EE392n
Intelligent Energy Systems: Big Data and Energy

April 1, 2014

Dimitry Gorinevsky
Dan O'Neill

Today's Program

- Class logistics
- Introductory lecture on Intelligent Energy Systems: Big Data and Energy

Instructors

- Dimitry Gorinevsky, Consulting Professor in EE
  - Big Data analytics for energy and aerospace
  - Information Decision and Control Applications in many industries
  - www.stanford.edu/~gorin
- Daniel O'Neill, Consulting Professor in EE
  - Network Management and Machine Learning in energy
  - Executive and Startup experience
  - www.stanford.edu/~dconeill

Class Logistics

- 1 unit graded CR/NC
  - Attendance
  - Pre-requisites
  - Submitting an one page report in the end
- Weekly on Tuesdays
  - The room and time might change!
  - Watch the class website announcements
- Introductory lecture - today
- Nine lectures from industry leading companies

Planned Lectures

April 1, Introductory Lecture, Dimitry Gorinevsky, **Stanford**

April 8, The Industrial Internet Economy, Marco Annunziata, **GE**

April 15, Revenue Protection in Smart Energy Networks, Creighton Oyler, **Oracle**

April 22, Intelligent Technology for Managing Grid Assets, Jeff Ray, **Ventyx/ABB**

April 29, AMI Data Management & Analysis, Aaron DeYonker, **eMeter/Siemens**

May 6, Internet of Things Platform, Aakanksha Chowdhery, **Microsoft**

May 13, Feature Discovery in Data, Jennifer Kloke, **Ayasdi**

May 20, Improving Energy Efficiency with AMI Big Data, **OPower**

May 27, to be confirmed

June 3, Software Architecture for Energy Applications, Tom DeMaria, **GE**

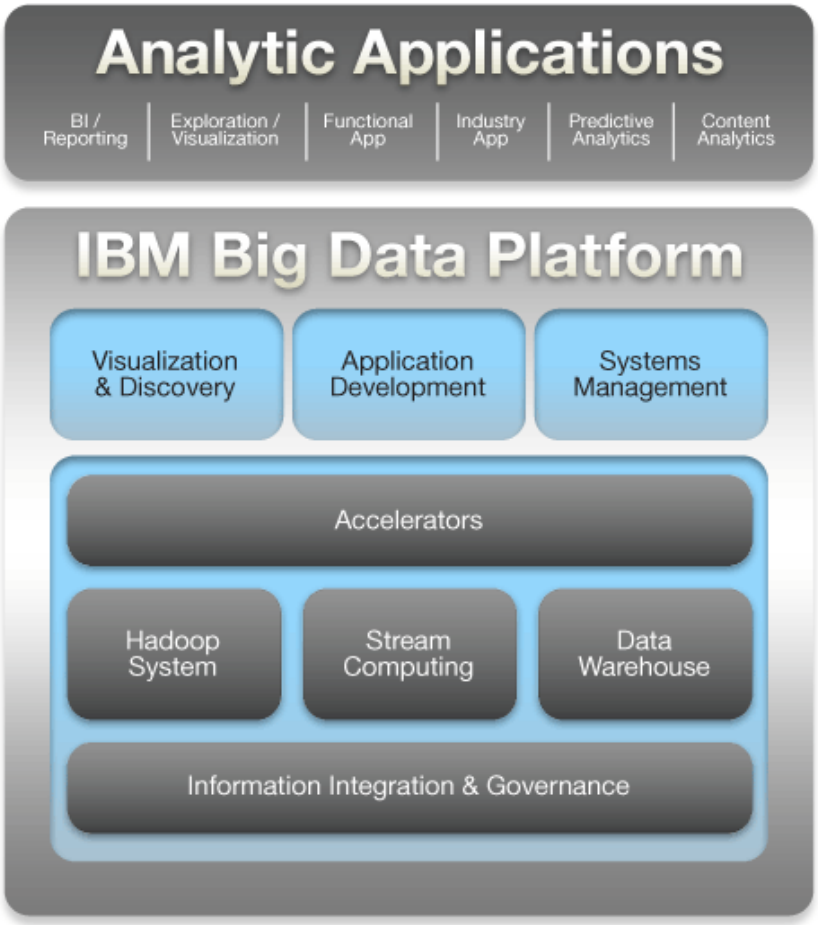
Big Data

~~Next~~ Current Big Thing

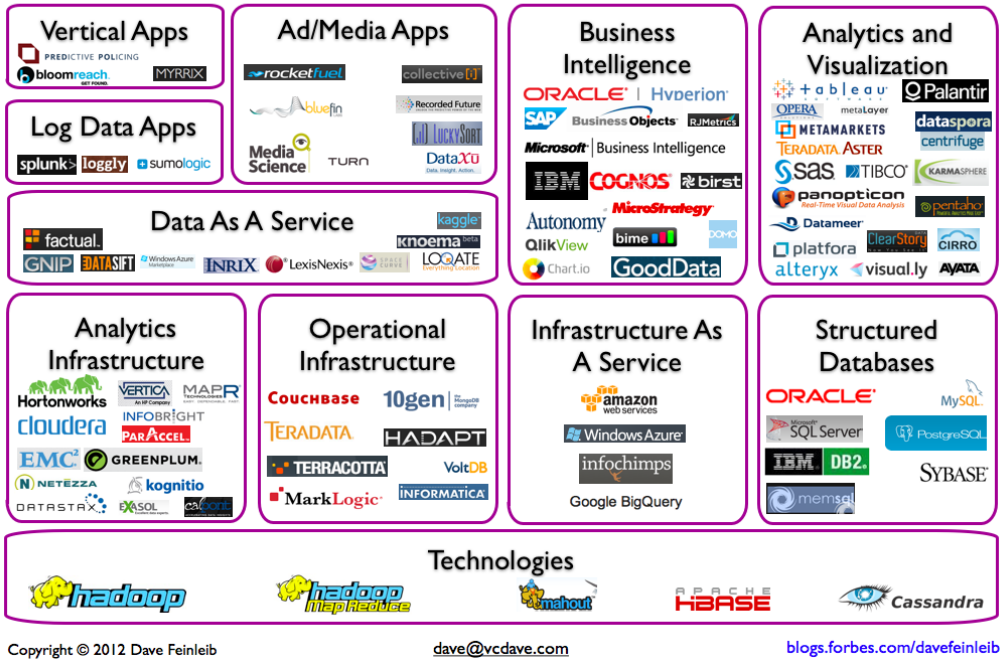
Data Science

Big Data Analytics

Example: IBM marketing



- Analytics provides value
- Need support infrastructure



Internet of Everything

- "The Next Big Thing for Tech: The Internet of Everything", *Time*, Jan 2014
  - IT/OT convergence

Information **T**echnology

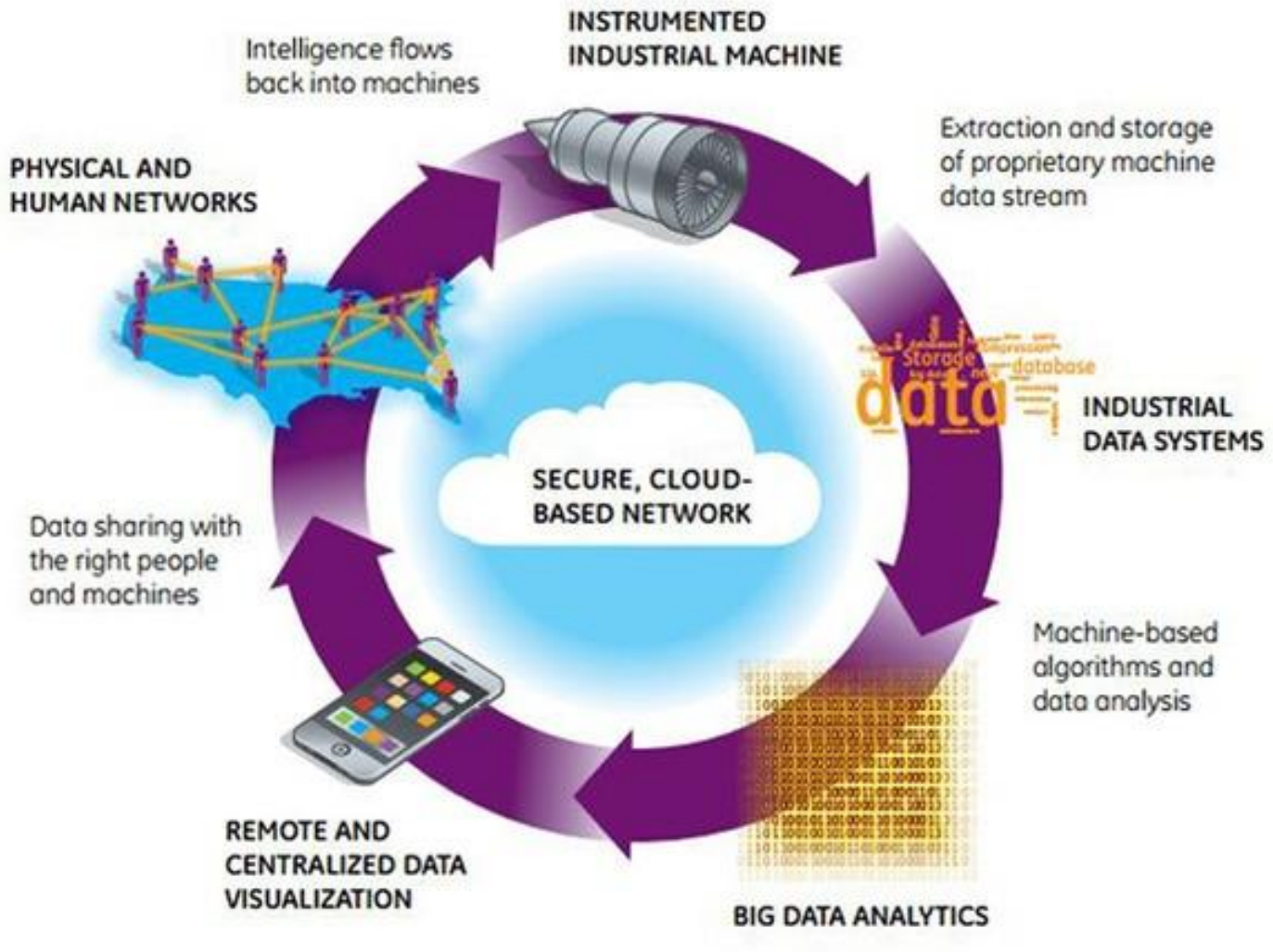
Operations **T**echnology

IT ↑ ↓ OT

- IT: Enterprise computing. Big Data
- OT: Embedded and industrial systems. Connected Everything.

Industrial Internet

@GE



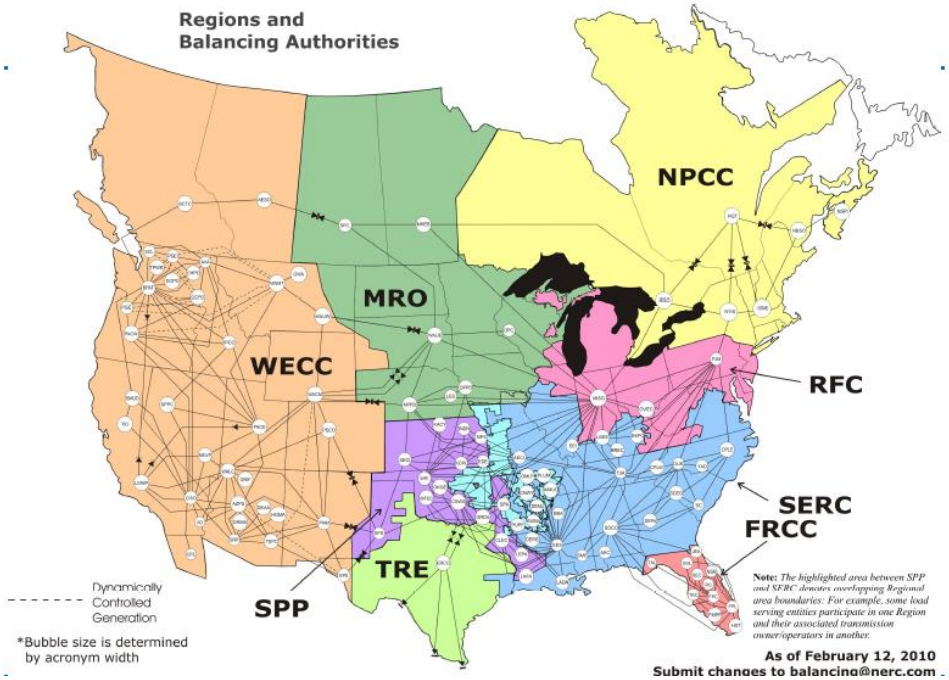
Energy Systems

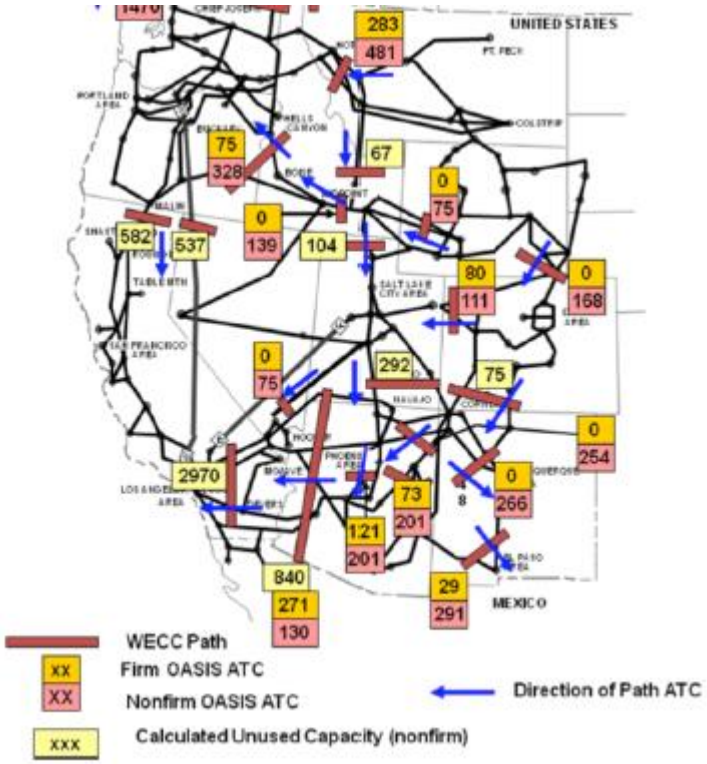
- The focus of the class
- Power systems
  - Power generation
  - Power consumption
  - Smart Grid

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

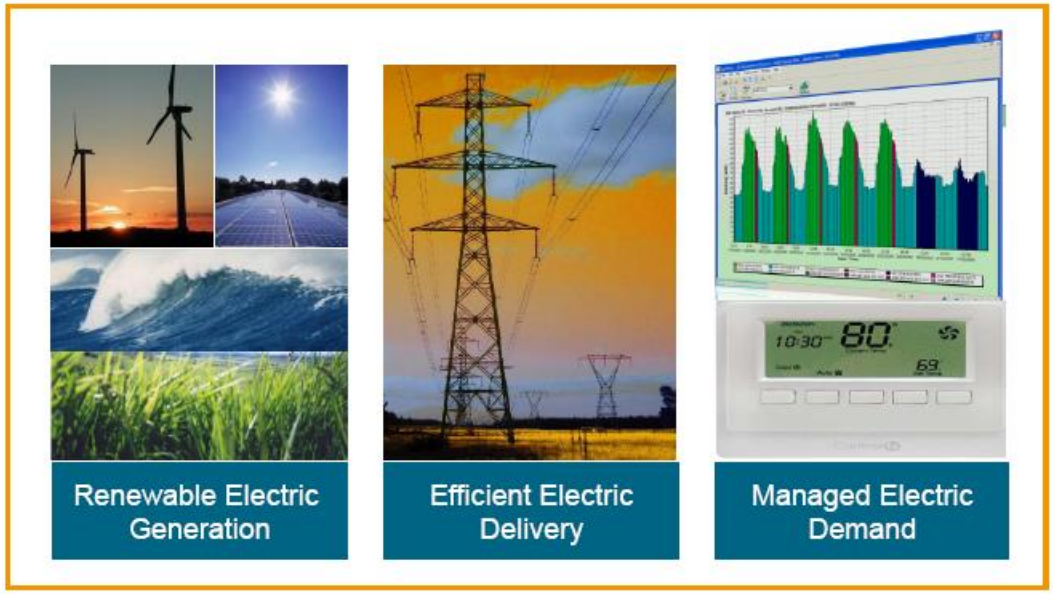
Interconnect





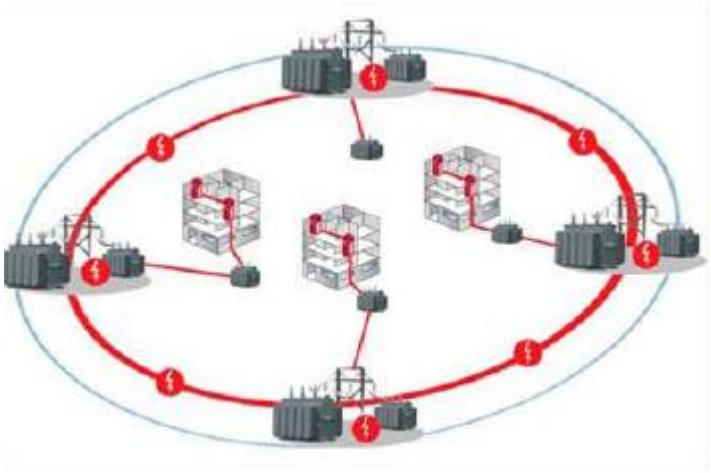
Nearer Term Initiatives

- Energy Usage
- Power Flow Management
- Asset Management

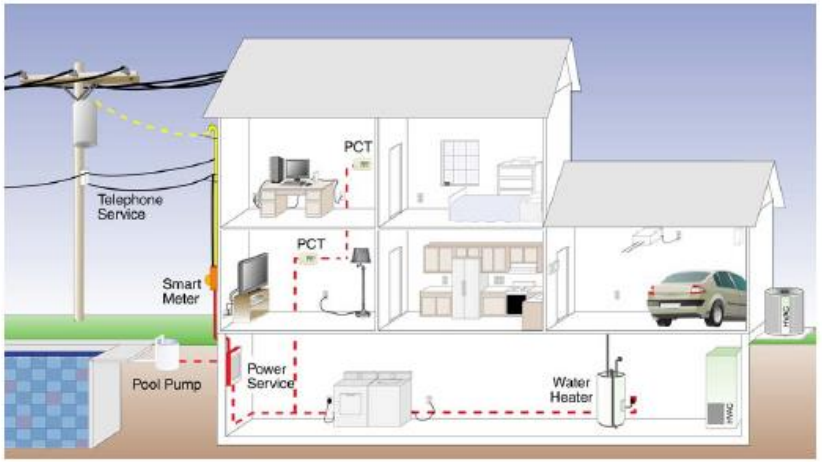


Energy Usage

Campus and Buildings



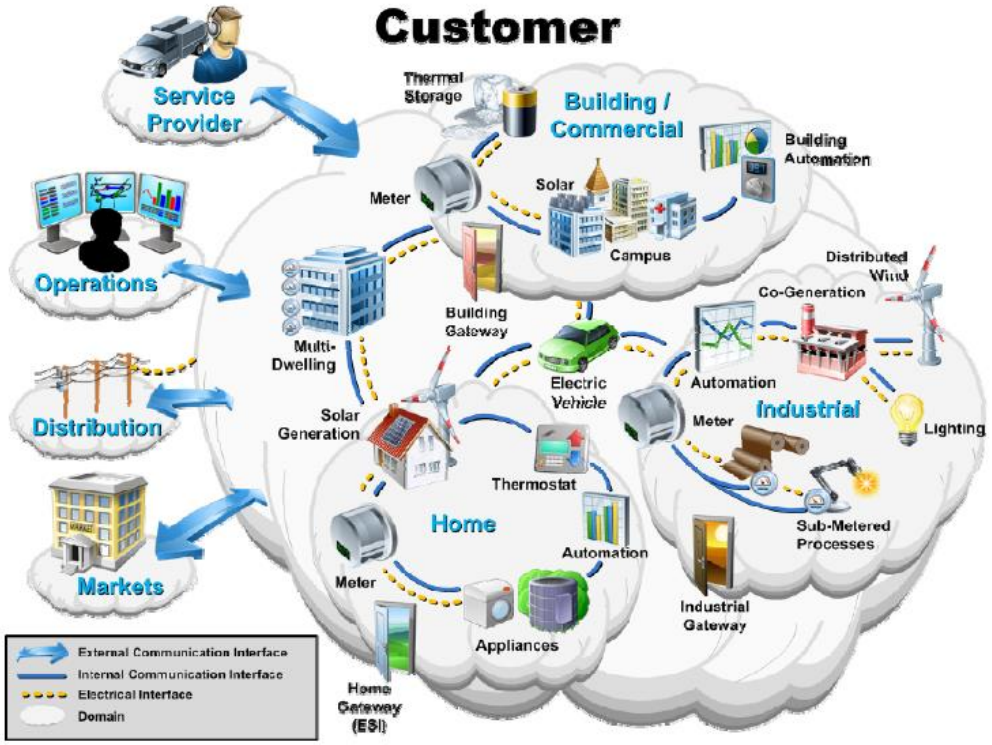
Home



- DR – Demand Response
- AMI – Advanced Metering Infrastructure
- EMS – Energy Management System
- Smart devices

Power Flow Management

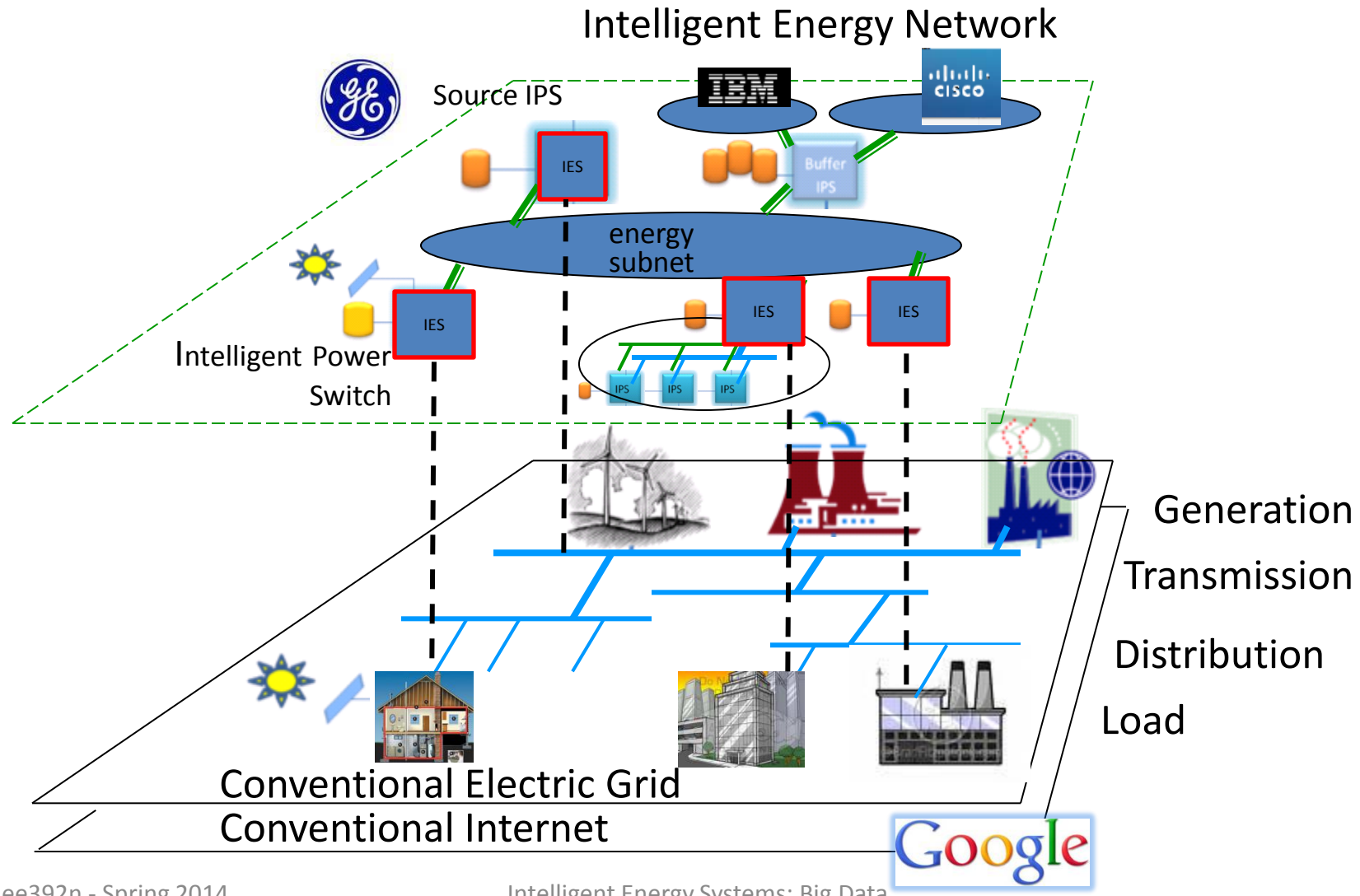
- Adjusting supply
- Routing power flow
- Managing demand
  - for aggregated users
  - for commercial buildings
- Revenue protection



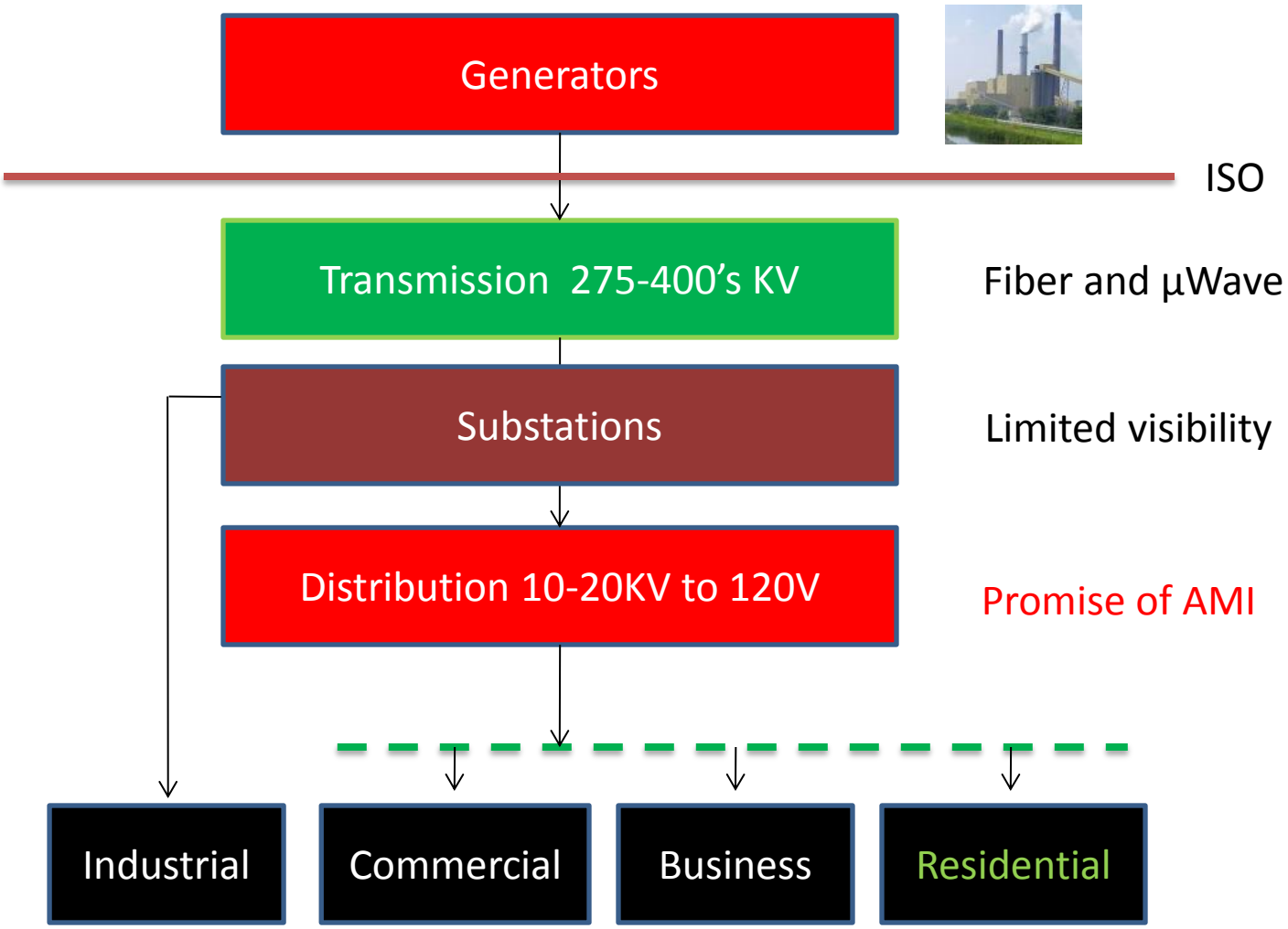
Asset Management

- $10T in assets
  - 1% of failures per year = $100B

Computing and Communications

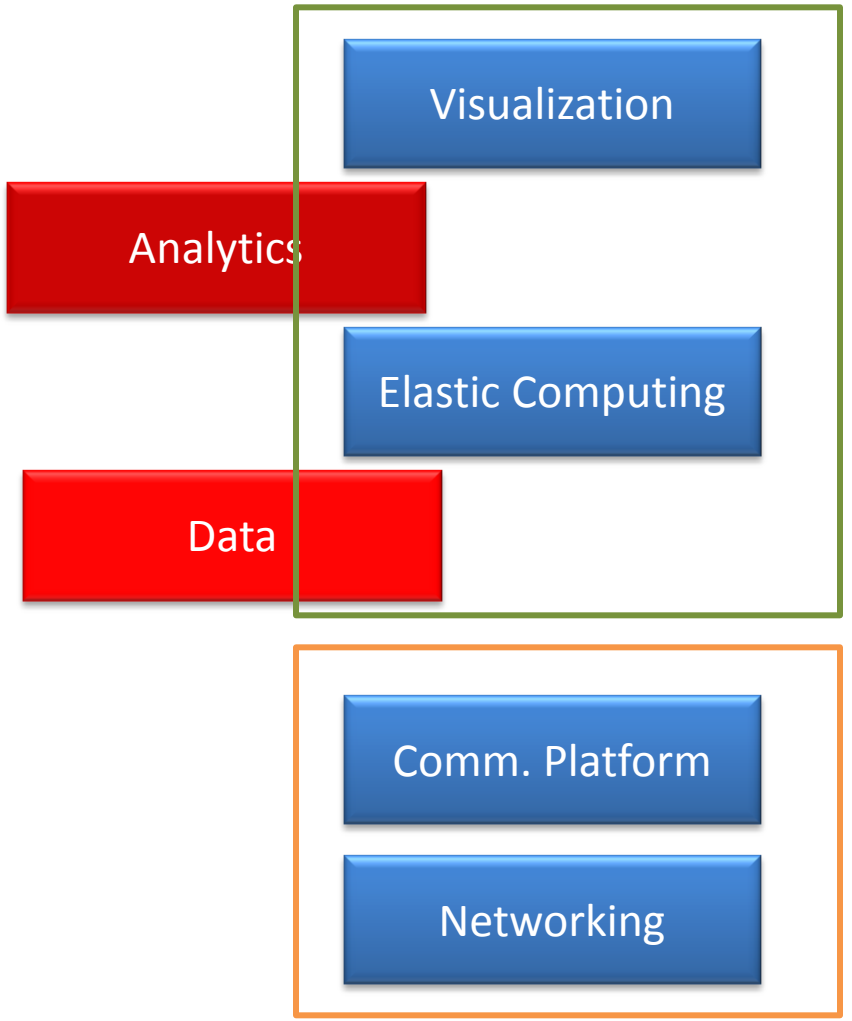


T&D and Data Flow



Today…

- Integrated platforms
  - IBM, Oracle, …
  - GE, Siemens, ABB,…
  - Cisco, …
- But
  - Analytic tools
  - Vertical analytic products
  - Data integration

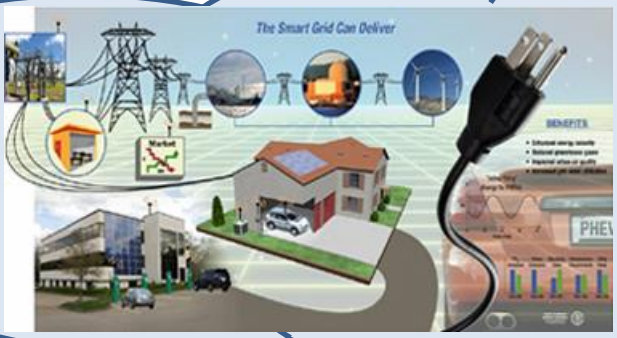


Intelligent Energy Systems

Analytics: Software Function

Computing
and
Communication

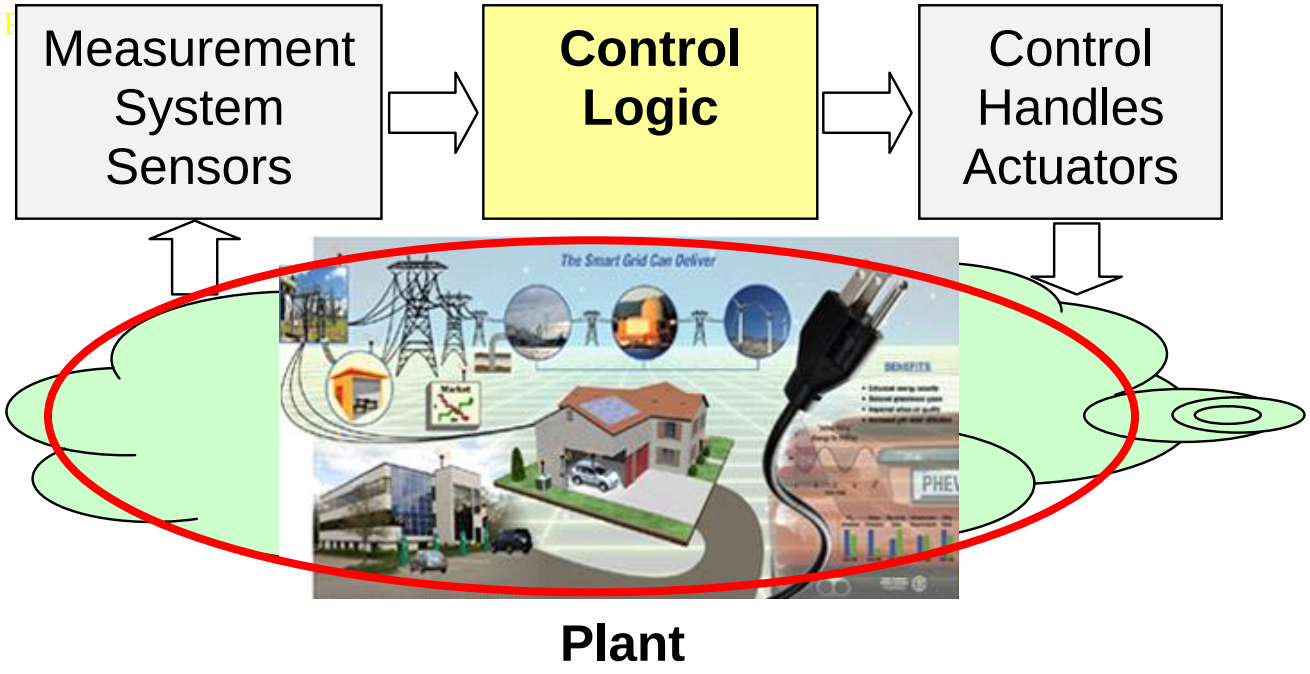
Data



Energy
System

Feedback Control Functions

- Closed loop update



Closed Loop Control Energy Applications

Supply

- Real time energy and reserve optimization at ISO
- Power Flow Optimization
- Volt Var Optimization

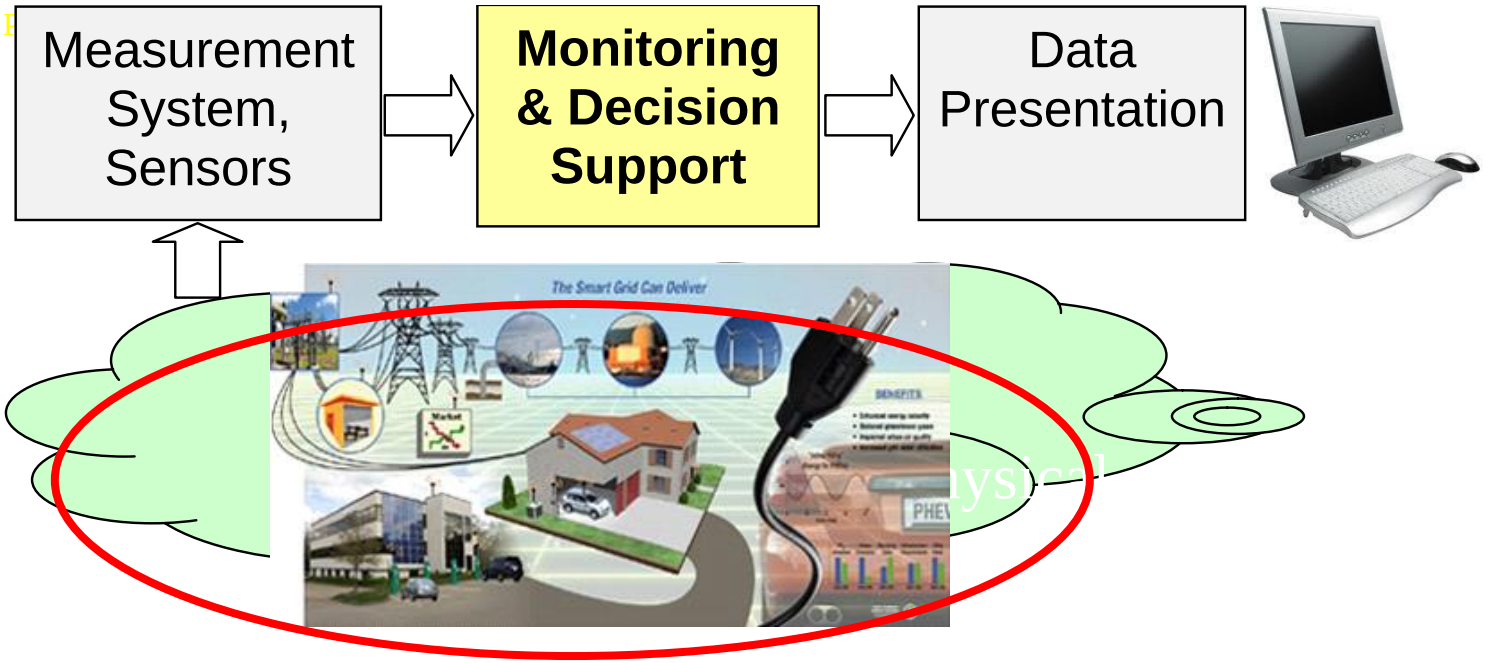
Demand

- Demand Response
- Thermostat

OT Applications

Monitoring and Decision Support Functions

- Open-loop functions
  - Results are presented to an operator



Decision Support Applications

Supply

- Asset Management
- Load Forecasting
  - Renewables generation
- Power Quality Monitoring

IT

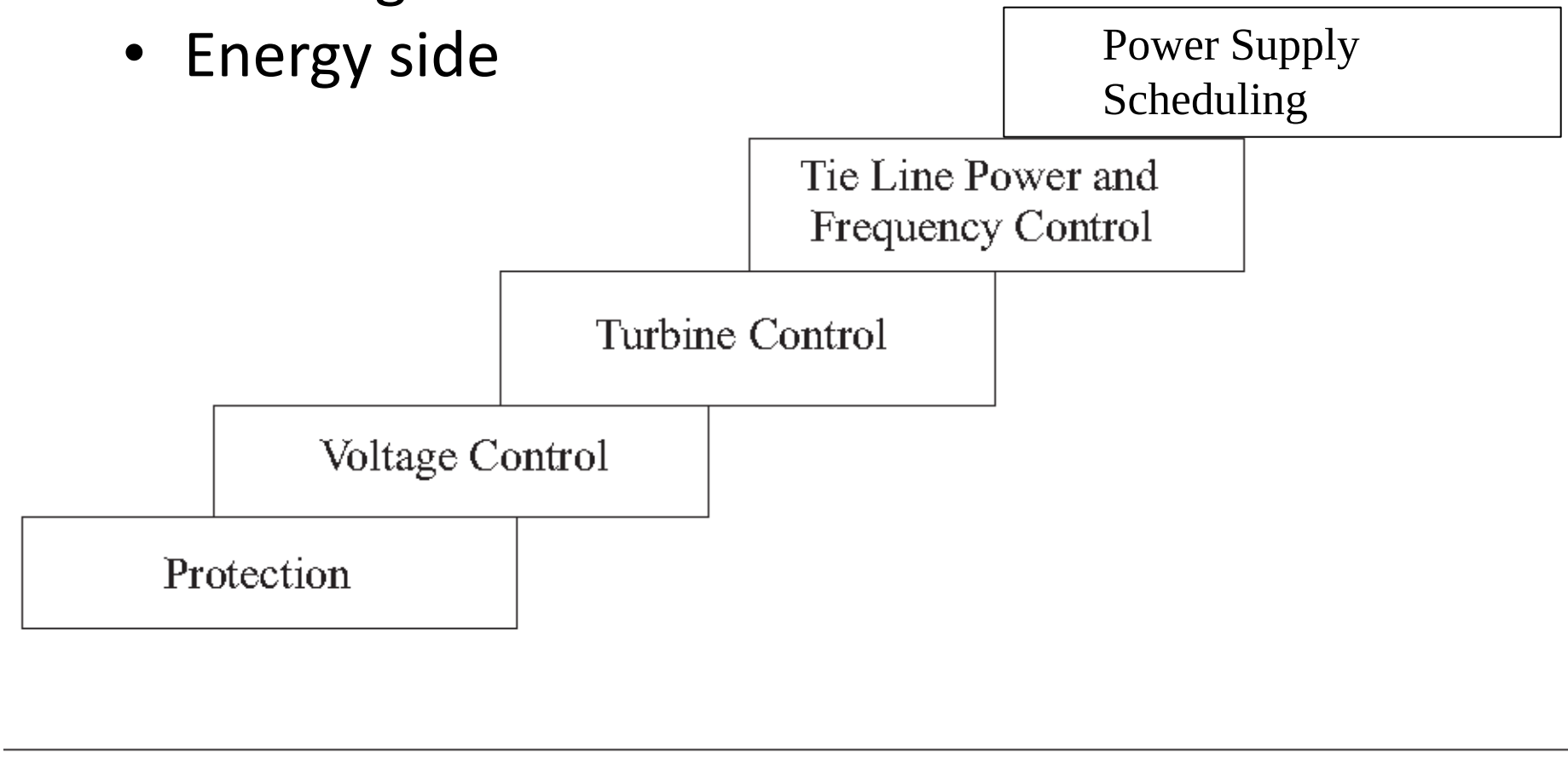
OT

Demand

- Energy Efficiency Monitoring
- Revenue Protection

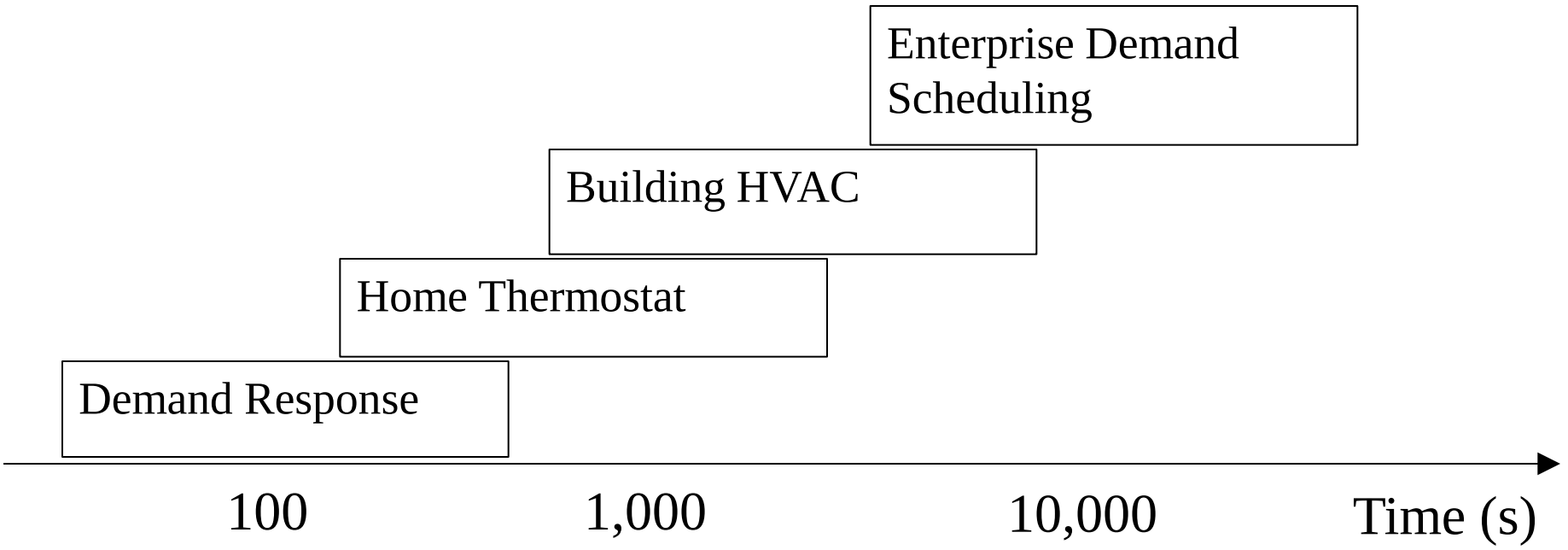
Power Generation Time Scales

- Power generation and distribution
- Energy side



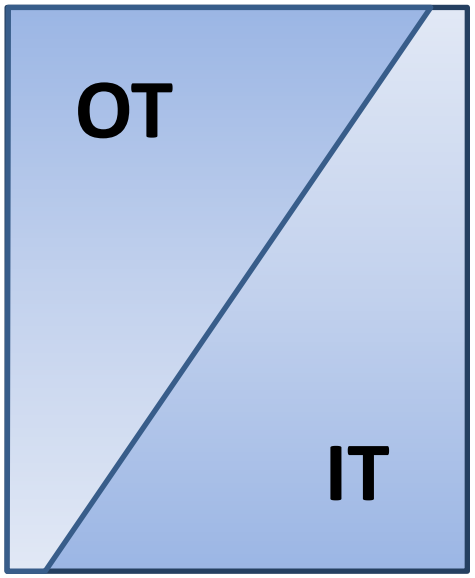
Power Demand Time Scales

- Power consumption
  - DR, Homes, Buildings, Plants
- Demand side



Big Data Analytics

- Feedback Control Functions
- Monitoring and Decision Support Functions
- Data Mining Functions



Data Mining Functions

- Data Exploration
  - Performed interactively
- Model Training
  - Known as system identification in control
- Model Exploitation
  - Estimation, eg, forecasting
  - Decision support, eg, monitoring
  - Control, eg, embedded optimization