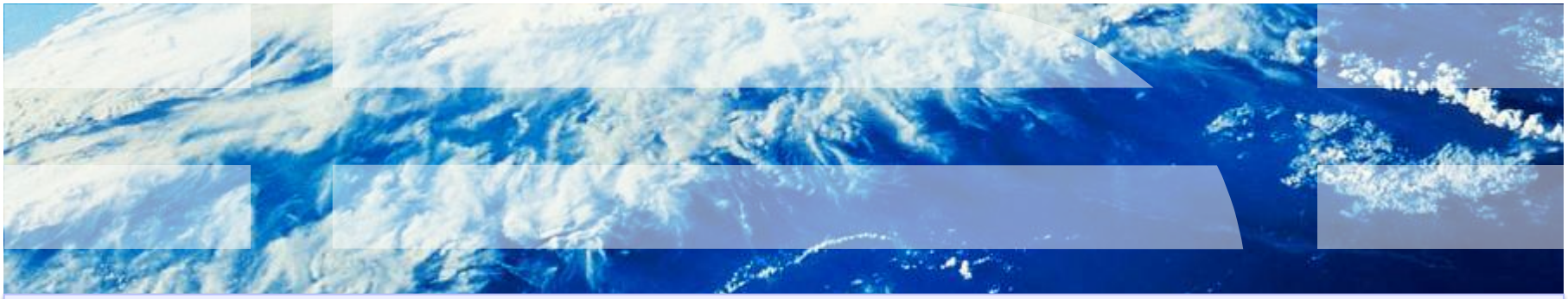
Evolution Toward Decentralized Management and Coupled Systems



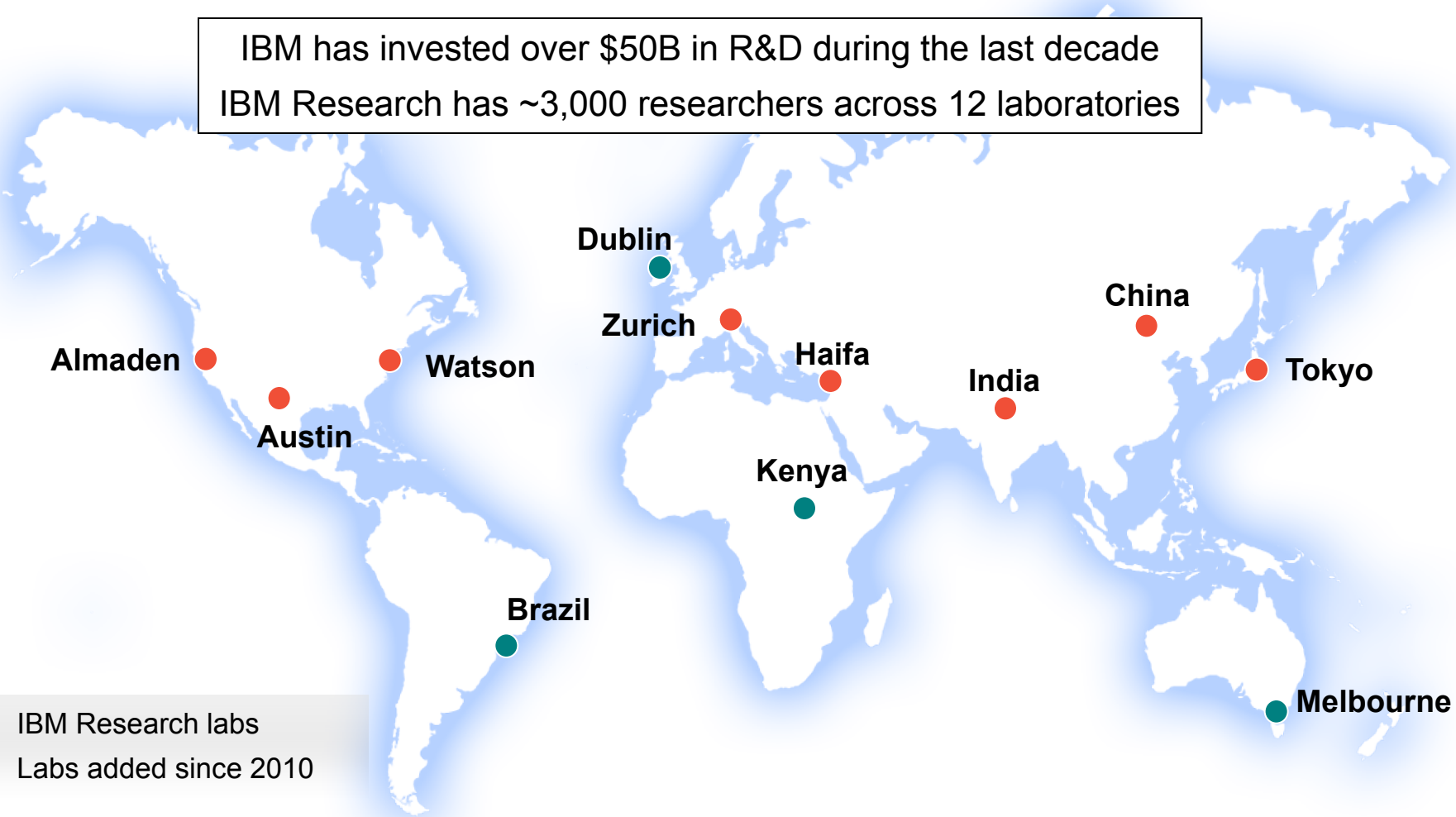
Ron Ambrosio
IBM Distinguished Engineer
Chief Technology Officer, IBM Smarter Energy Research

International Energy Systems Integration Workshop
Arlington, VA
February 18-19, 2014

IBM Research Today

IBM has invested over $50B in R&D during the last decade

IBM Research has ~3,000 researchers across 12 laboratories



Five Nobel Laureates

Nine Medals of Technology

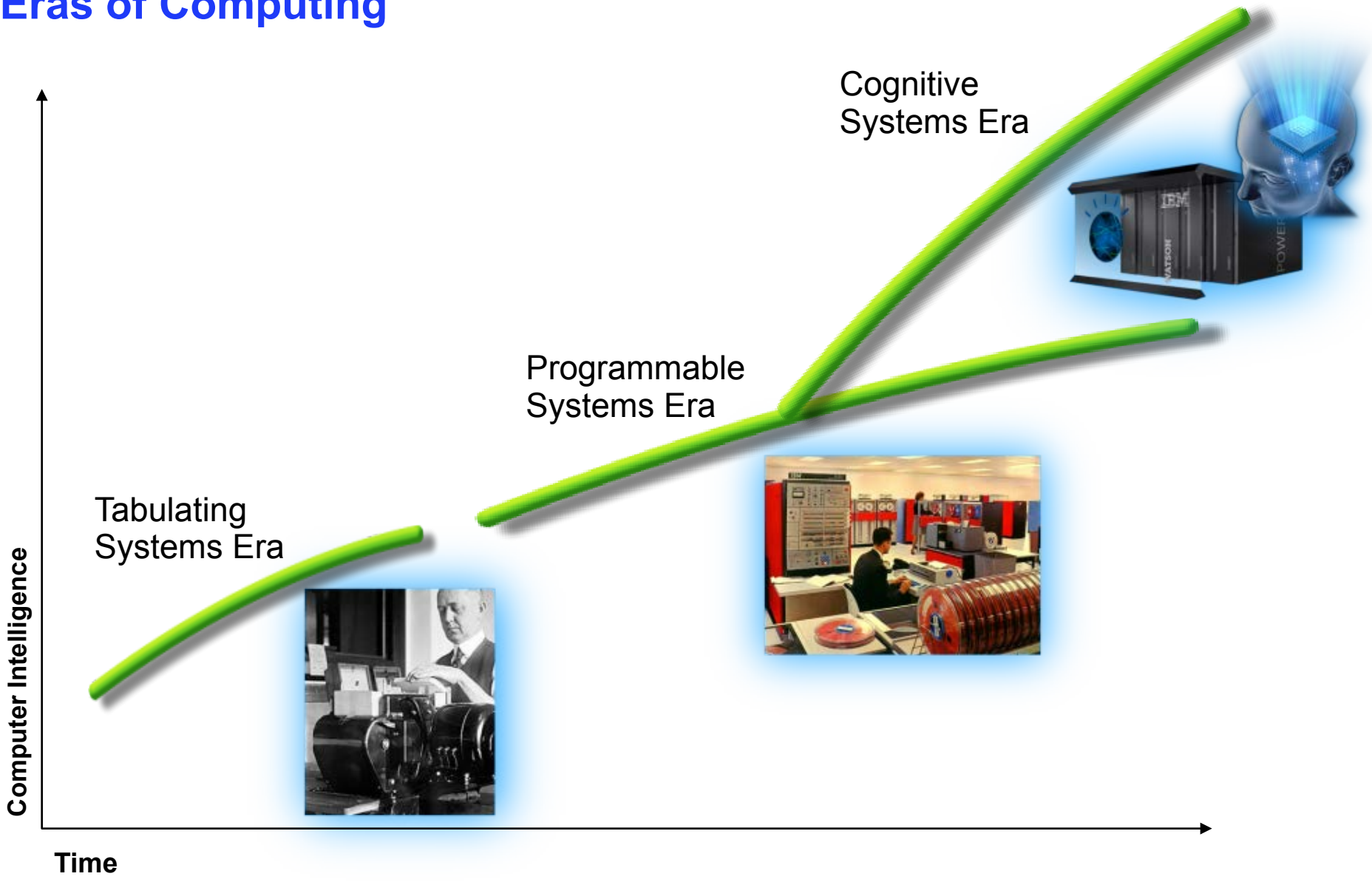
Five National Medals of Science

Six Turing Awards

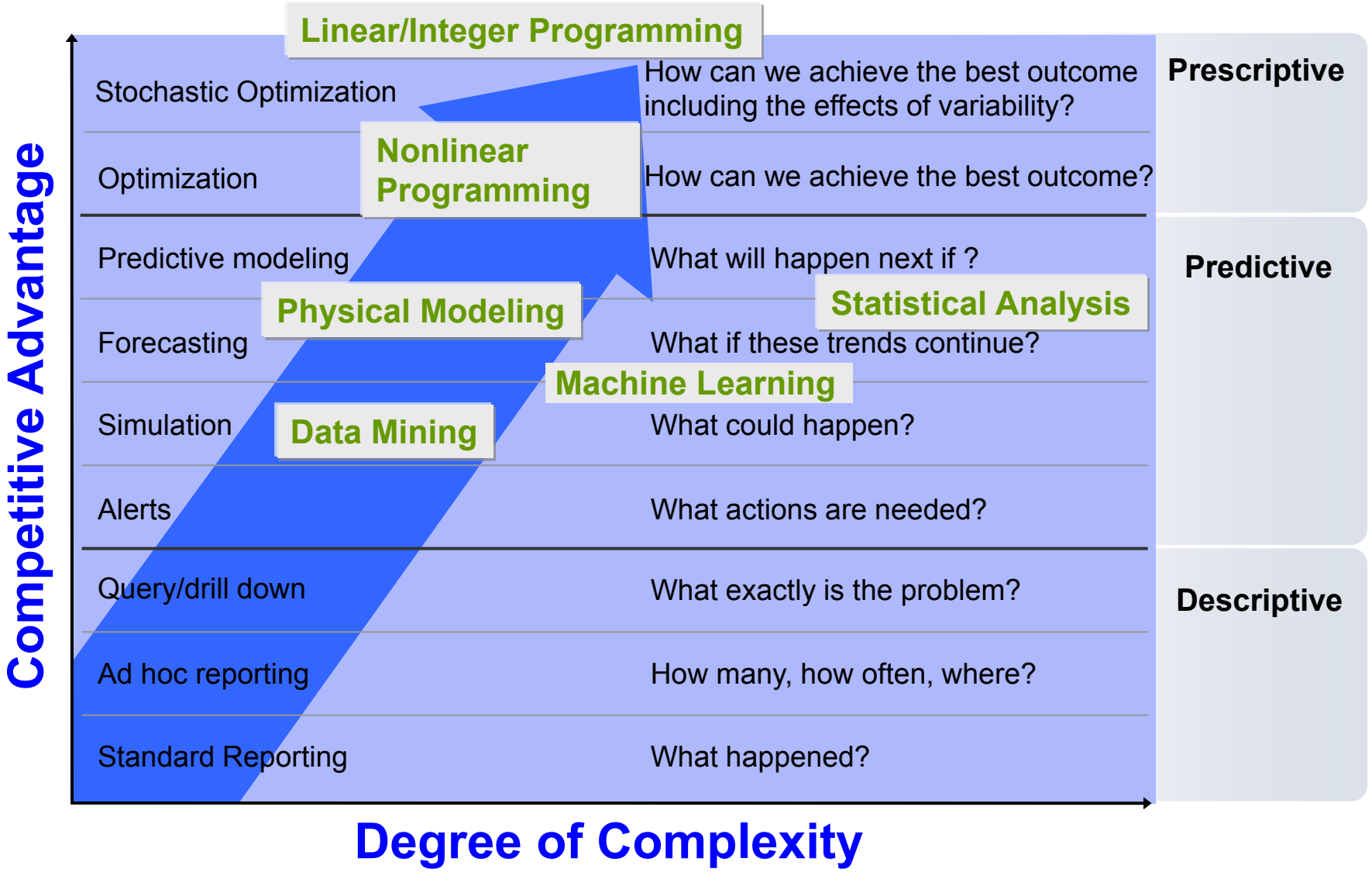
Continuing trend to take advantage of distributed resources

- **Integrating the management of distributed resources is a significant challenge**
  - Many are customer owned, with evolving communication and control protocols
  - There are multiple parties that can benefit from their responsiveness
    - System operators
    - Distribution operators
    - The resource owners themselves
  - Each of these has different business and operational objectives and constraints
    - A decentralized, but coupled, management approach would could allow optimal use of these resources across this set of interested parties
- **New approaches are needed to address the loosely-coupled nature of such systems**
  - Coupled-system modeling
  - Emergent phenomena detection and management

Eras of Computing

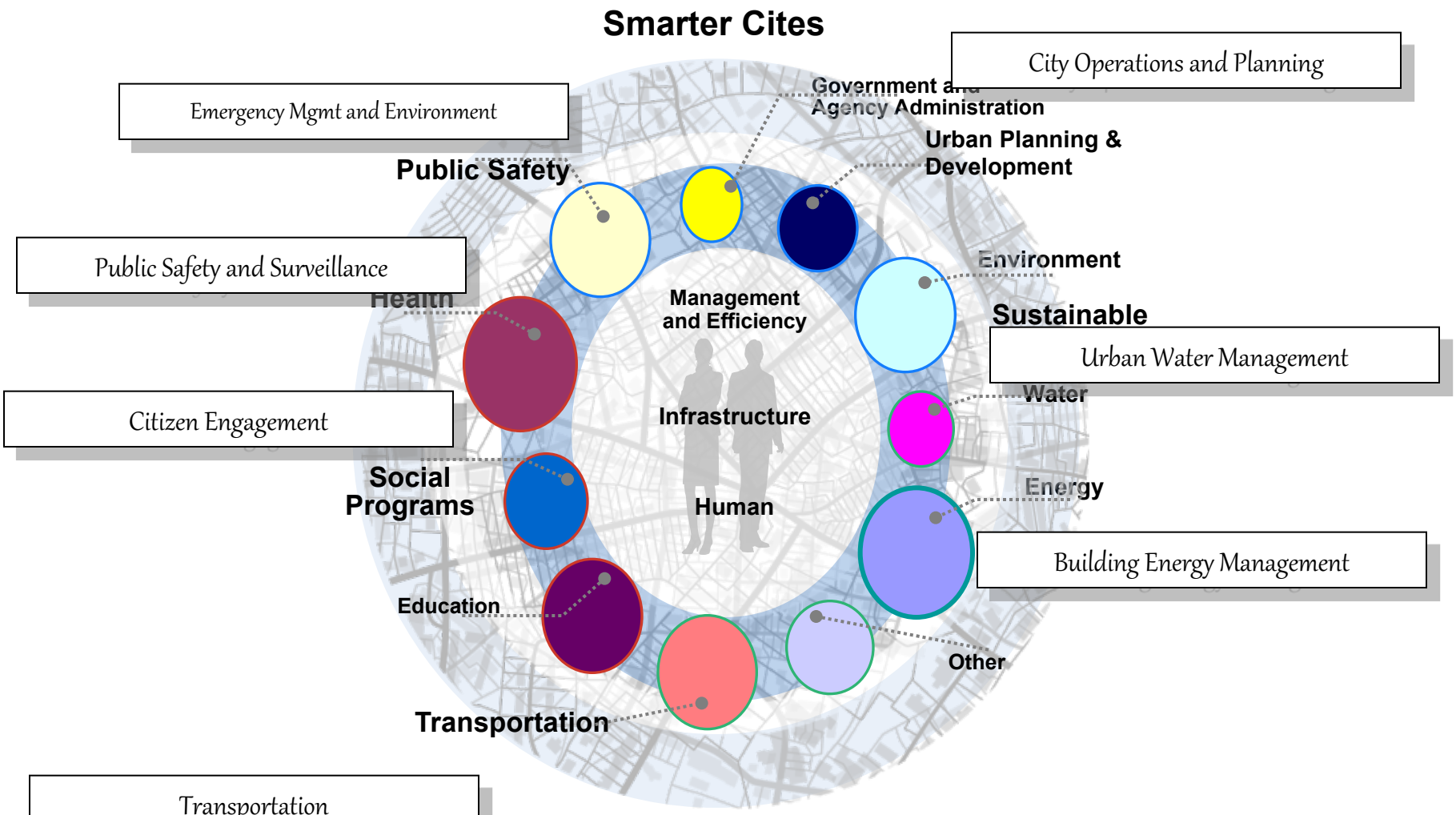


Big Data, Analytics & Value Creation

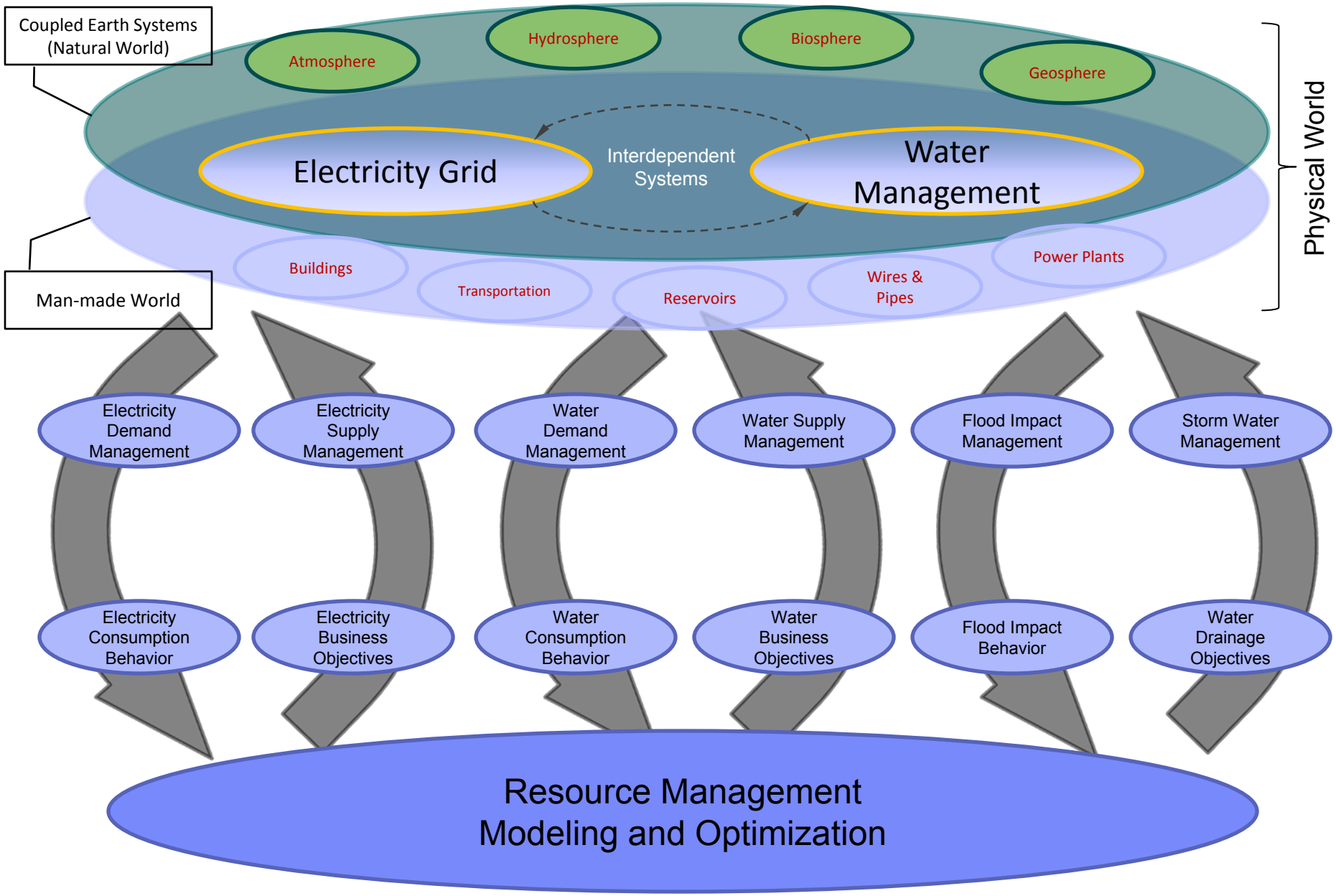


Based on: Competing on Analytics, Davenport and Harris, 2007

Smarter Cities topics depend directly or indirectly on energy



Coupled Systems



Energy Cost Minimization in Water Systems

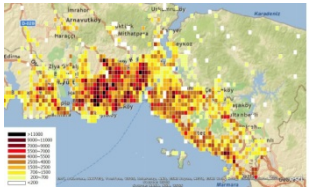
Description

- **The solution minimizes the energy cost associated with pumping water through a treatment and distribution network, while meeting customer requirements and hedging against energy price uncertainty**

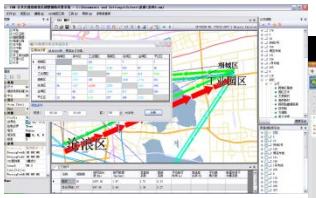
Significance

- **Demonstrates significant cost savings by using mathematical optimization models to schedule pumps**
- **Demonstrates how to best leverage lower (but uncertain) dynamic prices by hedging against uncertainty**
- **Targets some of the major segments/pain points, namely energy cost reduction and leveraging renewable energy**

Transportation systems are also coupled to energy



CiM
urban commuter
mobility analytics

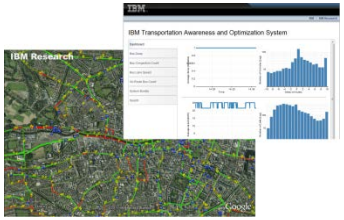


TOPS
Transit passenger demand analytics,
network optimization & multimodal simulator

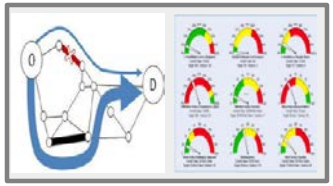
MegaTraffic Simulator
Large scale traffic flow
simulator

Analytics, Optimization & Simulation empowered by transportation domain models

TPT/DSSO
Real time prediction &
control optimization



PTA
Transit service awareness
& bus arrival prediction service



DOCIT
Dynamic optimization of
intermodal transport

Techniques like Transactive Control show promise

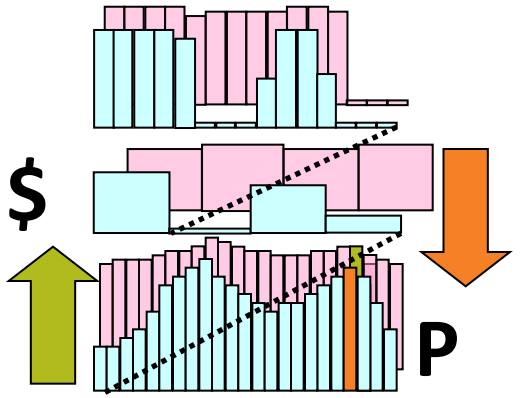
- **The use of an economic value signal as a control signal can enable interoperability and the exchange of objectives and constraints between highly heterogeneous systems**
- **It can be overlaid on any type of system – not just energy systems**
  - So it can provide a well-defined method of coupling the management of dissimilar systems

Transactive Control Definition

A distributed overlay approach utilizing a *cost-based* economic signal as a distributed control system signal

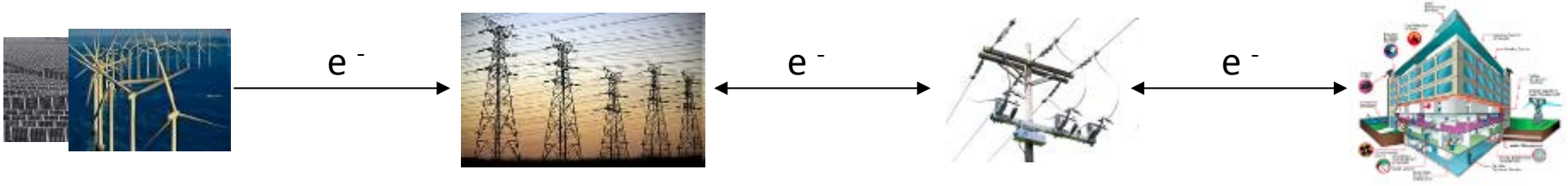
- All *business* and *operational* objectives and constraints can be assigned a value, and thereby incorporated into the signal

Signals forecast several days



Transactive Incentive Signal (TIS): reflects true *cost* of electricity at any given point

Generation **Transmission** **Distribution** **Customers**



Transactive Feedback Signal (TFS): reflects anticipated consumption in time

Challenges that must be addressed

- **Management across highly heterogeneous, loosely-coupled Systems**
- **Dealing with emergent phenomena as an integral part of overall system management**
- **The challenges of modeling and optimizing these complex systems**
  - Faster than real-time, so those models can be part of the operational system
- **Working with the policy and regulatory communities to evolve in a way that enables such approaches**
  - Across multiple industries, if we are to take full advantage of the coupled nature of our energy-dependent society