Scalability Analysis of VOLTTRON Platform

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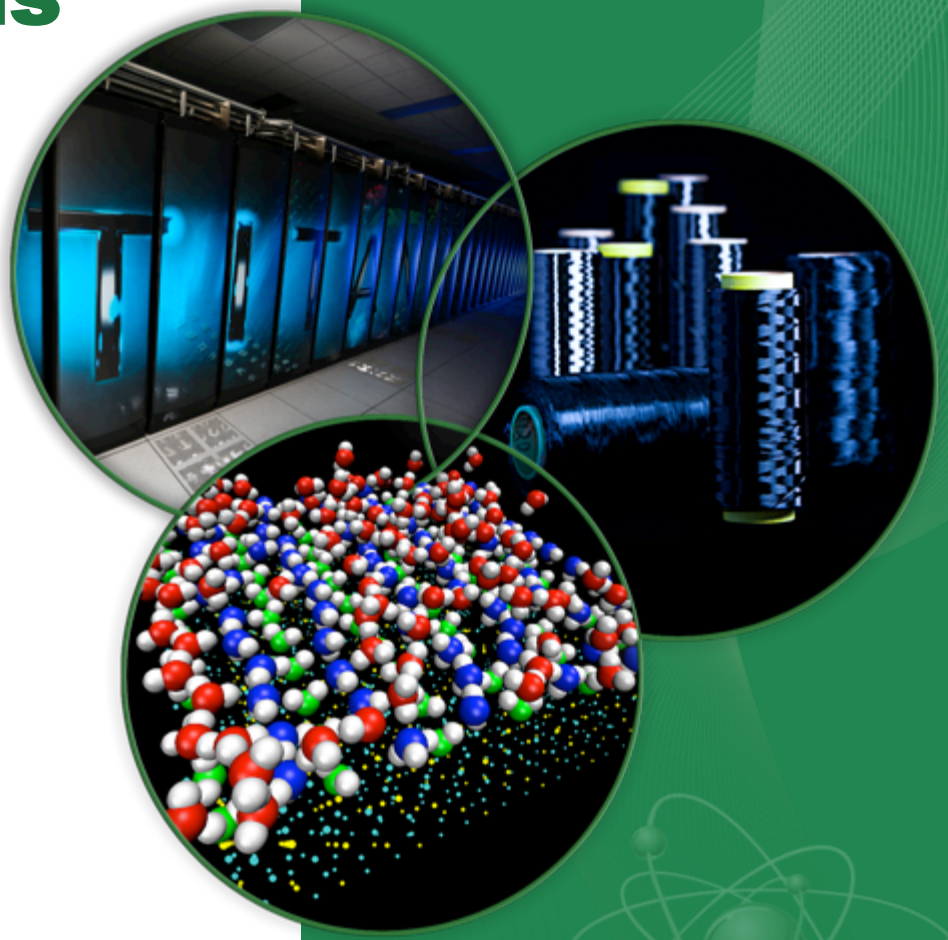

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Objective

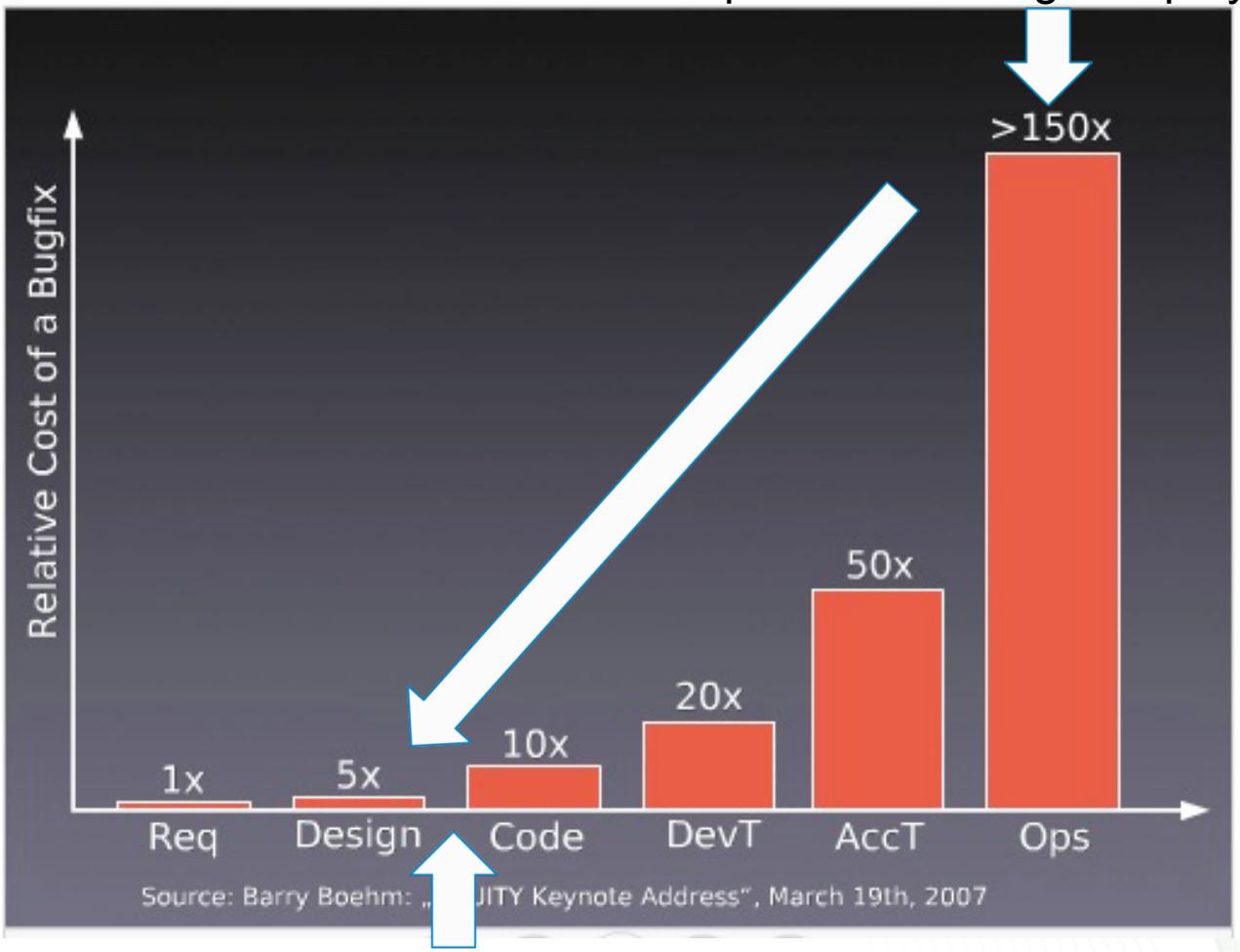
- Develop a simulation-based deployment environment for testing VOLTTRON applications at scales that cannot be cost-effectively realized in a field or laboratory setting
- Identify system-level requirements to support building-grid applications.
  - How much load can each device handle
  - How do the number of devices scale
  - What are the communication requirements
- Explore alternative topologies
  - Hierarchy of platforms
  - Devices per platform

Motivation

- Field trials at a large scale are prohibitively expensive
- Example: Pacific Northwest Smart Grid Demonstration Project
  - Demonstration of unprecedented geographic breadth across five Pacific Northwest states
  - 60,000 metered customers and contained many key functions of the future smart grid
  - http://www.pnwsmartgrid.org/about.asp
- Cannot afford large scale demonstrations at the prototype stage
  - No way to test for scalability prior to a large scale deployment
  - This drives up costs by finding and fixing problems after, rather than before, a large deployment

Shifting the cost curve

Finding and fixing scalability problems during a deployment



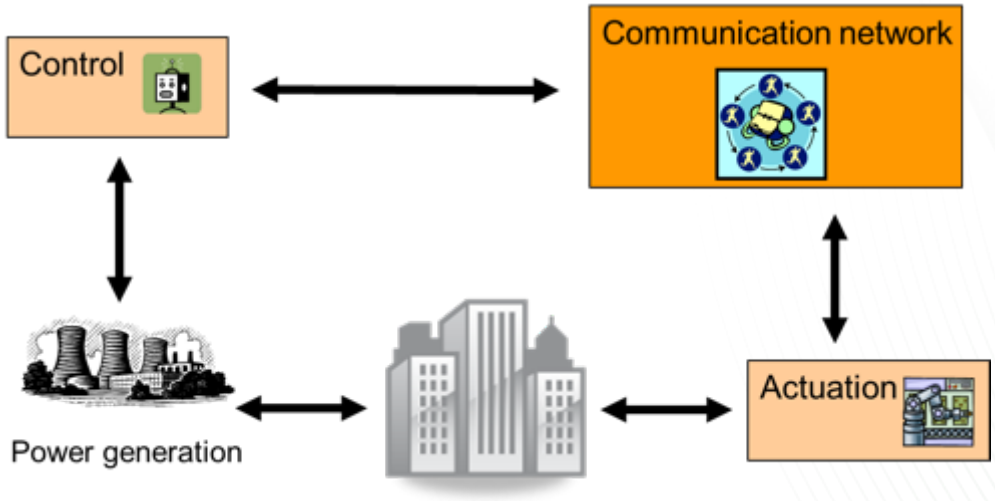
Finding and fixing scalability problems in simulations

Tasks

- Define scalability metrics and conceptual models for one or more deployment environments suitable to assessing those metrics
- Construct simulation models for those deployment environments
  - Buildings and building equipment, energy delivery, and communication networks at levels of detail appropriate to the selected metrics and conceptual models
  - Interface points for VOLTTRON applications to interact with simulated sensors, actuators, and communication networks
- Devise and conduct simulation experiments with a selected VOLTTRON application
  - Tailor deployment environment to match the selected application
  - Define detailed performance metrics for the selected application
  - Design and execute simulation experiments

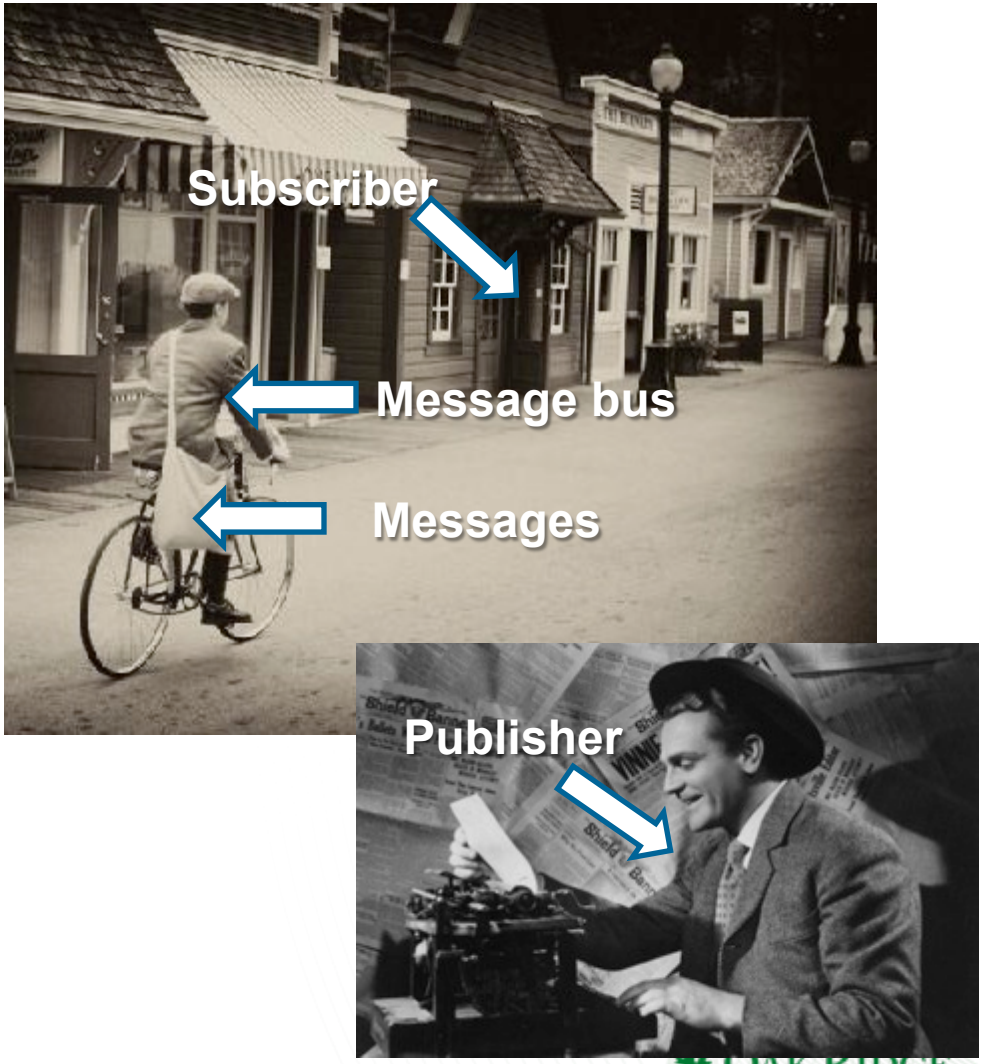
Task #1: Metrics and Conceptual Models

- Scalability metrics will define the scope of the conceptual and simulation models
  - Messaging rates?
  - Energy savings?
  - Peak reduction?
- Conceptual models will be devised to reflect metrics
  - Models of a network are important for assessing messaging rates
  - Models of building systems may be needed to answer energy savings or peak reduction questions?
  - What about energy delivery and building impacts on distribution or transmission?



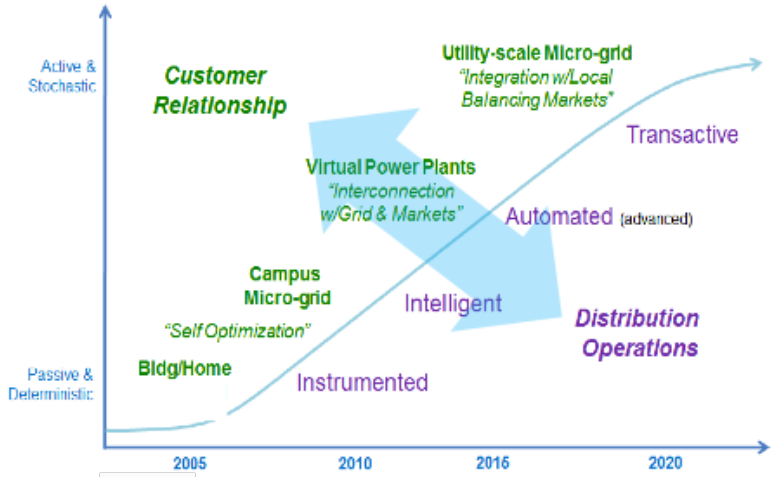
Basic Assumption of Pub/Sub systems

- Intermittent and irregular updates to data subscriptions are consistent with the component's proper operation
  - You can wait for the data
  - You can do without the data
  - Or both



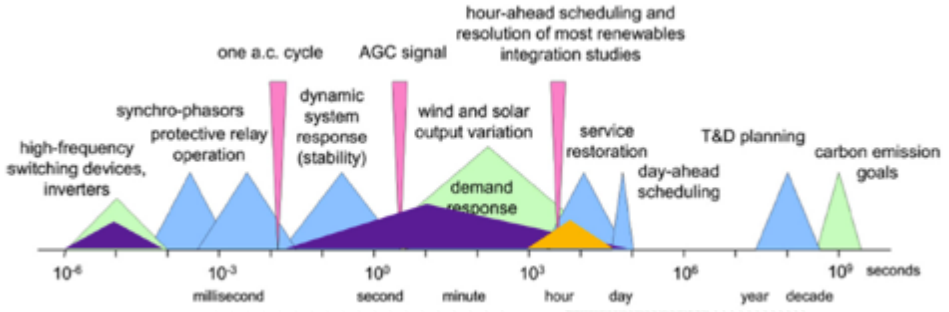
Applications Supporting Transactive Energy

- Transactive energy requires high-speed wide area control of loosely coupled loads
- Control response can be generated in a centralized or decentralized fashion
  - Utility level information
  - Building-level loads
- Embedded transactive devices that can control building systems over wide-area heterogeneous networks
  - How to guarantee quality of service?



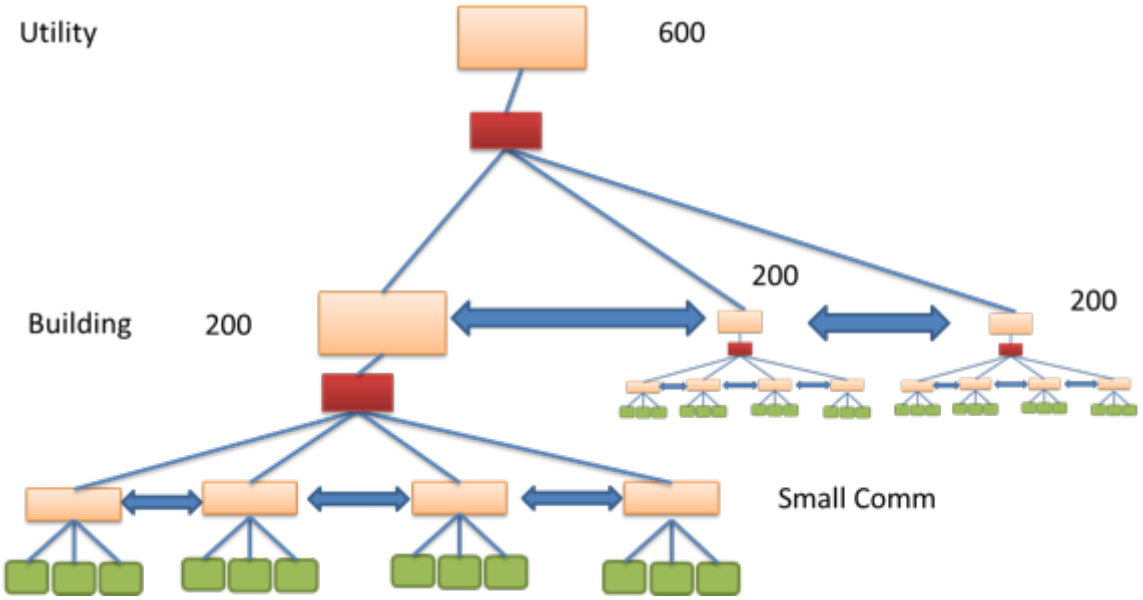
Stages of adoption of transactive operations for industry

Source: Paul De Martini, 1st International Conference and Workshop on Transactive Energy[9]



" To 33% and Beyond: Grid Integration Challenges for Renewable Generation", Alexandra von Meier, CIEE, presented to UCLA Smart Grid Thought Leadership Forum, March 28, 2012

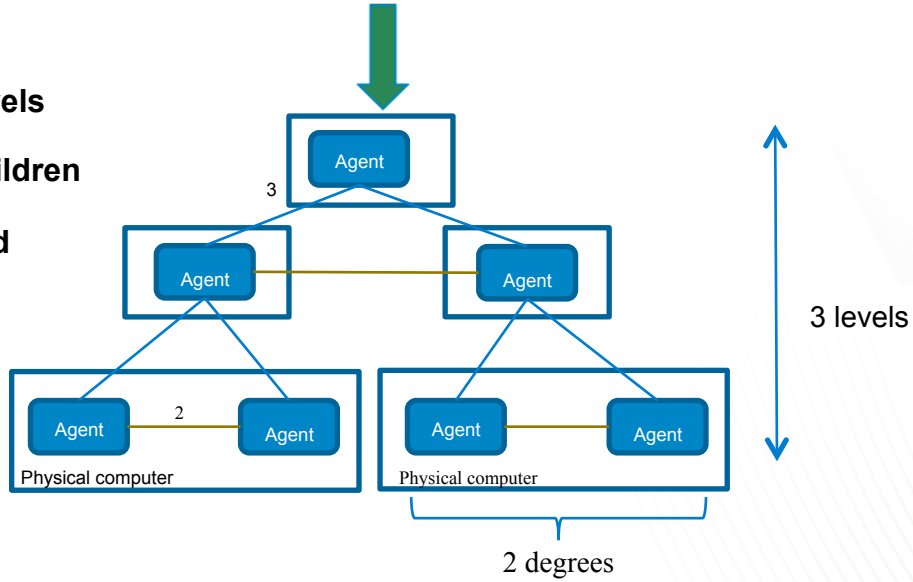
Scenario Definition



3 topics between levels

2 topics between children

10 messages/second

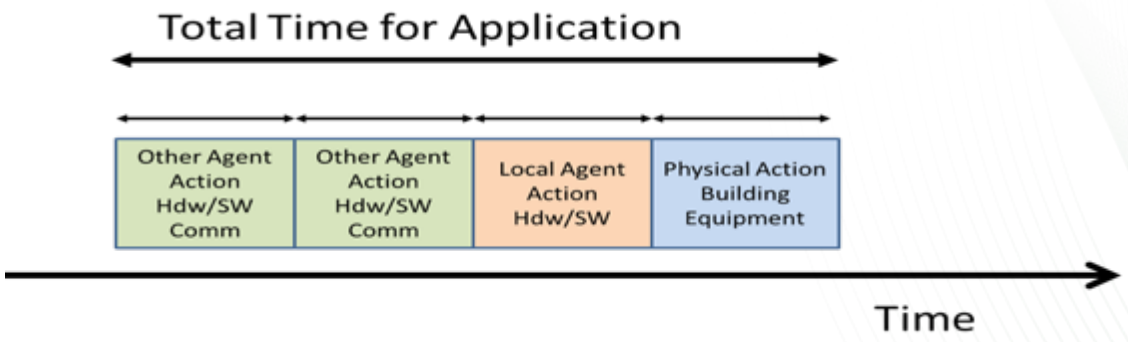


Define Metrics

- Average delay and variation of delay for messages within a single computer (i.e., between leaf nodes)
- Average delay and variation of delay for messages between computers.

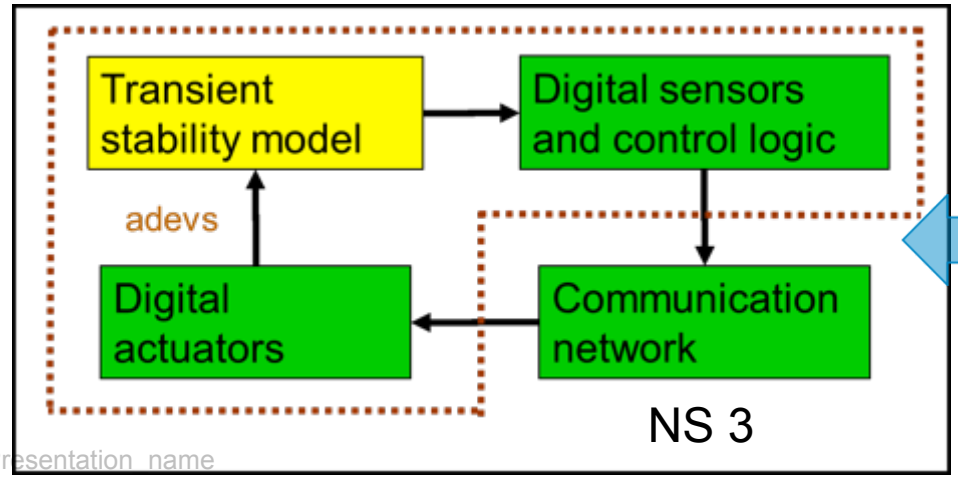
$$avg = 100\frac{messages}{second} \times 0.001\frac{seconds}{message} = 0.1$$

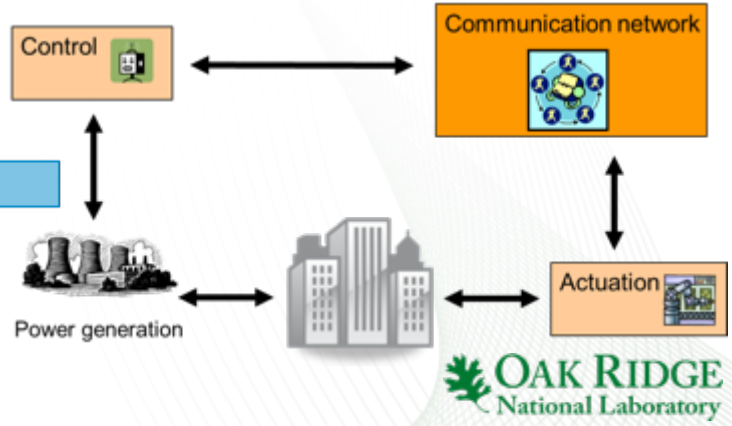
$$var = 100\frac{messages}{second} \times 0.00025\frac{seconds}{message} = 0.025$$



Task #2: Construct Simulation Models

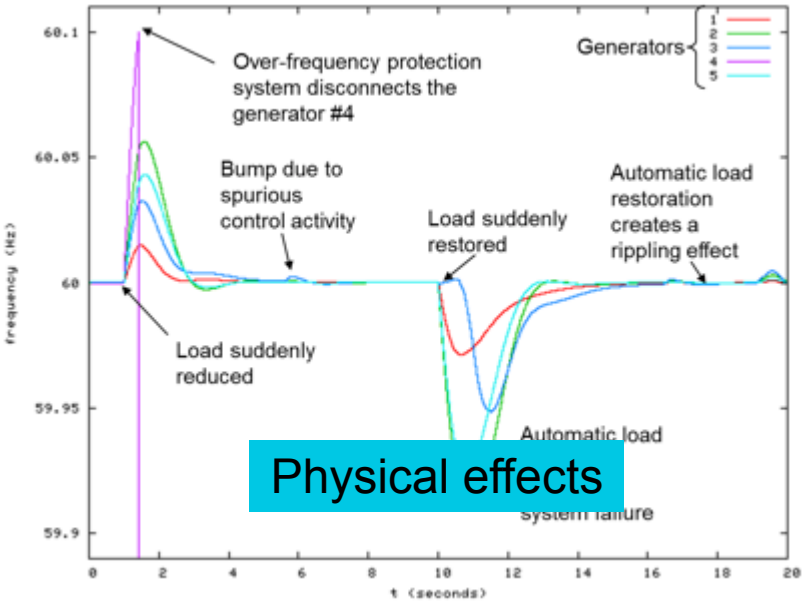
- Select and integrate simulation tools as appropriate
  - Will be specific to metrics and conceptual models devised in Task #1
- Create infrastructure for linking to VOLTTRON
  - Scope of this infrastructure limited to relevant applications
- Create detailed model components as necessary
  - To facilitate simulated actuation and sensing
  - For calculating metrics that look at secondary effects
    - Voltage in distribution system?
    - Peak energy use across a collection of buildings

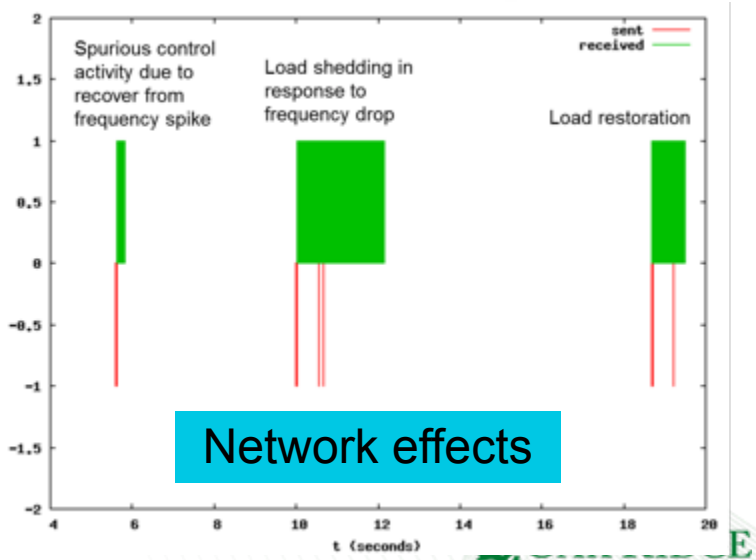




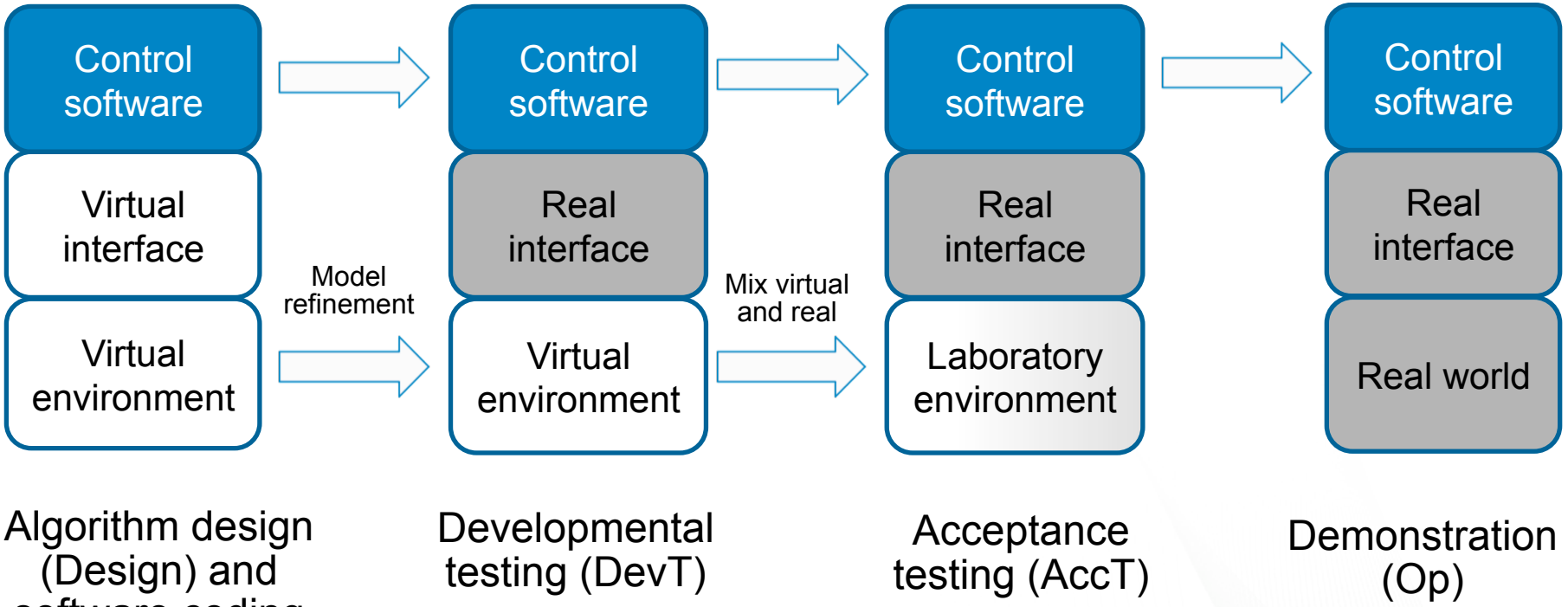
Task #3: Simulation Experiments

- Detailed model development for specific, simulated deployment
- Integration of specific VOLTTRON application with the simulated deployment environment
- Design and execute simulation experiments
  - Collect data for relevant variations of the deployment environment
  - Calculate metrics and demonstrate scalability





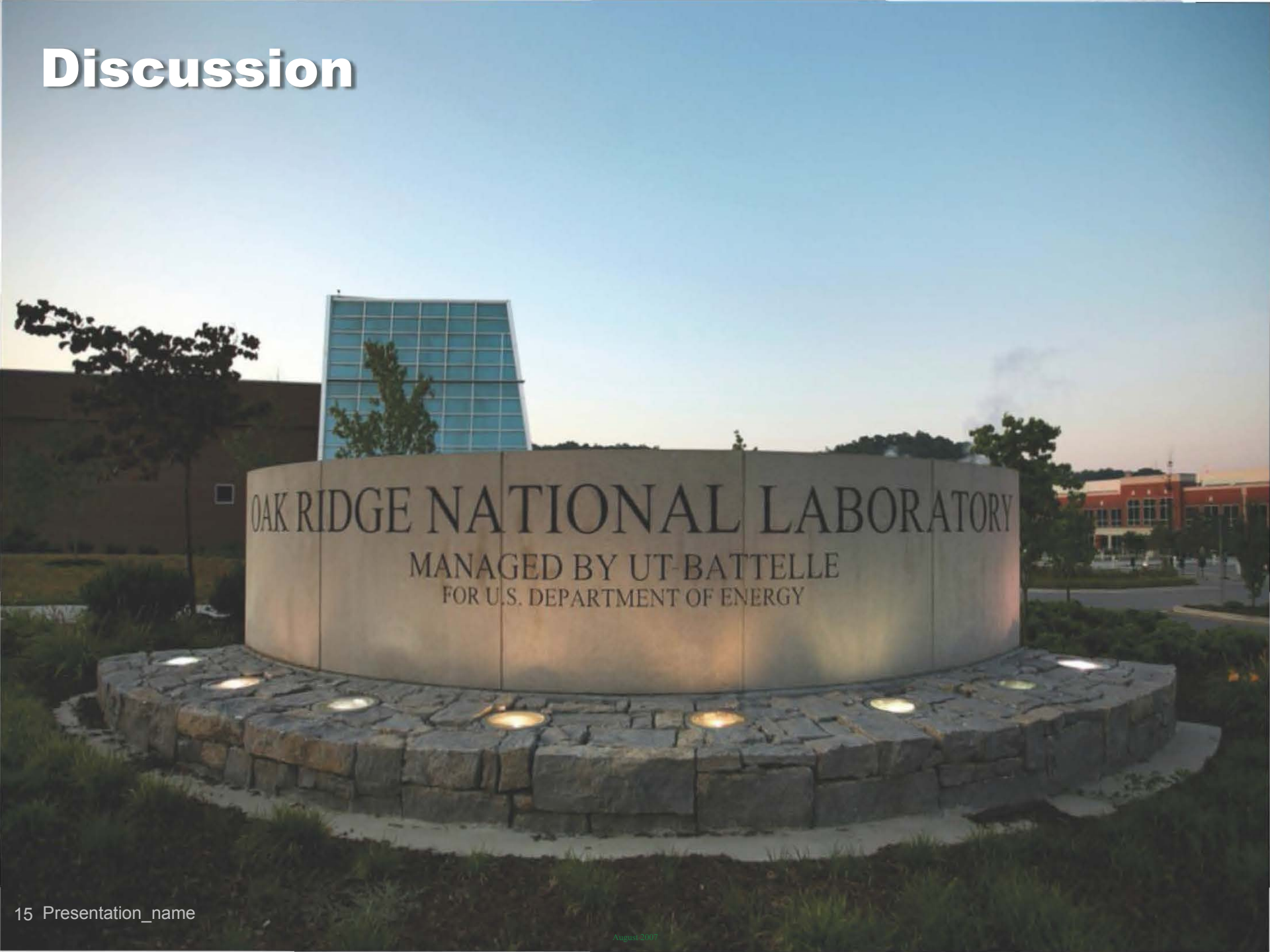
Incremental approach to Scalable Applications



Outcome

- **Near term**: A demonstration of a scalable, transactive energy application
  - Metrics for scalability measured for a specific application in a relevant, simulated deployment
- **Midterm**: Residual capability to demonstrate other large scale, transactive energy applications
- **Long term**: A virtual deployment laboratory for testing and refining VOLTTRON-based applications

Discussion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