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Experiment, Test, and Assessment Platform

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Asymmetric Resilient Cybersecurity Initiative Roadshow

May 12, 2017

Science of Cyber Security

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- **Need**
  - Confidence in measurements, mechanics, and prediction in cyberspace
- **Problem**
  - Treating as applied science without fundamental science foundation

Science of Cyber Security

- **Approach**
  - Methods for performing rigorous scientific research
  - Theories for the field to begin building a body of knowledge
  - Review field for successful research

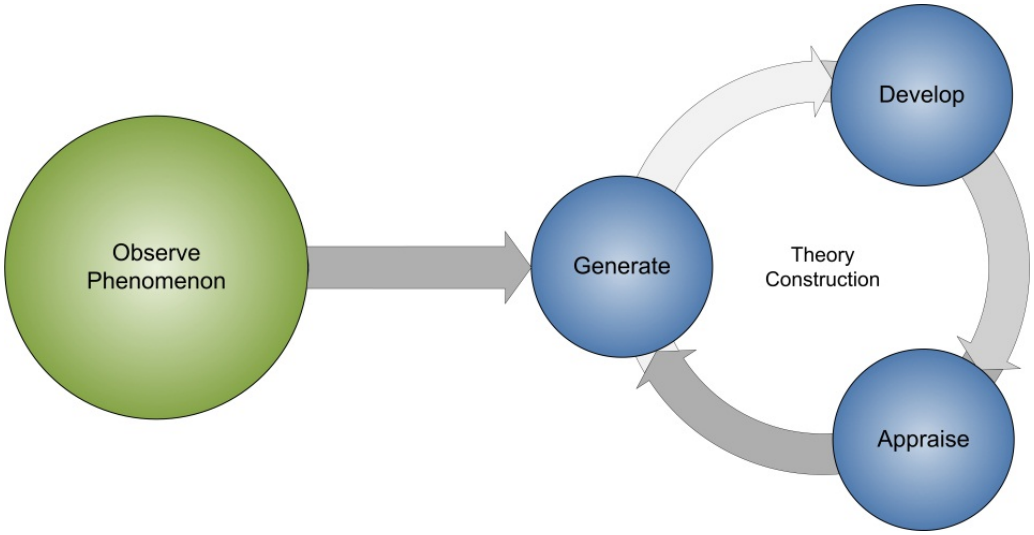
Science of Cyber Security

- **Benefit**
  - Move toward symmetry for defender
  - Enable metrics – ability to meaningfully measure
  - Support decision making
  - Grand challenge: Prediction

Cyber Security Scientific Methods

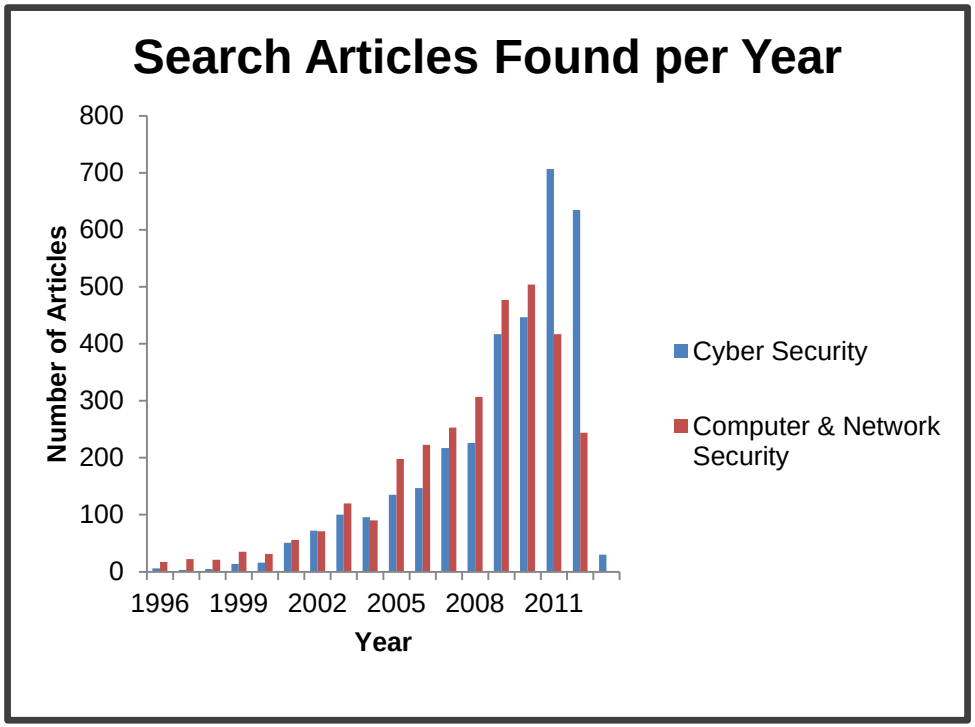
- Survey of other scientific fields
  - Medicine, physical sciences, social sciences, etc.

- Theory created from generation process
  - Inductive (generate ideas for theories from community datasets)
  - Abductive (reduce set of theories to most likely with additional datasets)
  - Hypothetico-deductive (design and execute experiment to test theory)



Progress to Date

- Following method outlined by Tichy et al[1] and Wainer et al[2]
- Sources: ACM, IEEE, etc.
- Search terms (15 years)
  - Cyber security or cybersecurity
  - Network security
  - Computer security
- 5645 documents collected



Preliminary Results Continued

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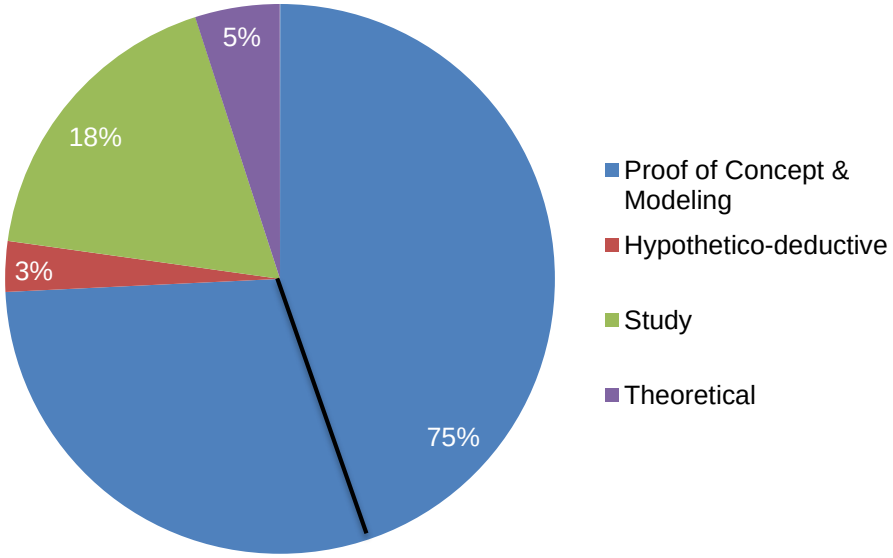
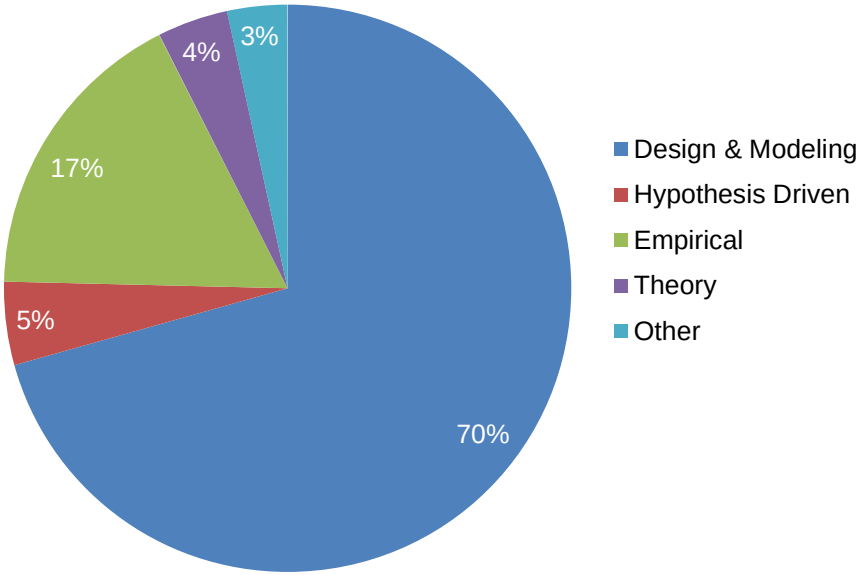
PNNL Preliminary Results Merged



2009 Computer Science Study



Need for Experimental Testbeds

- Increasing scrutiny and threat
- Large amounts of functionality upgrades
  - Deployments without adequate investigation
- High resource requirement
  - Expensive equipment
  - High knowledge/experience barrier to configure and maintain
- Lack of access to equipment by researchers
- Experimentation can not occur in operational environments

Vision for a Testbed

- Experiment-based
  - Fidelity and repeatability
    - Simulated environments
    - Low-level access to equipment
- Scalable
  - Emulation and simulation
- Dynamic and flexible
  - User-friendly
  - Common library of scenario templates
  - Reset to known between configurations
- Multi-user capability
  - Experiment and data separation
  - Access controls
- Modular and expandable
  - Capable of federation
- Self supported user community

Research Infrastructure @PNNL: Holistic view

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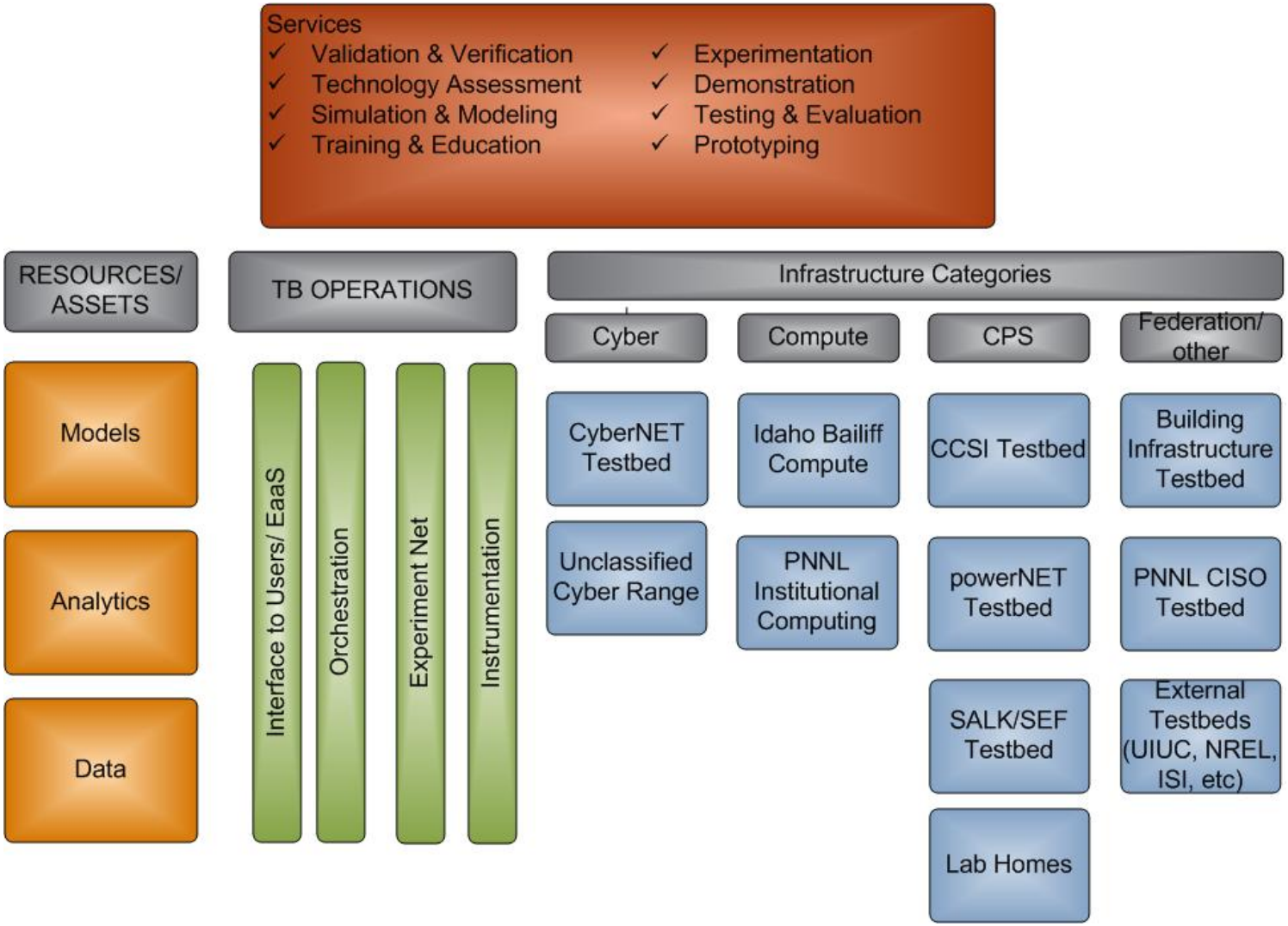

PNNL powerNET Facilities

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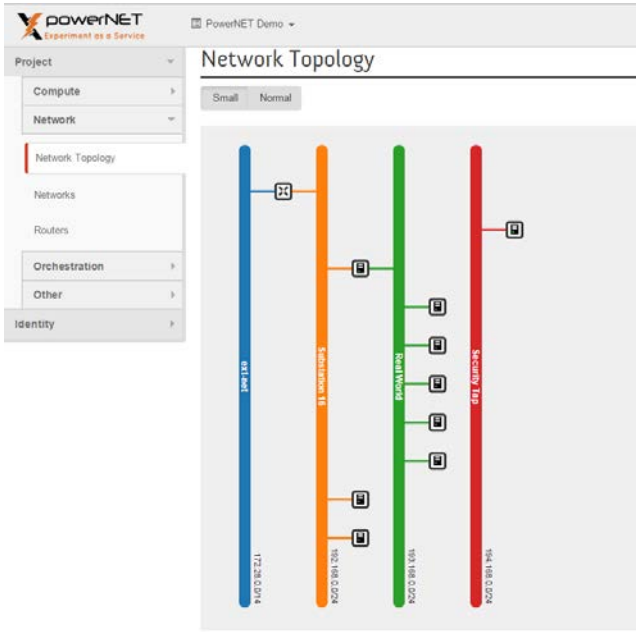
- **Cloud technology based orchestration with web based user portal**
- **Network Emulation**
  - Emulate LAN/WAN communication characteristics.

  Examples:
    - Dedicated Line
    - Dial-up
    - Wireless
- **SCADA environments**
  - Real equipment to model ~two substations
    - ABB, GE, Siemens, SEL, …
  - Software simulation of dozens of SCADA equipment
  - Support for legacy communications



powerNET
Experiment as a Service

powerNET Facilities (cont.)

- **Physical Process Emulation**
  - Hardware-in-the-loop modeling
  - Opal-RT
  - Large scale simulation
- **Synchrophasors**
  - 9 PMUs from variety of vendors
    - 1 PMU Development Platform
  - 1 Hardware PDC
    - (Many software PDCs possible)
- **Up to ~1000 general purpose virtual nodes possible**
  - XenServer hypervisor
- **Energy Management System**
  - **Alstom System**

PNNL cyberNET Facilities

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- Facility investment by PNNL
  - Scientific experimentation
  - Real-world scenarios
  - Cyber security metrics

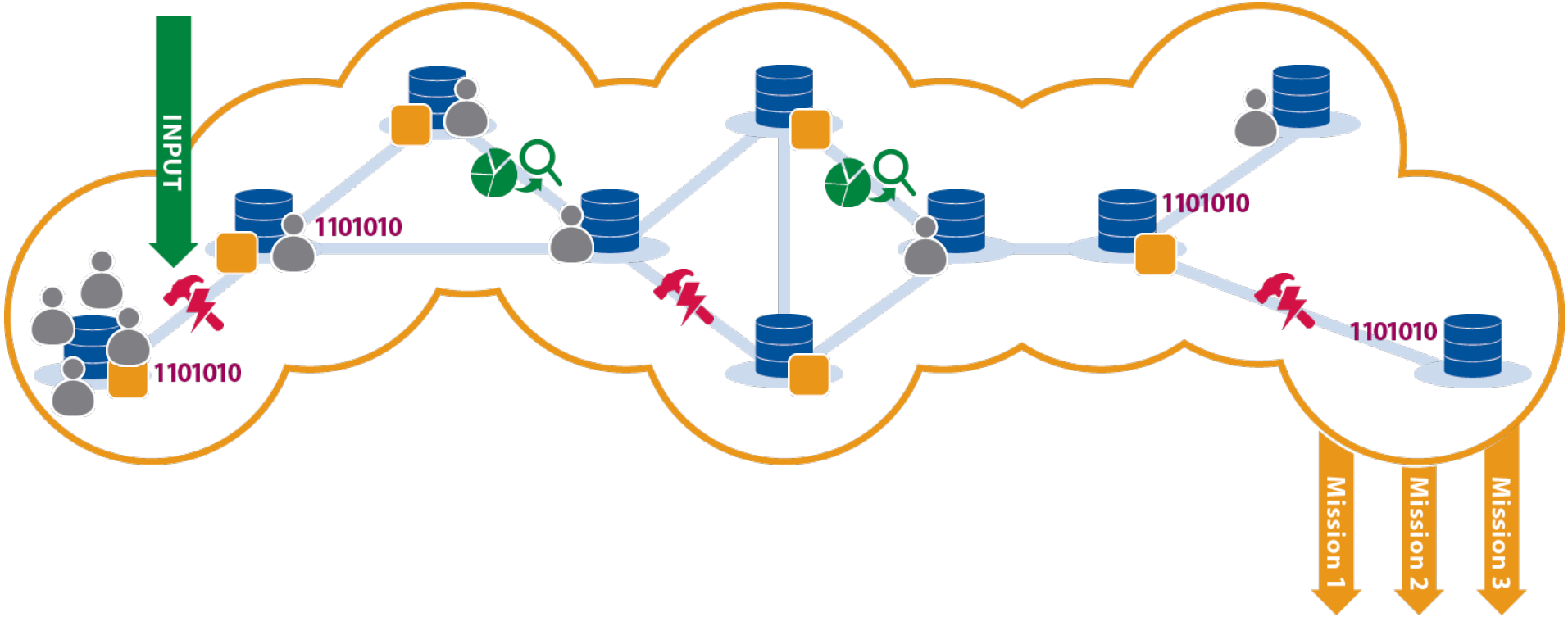
- Leverages:
  - Commodity hardware
  - Commercial and open source software
    - Citrix XenServer, OpenStack
    - Agent platform for user emulation
  - PNNL modifications for science
    - Repeatability, sensoring, control…

cyberNET
Experiment as a Service

cyberNET Facilities (cont.)

- Combination of simulation, virtualization, and real equipment
- Repository for storage/retrieval of experiment data
  - 120TB
  - Support development of "gold standard" test datasets
- Multi-user/multi-project support
  - Share resources
  - Quick setup/configuration
- Simulates up to ~4000 virtual nodes
  - Currently 28 nodes (32 core, 256GB)

ViSR Company



System | Network | ViSR | Application | User | 1101010 Data | Actuation | Sensing

Testbed Uses

- Technology assessment and prototyping
- Simulation and modeling, verification, and validation
- Experimentation
- Demonstration
- Training and education

Cyber Security Science Contributions

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- Testbeds for rigorous experimentation
  - Multi-user shared facility and equipment
  - Time and resource efficient
  - Dynamically configurable
  - Federatable to a larger user community
- Measurable science
  - Understanding and creation of gold standard data sets
  - Rigorous approach (repeatability, system under test, appropriate fidelity, etc.)
- Improved awareness through training and exercises

Cyber Science & Community Challenges

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- Accuracy of system
  - Scale
  - Fidelity
  - M&O (staleness)
- Accuracy of humans (cyber)
  - Blue team automation
  - Red team automation
  - Human red team utilization (sample size, learning, uniformity, access)
- Reproducibility
  - Who does it?
  - Who pays for it?
  - How do we facilitate it?

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Asymmetric Resilient
Cybersecurity Initiative

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