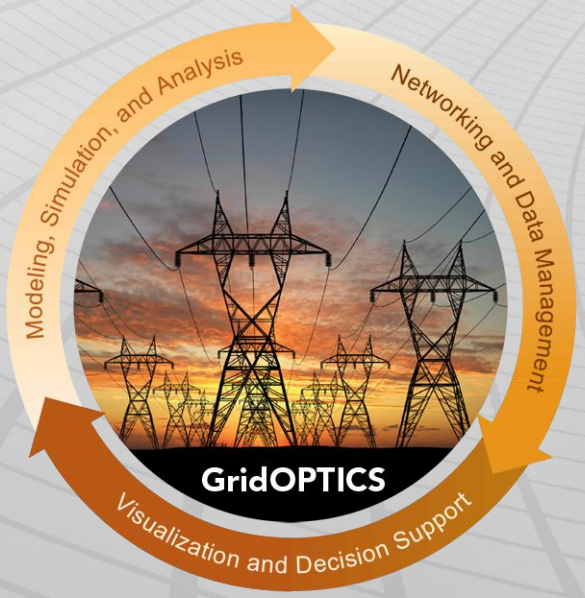
Future Power Grid Initiative
Transforming the U.S. Electric Grid

GridOPTICS powerNET

A Research Laboratory and Testbed for Energy Networking, Equipment, and Technology



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IEEE HST Cyber Security Panel

Strengthening Critical Infrastructure: Building and Testing Security Solutions for Cyber-Physical Systems

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Derivative Classifier: Jeffery A. Mauth, Manager, PNNL
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Outline

- Introduction
- What is GridOPTICS powerNET
- Capabilities
- Use Cases/Interest
- Operation
- Future Work

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Future Power Grid Initiative Key Outcomes

The Initiative will develop a suite of tools - GridOPTICS:

- Bridging operation and planning to enable more seamless grid management and control
  - Remove overhead involved in communication between operation and planning
  - Improve response when facing emergency situations
- Integrating transmission and distribution in end-to-end grid modeling and simulation capable of handling 10^9 devices with uncertainty
  - Understand the emerging behaviors in the power grid due to smarter loads, mobile consumption, and intermittent generation
- Managing interdependency between power grid and data network (a test lab for power grid data networking will be set up)
  - Enable “all-hazard” analysis
  - Prepare grid operators and planners with the knowledge of data network impact on the power grid

What is a Testbed?

- NSF workshop 2002
- A platform for experimentation
- Two broad types
  - Proof-of-concept
    - Purpose built for demonstration of technology
  - Multi-user experimental
    - Provide a service to a research community

Need for Cyber-Physical Testbed

- Cyber-physical systems under 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 researcher access to equipment
- Experimentation can not occur in operational environments

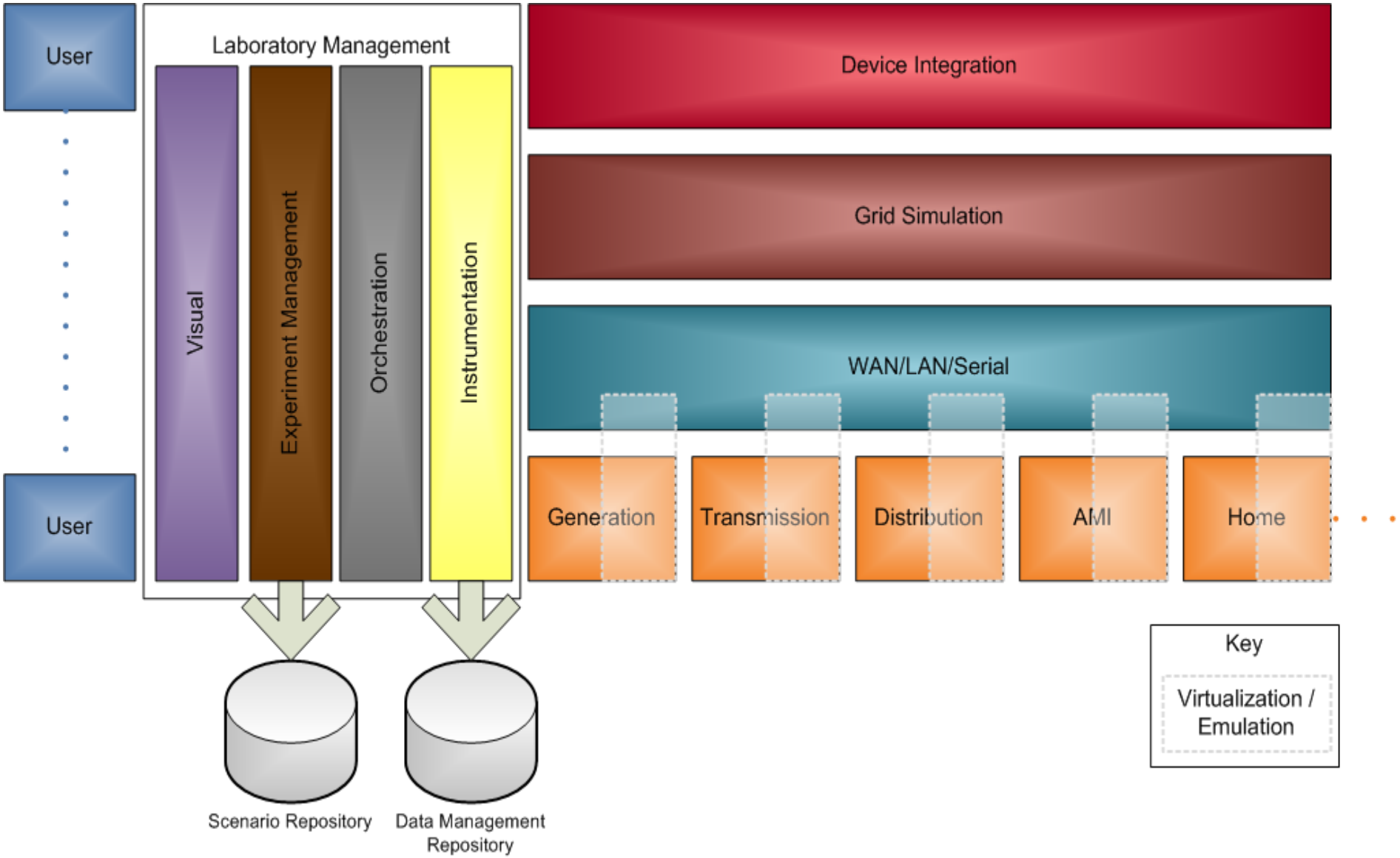
Vision for a Cyber-Physical Testbed

- Experiment based
  - Fidelity and repeatability
    - Simulated physical environment
    - Low level access to equipment
    - Real world equipment
- Scalable
  - Emulation and simulation
- Dynamically flexible and scalable
  - User friendly
  - Common library of scenario templates
  - Reset to known between configurations

Vision Cont.

- Multi-user capability
  - Experiment and data separation
  - Access controls
- Modularity and Expandable
  - Support for multiple cyber-physical industries
  - Federation
- Self supported user community
- Federation capable

GridOPTICS powerNET Functional Testbed



Facilities

- **Project/Program Based Access Controls**
- **Web GUI with Drag-and-drop network configuration**
- **Network Emulation**
  - Appliance to emulate LAN/WAN communication characteristics. Examples:
    - Dedicated Line
    - Dial-up
    - Wireless
- **Synchrophasors**
  - 8 PMU from variety of vendors
    - 1 PMU Development Platform
  - 1 Hardware PDC
    - (Many software PDC possible)

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Facilities Cont.

- **Up to ~250 virtual nodes possible**
  - Virtualization
- **SCADA/Energy Management System (In progress)**
- **AMI (In progress)**
- **Simulation Cluster**
  - 3 nodes with SSDs and Infiniband communication fabric
  - Scale experiments to thousands of nodes

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Capabilities for network design and testing

- Test phasor network performance
  - Latency, availability, cyber security
- Evaluate large-scale cyber-physical network architectures
- Design highly diverse networks and architectures
  - Equipment, topologies, protocols, etc.
- *Simulation & Scalability*

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Example Capability: Simulation & Scalability

- Computing cluster
- Virtualization: solution can scale to meet the needs of multiple simultaneous projects
  - create numerous virtual nodes (~250)
- Network Emulation
- Federation: within PNNL and with external partners
- 64 TB of networked high-speed shared storage

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Testbed Uses

- Validation and verification
- Technology assessment and prototyping
- Simulation and modeling
- Training and education
- Demonstration (with PNNL EIOC)

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GridOPTICS powerNET Testbed Benefits

- Multi-user shared facility and equipment
- Time and resource efficient
- Dynamically configurable
- Remote access
- Community portal for collaborative science and engineering and institutional knowledge management
- Test wide scale federation of testbeds and understand associated management and security concerns

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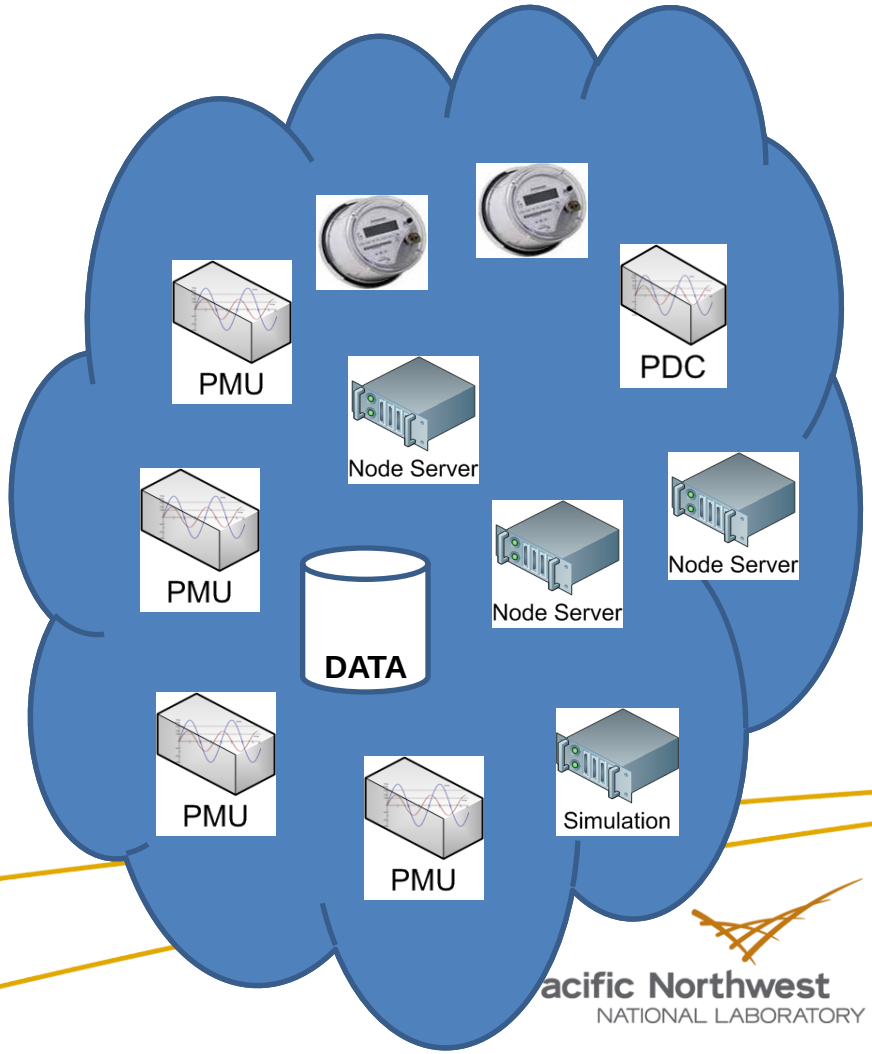
Testbed Operation



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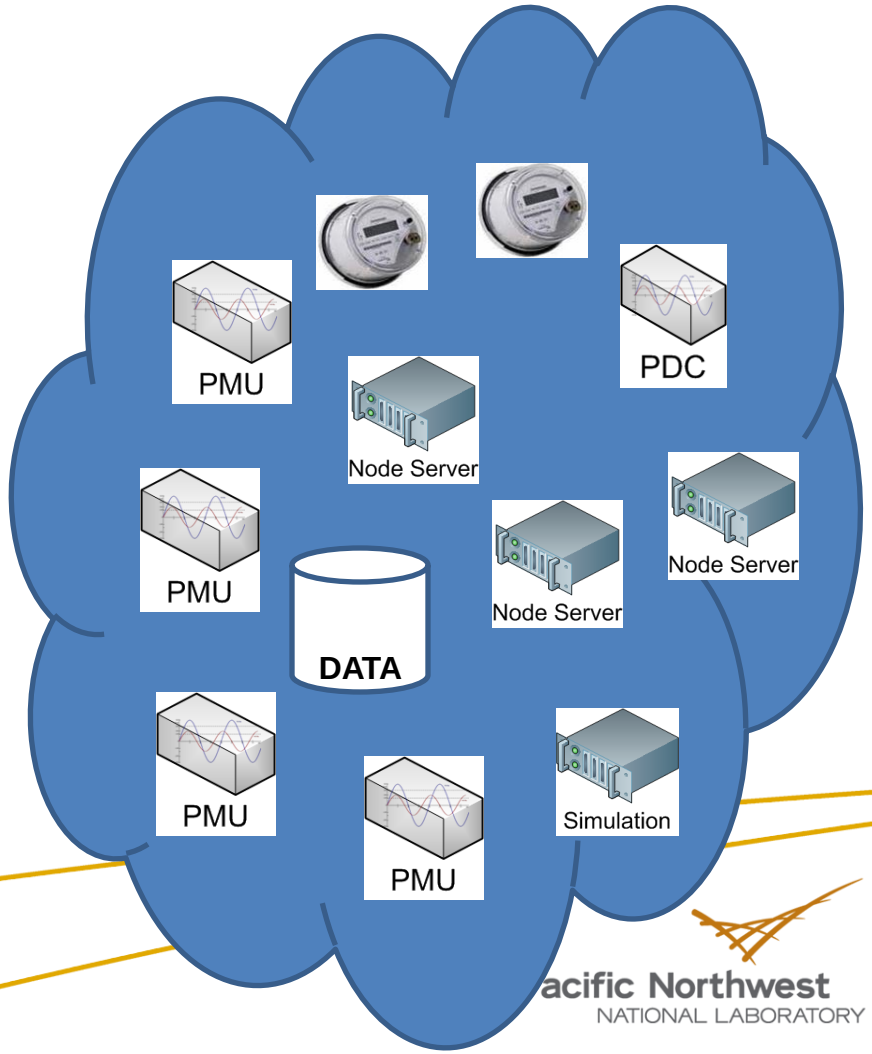

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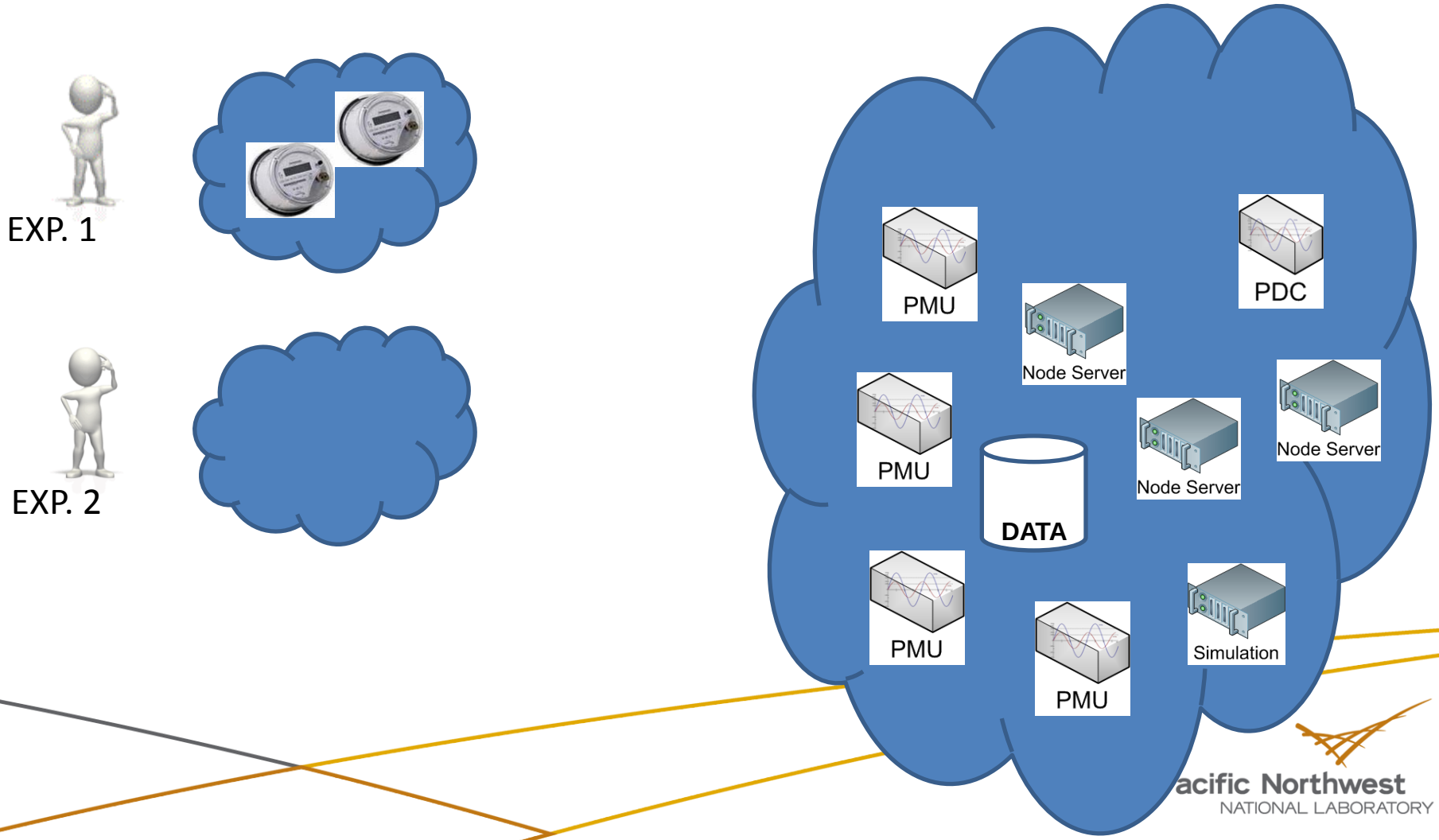

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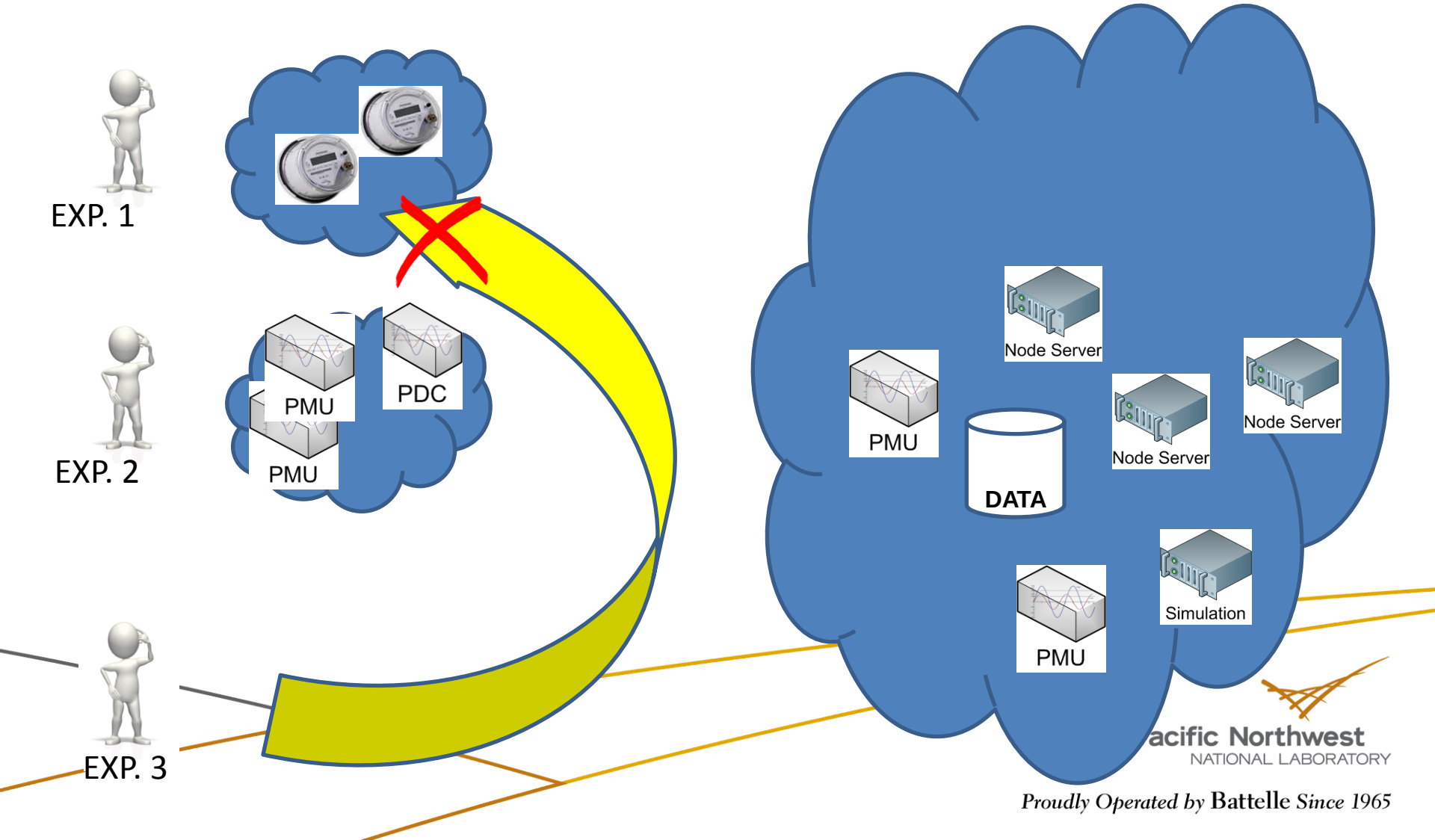

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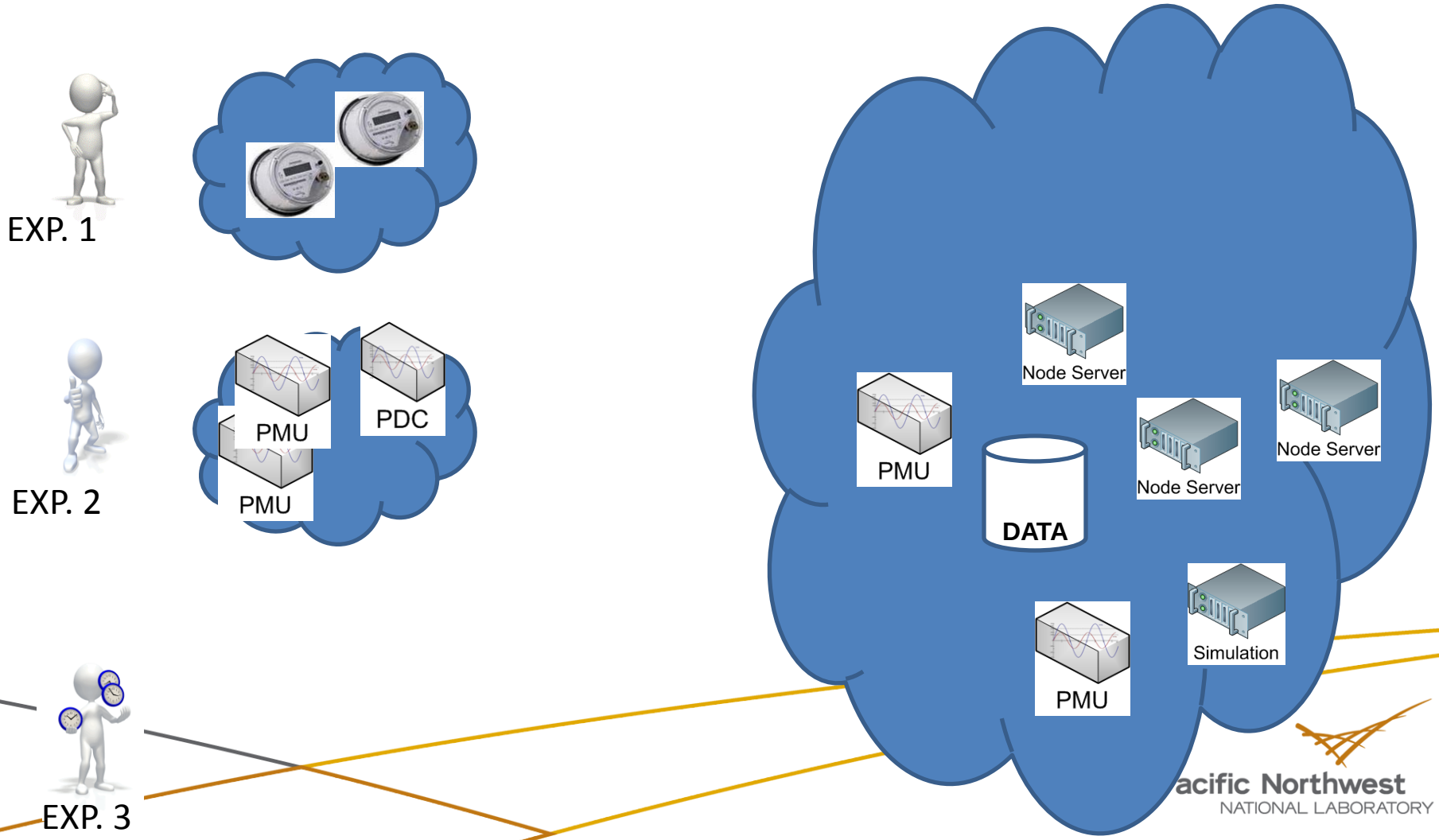

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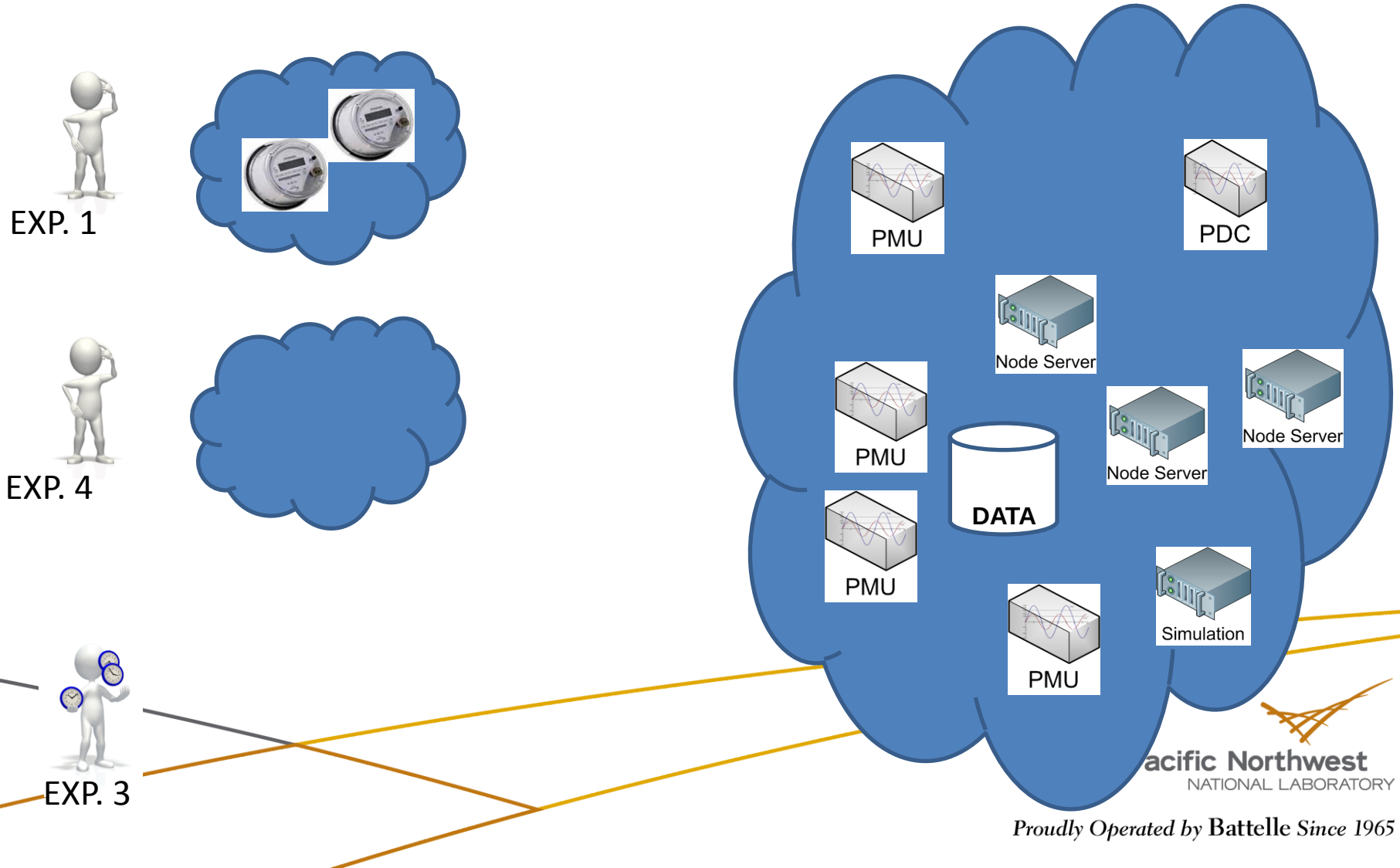

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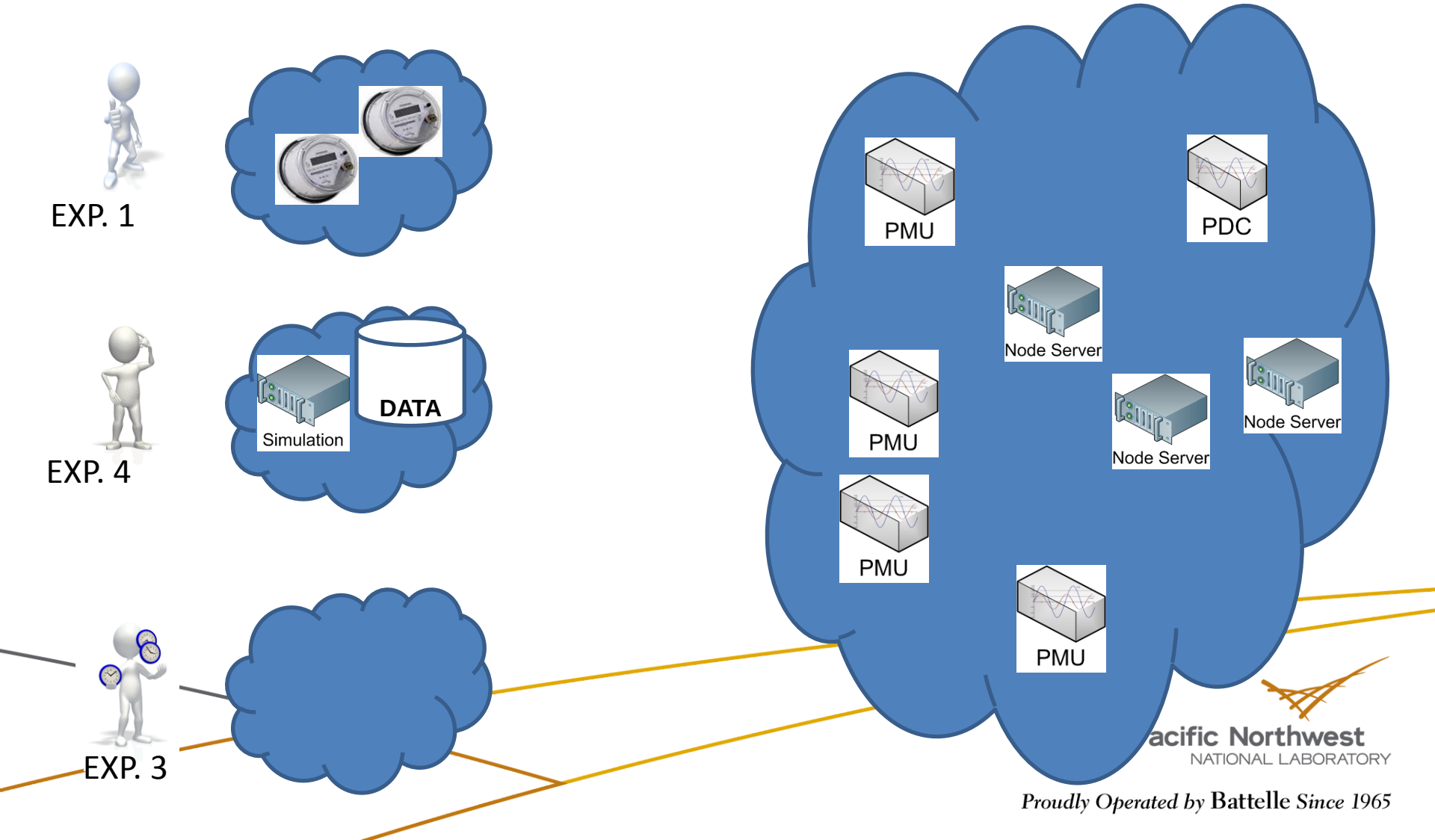

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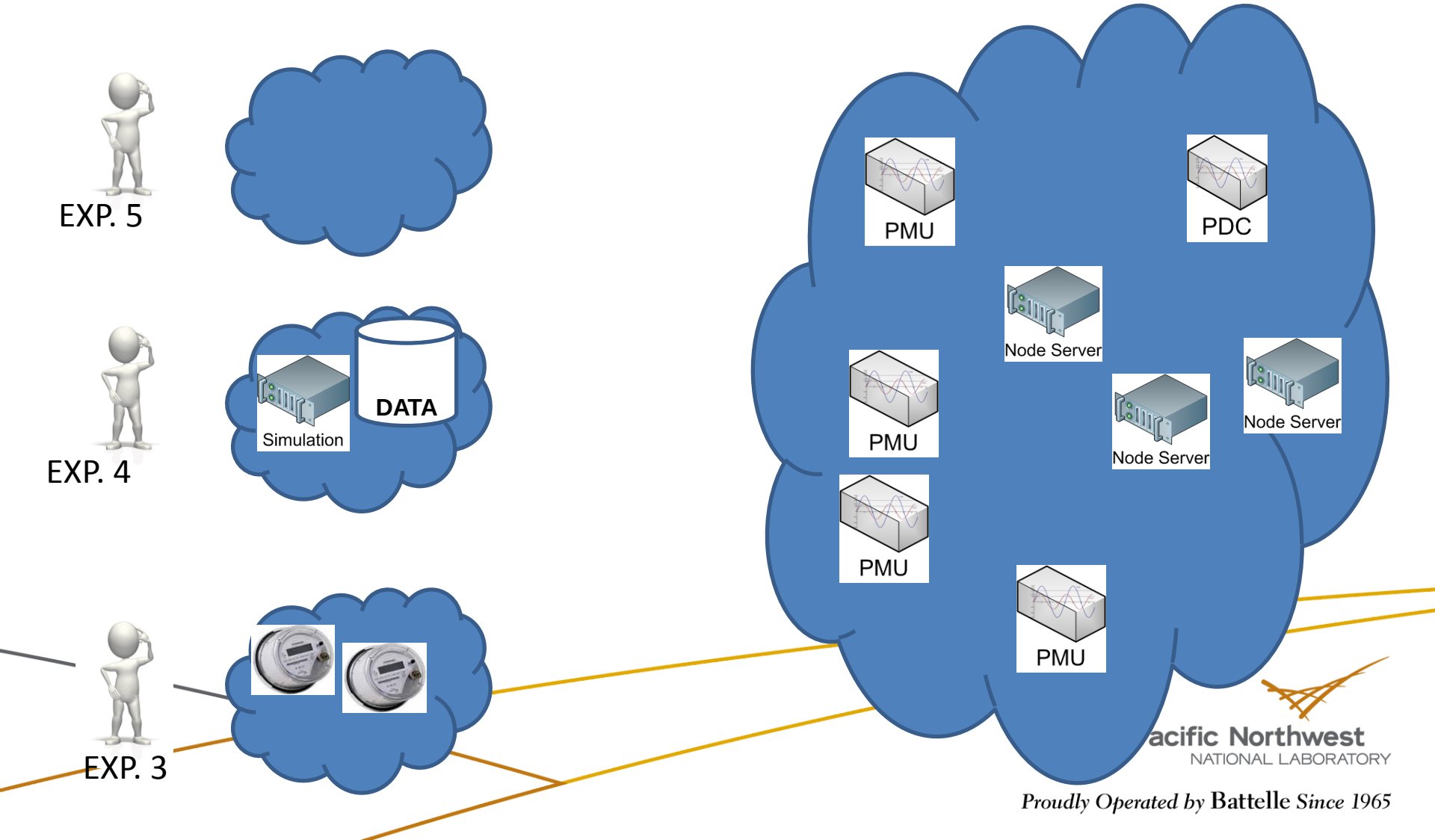

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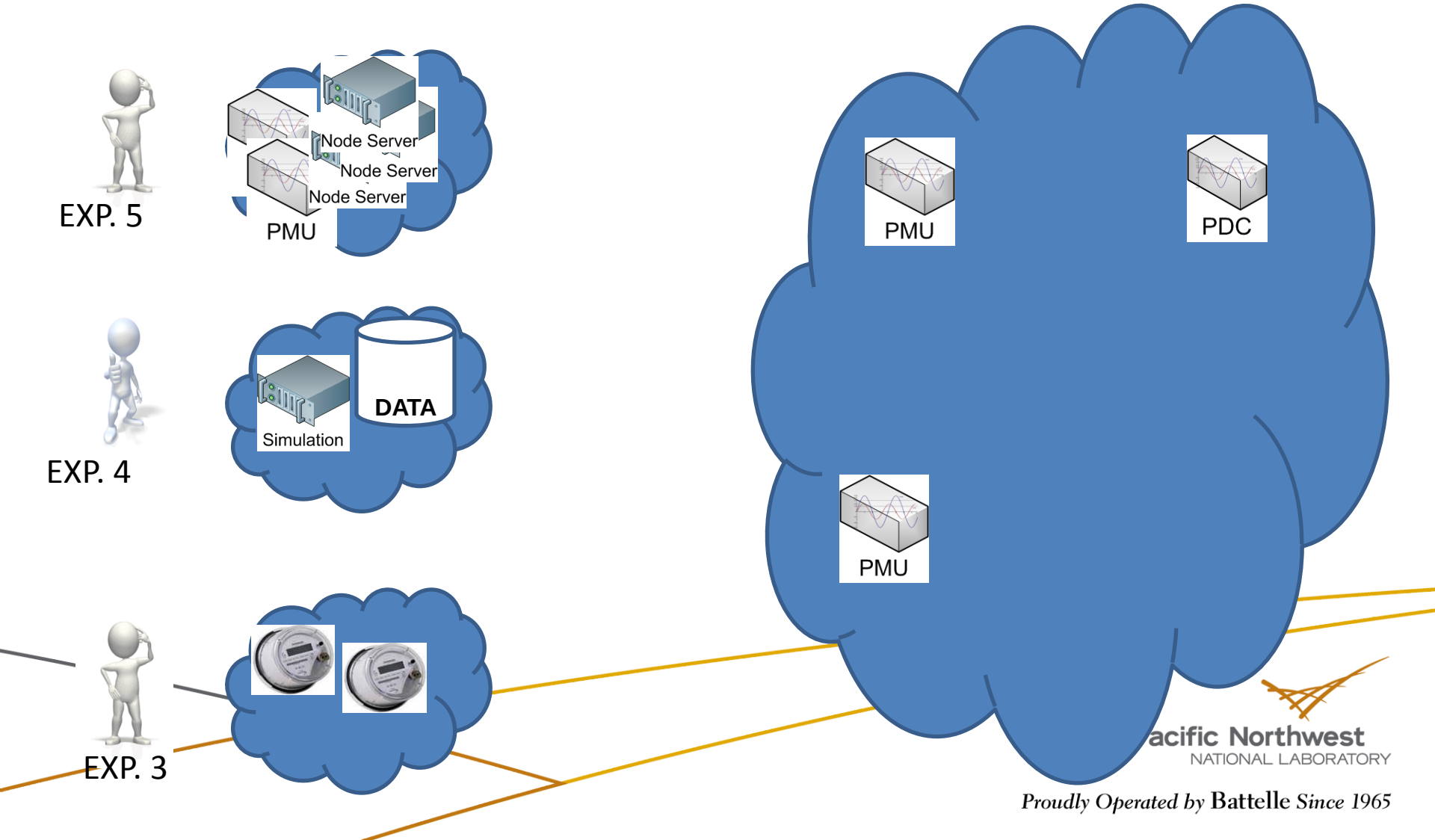

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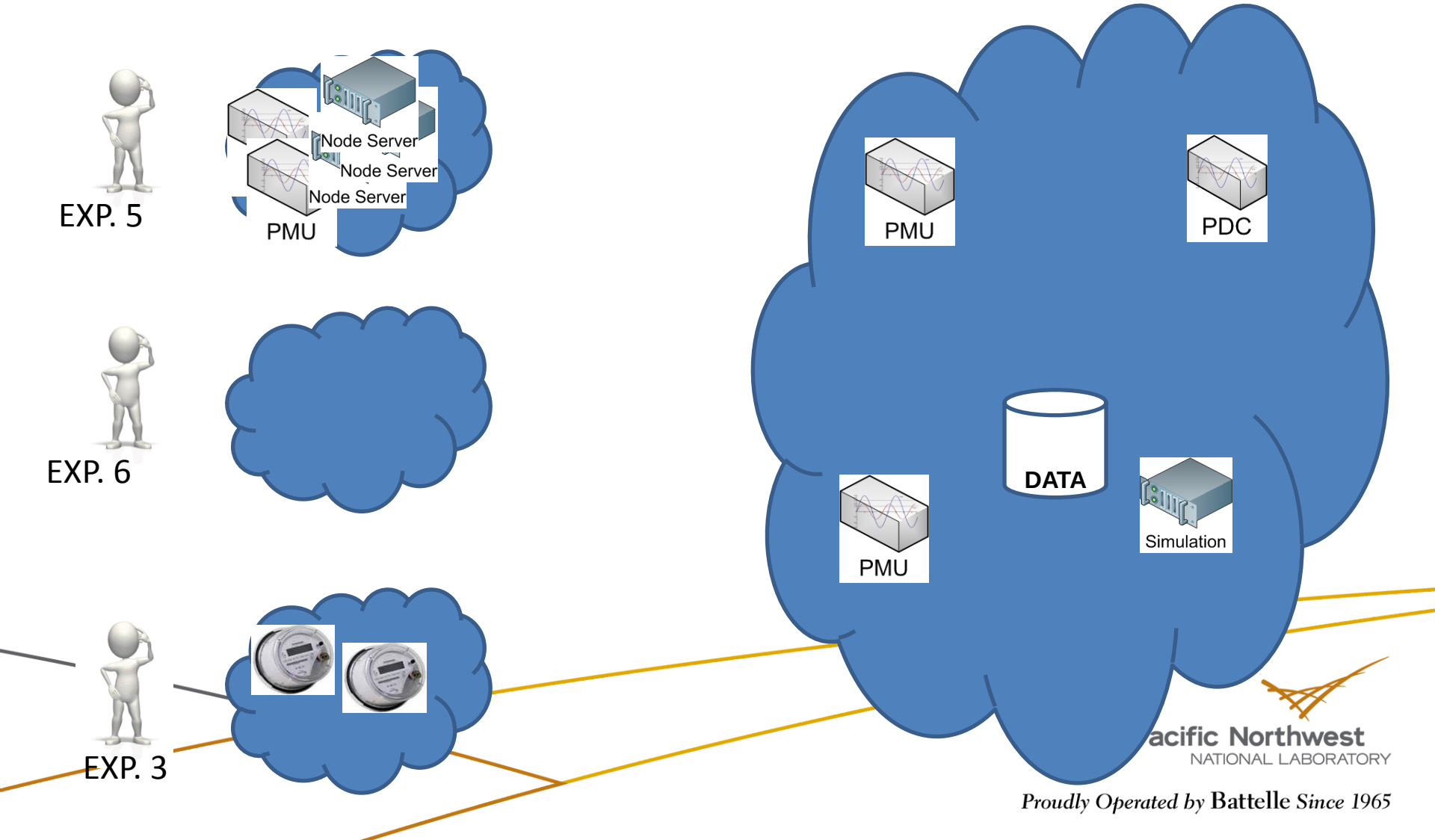

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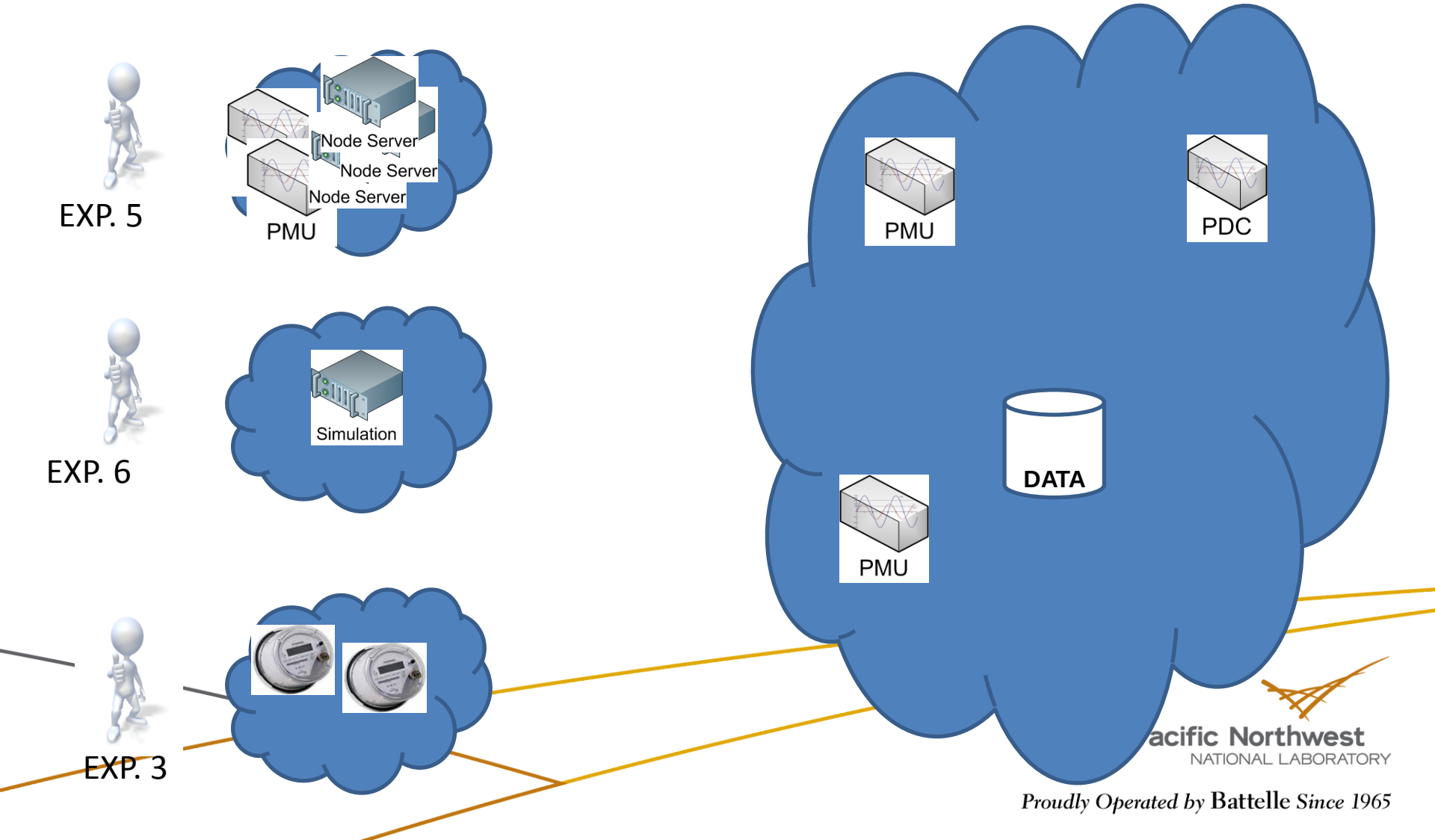

Future Work

- Improve usability & researcher interface
- More tightly coupled integration
- Continue outreach to internal PNNL projects and external partners (Federation)
  - E.g. PNNL GridLAB-D use of facilities

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Conclusion

- Speed of innovation is outpacing testing
- Easy to use experimental testbed is needed
- Table top exercises are not sufficient
- Federation is a method to quickly stand up broad and highly scalable testbeds
- Testing of cyber-physical system implications is necessary to secure nation

Questions?

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