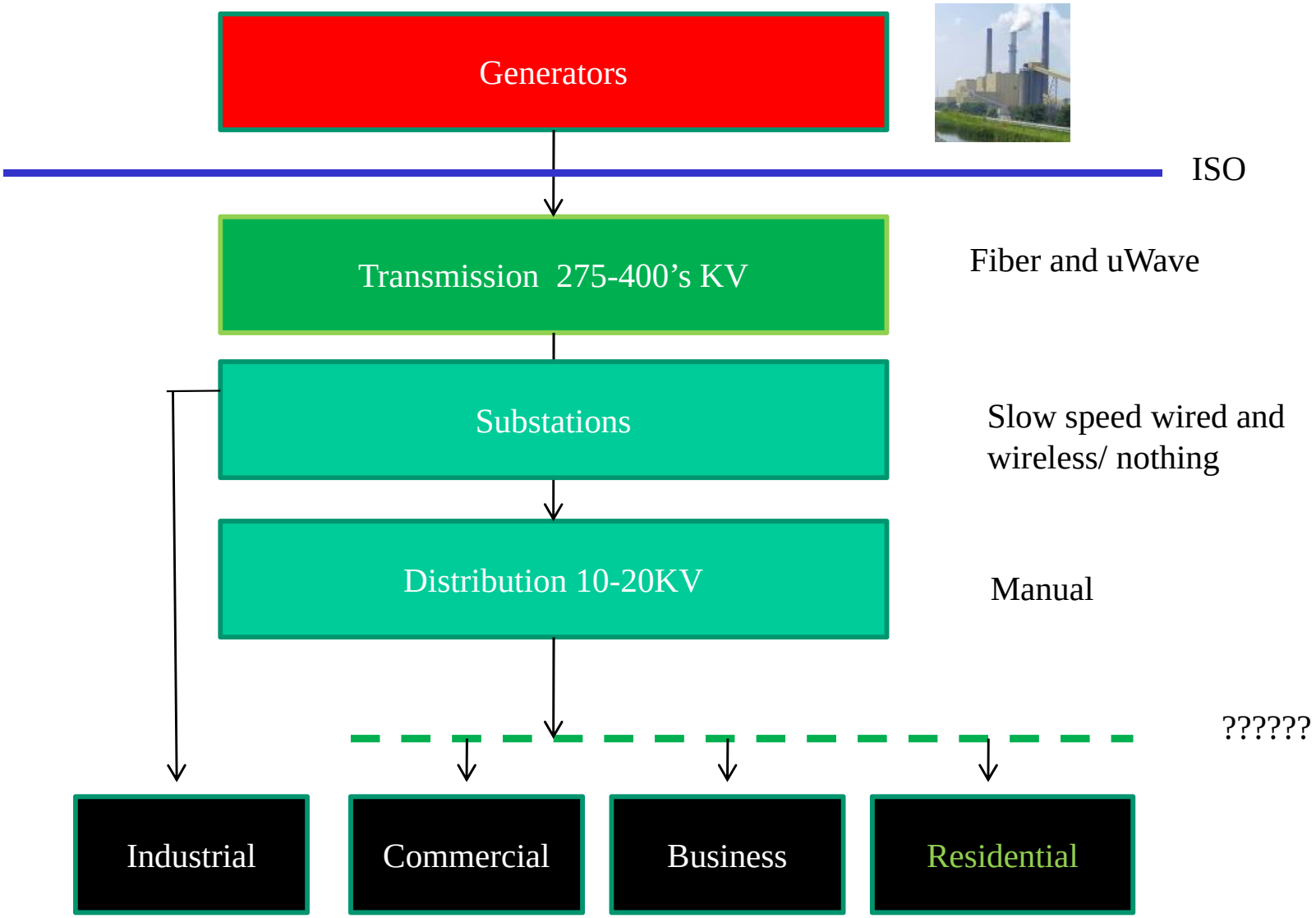




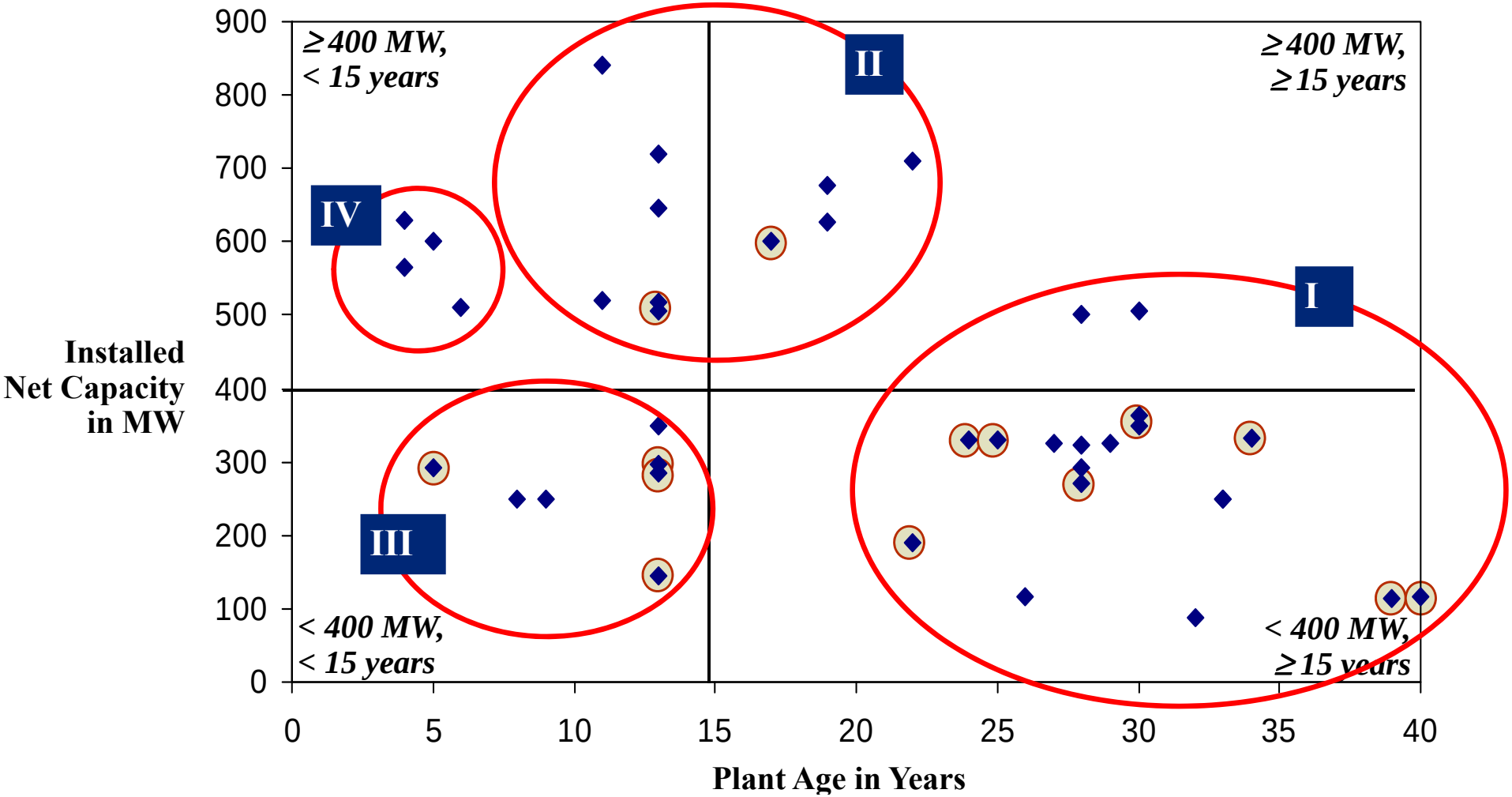
Traditional Grid



Power and Data Flow



Backup: Capital Plant Age



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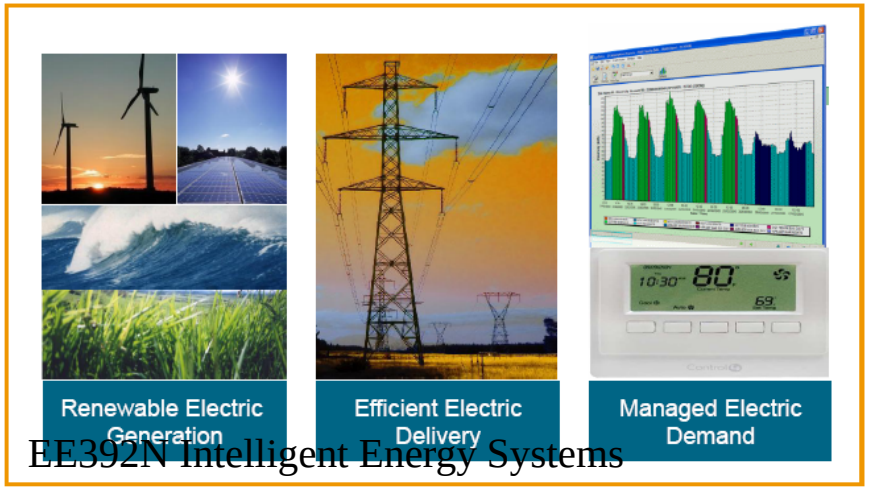
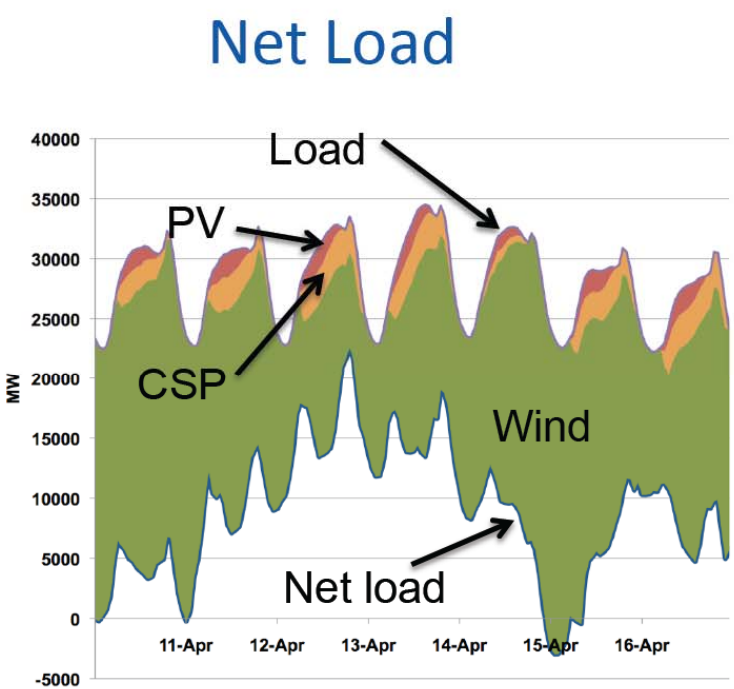
Nearer Term Initiatives

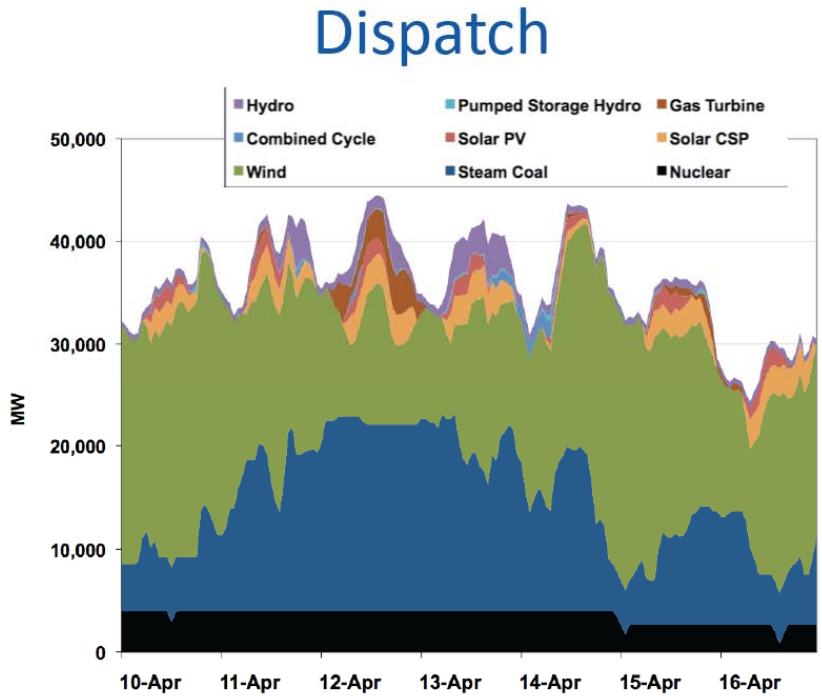
- Renewables
- Demand Response
- Grid optimization
- All drive need for connected embedded systems

De-commoditization and Differentiation



Renewables: The System Problem

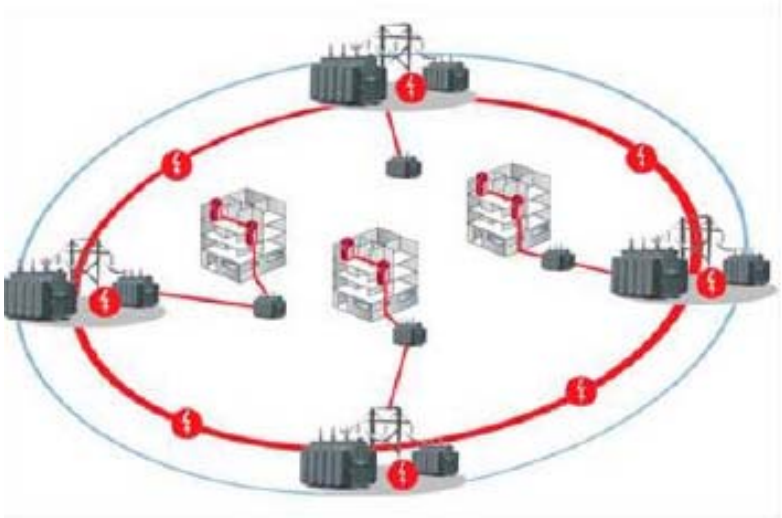


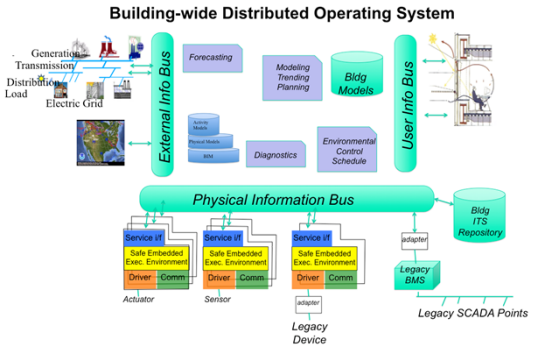


Need for conventional plants to cycle and ramp

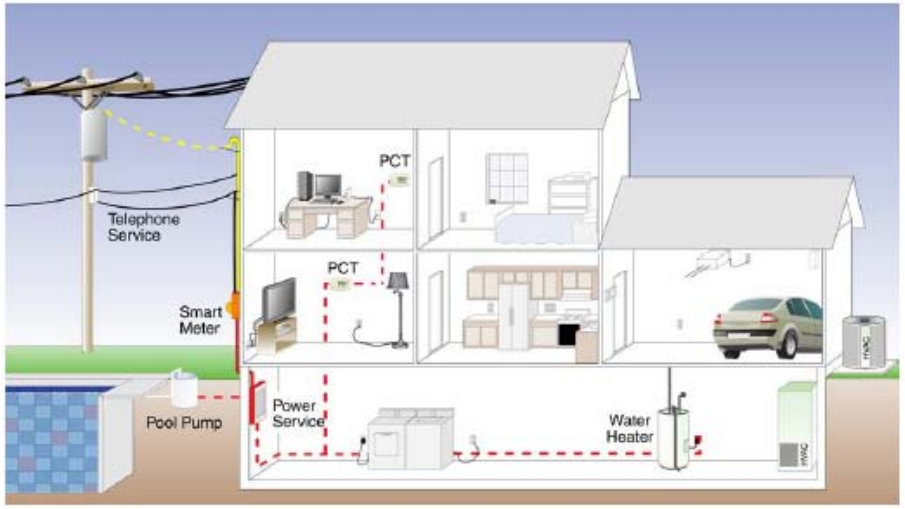
Demand Response

Campus and Buildings





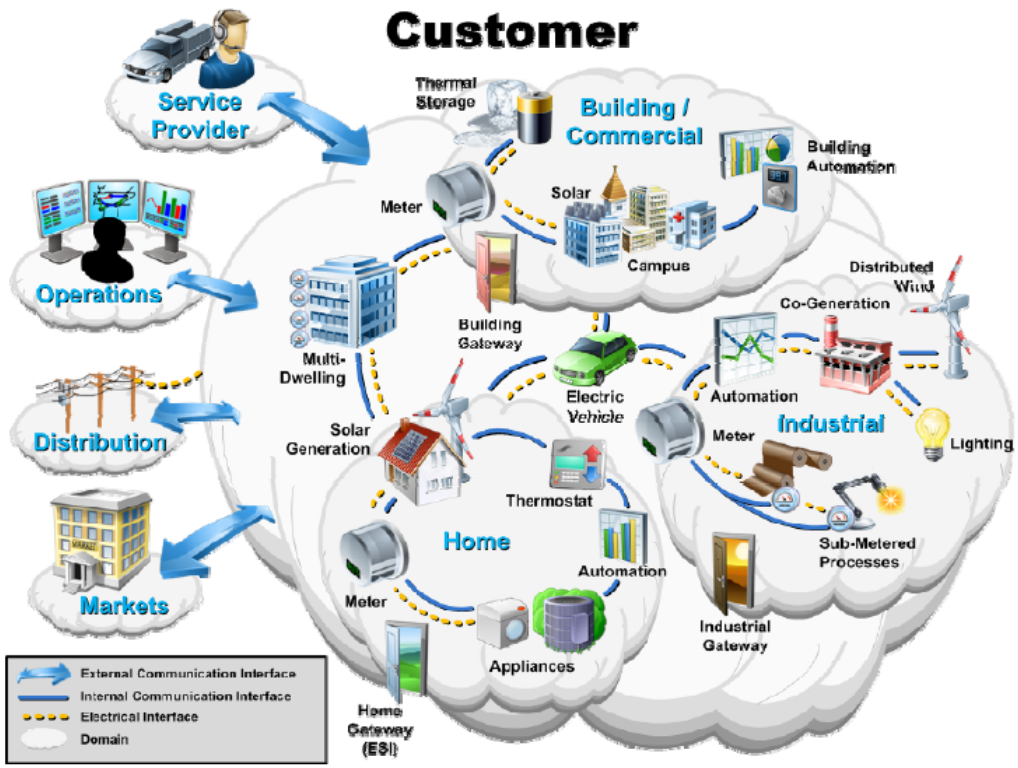
Home



- AMI
- EMS
- Smart devices

Grid Optimization

- Adjusting
  - Supply(t)
  - Connectivity
    - Transmission routing
    - Distribution Automation
  - Aggregating DR users
- Commercial buildings



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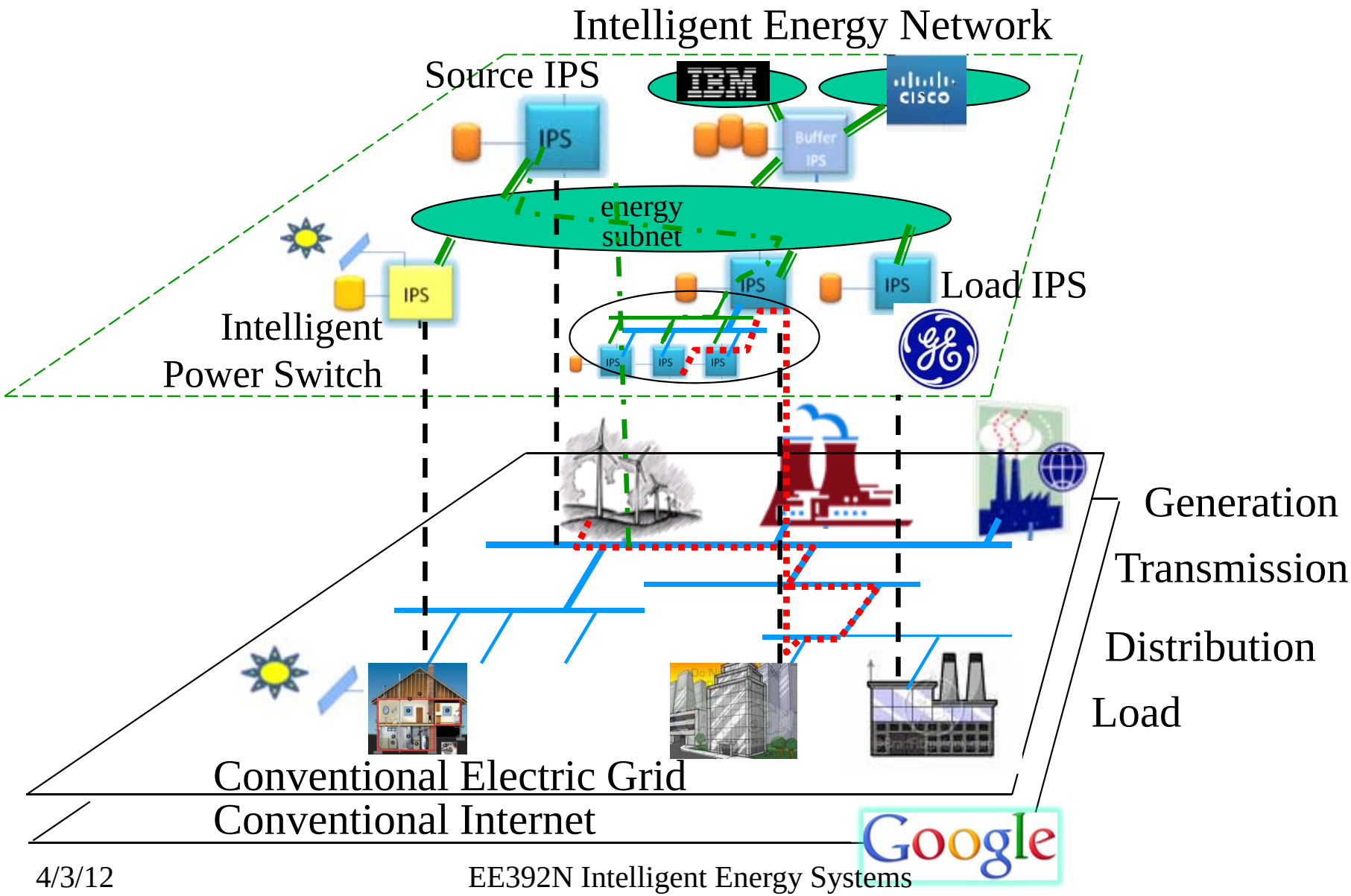
Smart Energy Grid

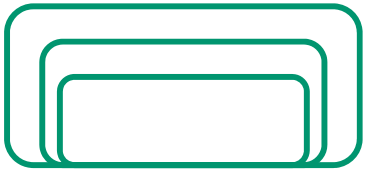


Three Planes

- Electrical power
  - Supply(t)=Demand(t)
  - Real and reactive power
- Management and Control (MC)
  - Local protection systems
  - SCADA: Supervisory Control and Data Acquisition
- Data systems
  - Billing

Segment Characteristics

- Energy is a *entangled multi-time scale* application
  - milliseconds for protection and control
  - Subsec for human in the loop interaction
  - Sec for Renewables variability management
  - Minutes for DR and building management…
- *Hierarchy of loops*
  - One optimizes the next
  - Latency sensitive
  - Computationally intensive
    - Iterative algorithms



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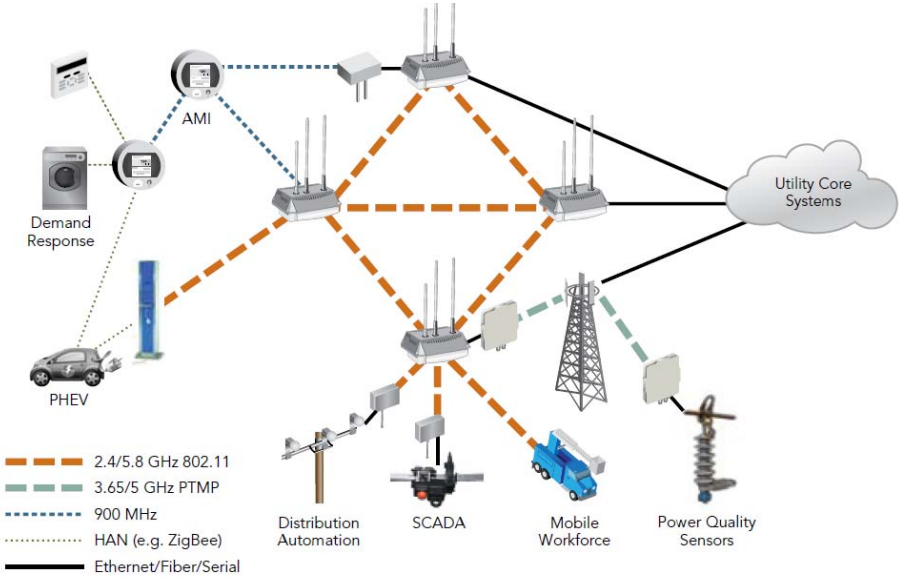
- Sense, Communicate, Transform, Services

Sense -> *Communicate* -> Transform -> Services

- Standards NIS & IEEE



WiFi

Sense -> Communicate -> *Transform* ->Services

- Transform data into information
- Hierarchy of entangled applications and computation
  - Intelligence at all levels of system
  - Issues in
    - Reliability – How many 9's?
    - Security – Residential gate ways…substation…plant
    - Storage – Brewers CAP and Hadoop?
    - Energy efficiency – Hugh issue: always on and unattended
    - System manageability
    - Interface with the cloud
      - » Hybrid Cloud?

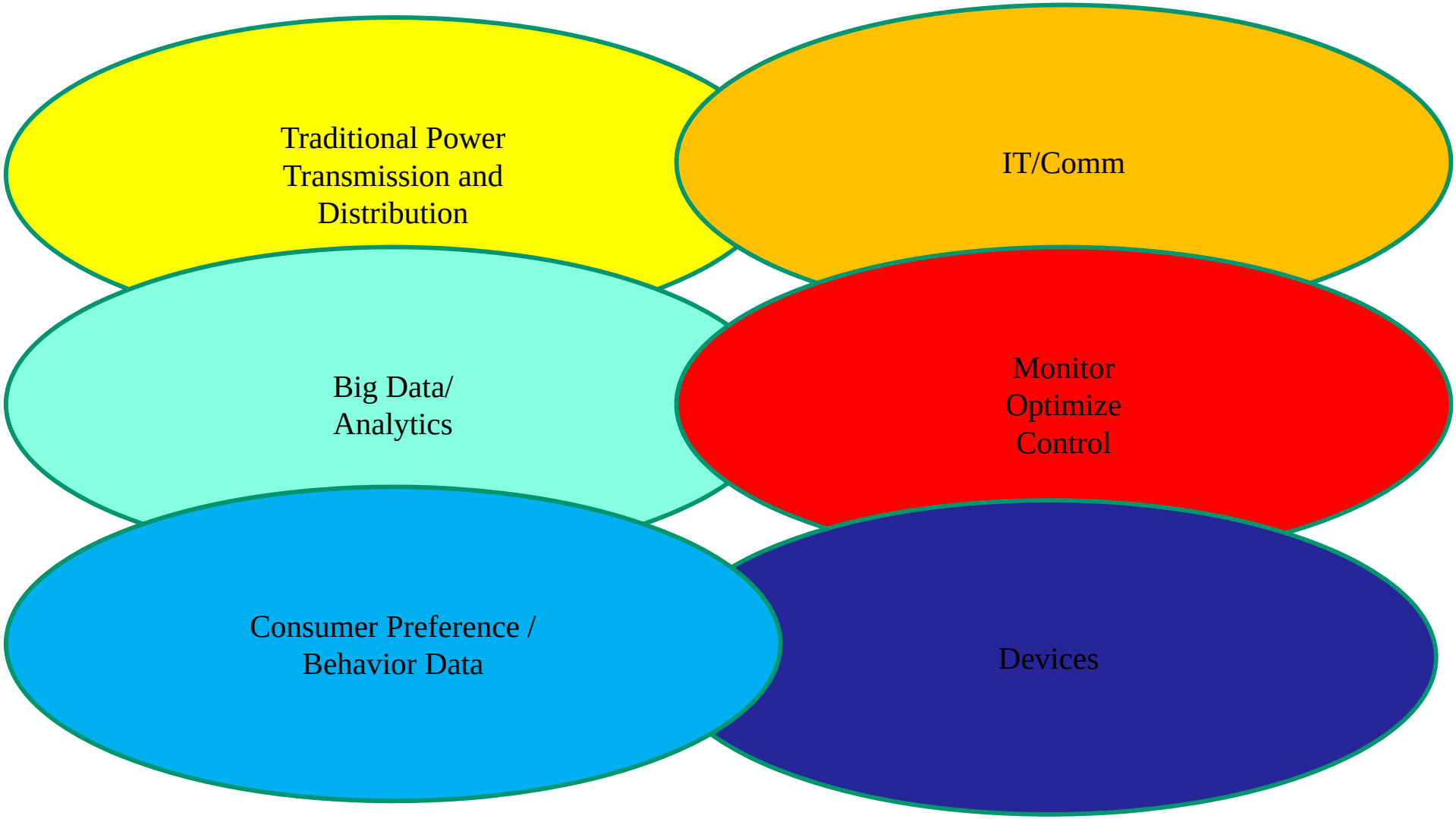
Sense -> Communicate -> *Transform* ->Services

- Streaming data for
  - Near real time control
  - Asset Monitoring (Longer time scale)
  - Not the same as “click” data
- Algorithms
  - Iterative and computationally intensive
  - De-centralized computation possible, But
  - Can be sensitive to data coherence and consistency
  - EVT – Extreme Value Theory issues (No Blackouts!)
- Big Data - Yes, But Hadoop maybe not.

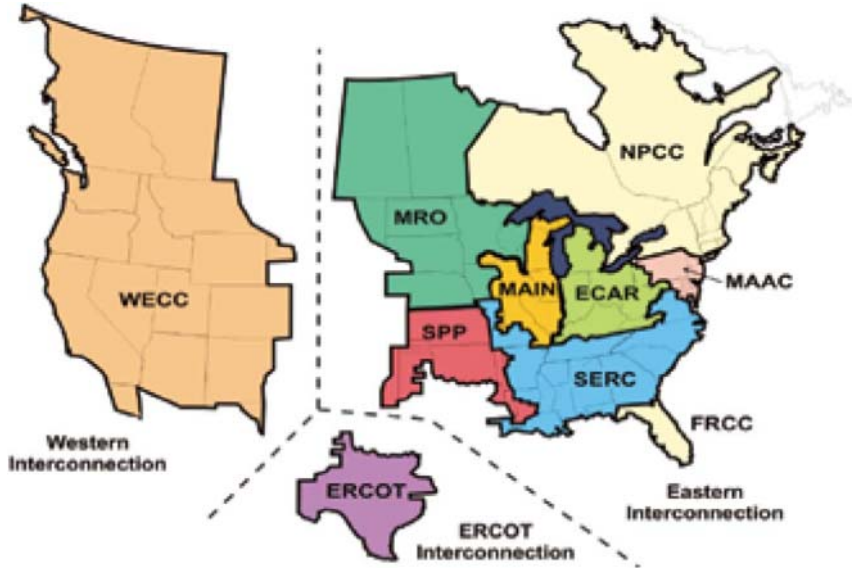
Next Week

- Dimitry will talk on Monitoring Basics

Many Different Segments and Players



Backup: Traditional Grid



Three major interconnects