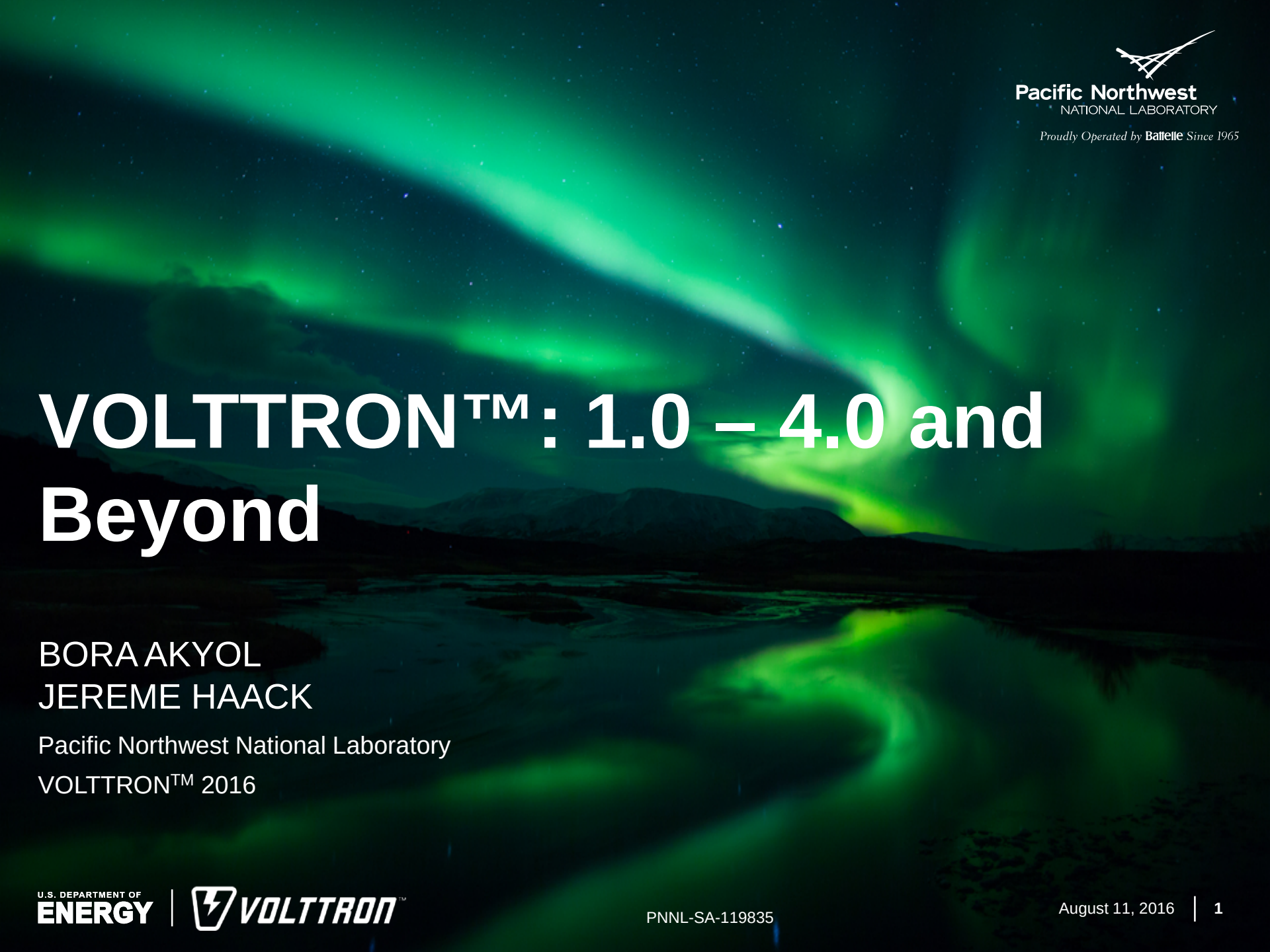


Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

VOLTTRON™: 1.0 – 4.0 and Beyond

BORA AKYOL
JEREME HAACK
Pacific Northwest National Laboratory

VOLTTRON™ 2016

VOLTTRON™ Team

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Software Development Team

- Bora Akyol
- Jereme Haack
- Kyle Monson
- Craig Allwardt
- Poorva Sharma
- Robert Lutes
- Michael Roup
- Chandrika Sivaramakrishnan
- Zach Beech
- Joe Chapman
- Leif Carlsen

Application Development Team

- Srinivas Katipamula
- Robert Lutes
- Wooyun Kim
- Rick Pratt
- Carl Miller
- Weimin Wang
- Siddartha Goyal
- Michael Brambley
- Lucy Huang
- Chad Corbin
- He Hao

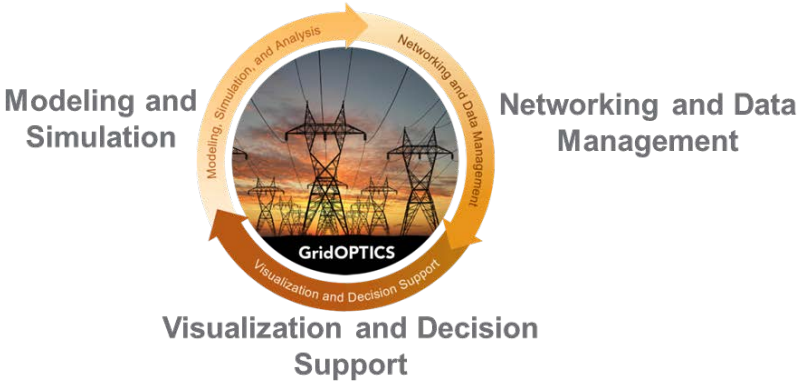
Overview

- Motivation
- Internal Development
- DOE Development
- Future

PNNL Internal Development

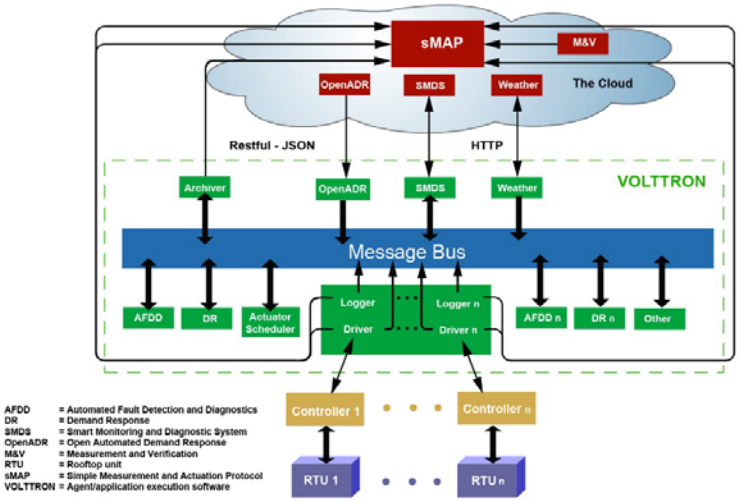
Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- 2010 Future Power Grid Initiative
- Proposed to deploy intelligence into the Smart Grid using an agent platform
- No existing platforms met the needs
  - Security
  - Resource management
- Create a design document laying out platform and use cases
- Developed proof-of-concept simulations
- Develop prototype platform
- Deploy in instrumented home



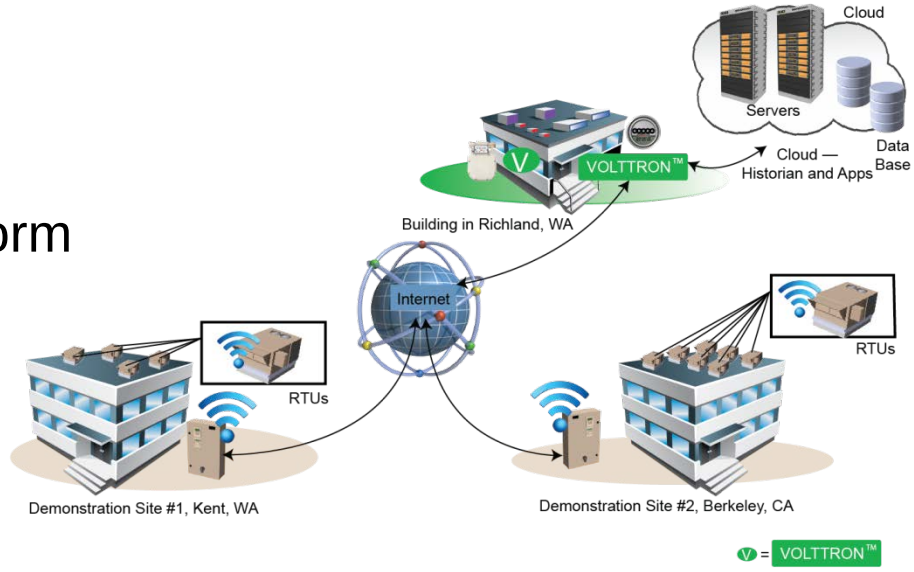
RTU Network Project

- Integrating platform for RTU Network Project
  - Coordinate behavior of rooftop HVAC units
  - Deploy researcher control algorithms
  - Provide single point of contact for
    - Appliances
    - Data historian
    - External resources
- Platform supported applications developed by
  - ORNL
  - LBNL
  - PNNL



VOLTTRON™ 1.0 – 1.2

- VOLTTRON™ platform based on PNNL research and needs of the RTU Network project
  - Open Source Reimplementation excluding patented features
  - Integrates researcher applications, devices, and cloud applications and resources
- 1.0 Focused on building up the framework
  - Agent execution environment
  - Basic platform services
  - Modbus driver
- 1.2 Expanded capabilities of platform
  - BACnet support
  - Multi-node communication
  - Released on GitHub



VOLTTRON™ 2.0

- 2.0 Incorporated PNNL IP from the original research
  - Different license: Free for buildings domain (we refer to this as “restricted” code)
- Resource monitoring
  - Agents must present an execution contract to the platform stating their resource requirements
  - Platform rejects agents which it cannot support
  - Expandable framework for specify additional resources
- Agent signing and verification
- Agent Mobility
  - Admin can send an agent to another platform for deployment/updating
  - Agent can request to move
  - Agent can bring along working files as part of ‘mutable luggage’
  - Receiving platform verifies agent package and examines resource contract before executing agent

VOLTTRON™ 3.0

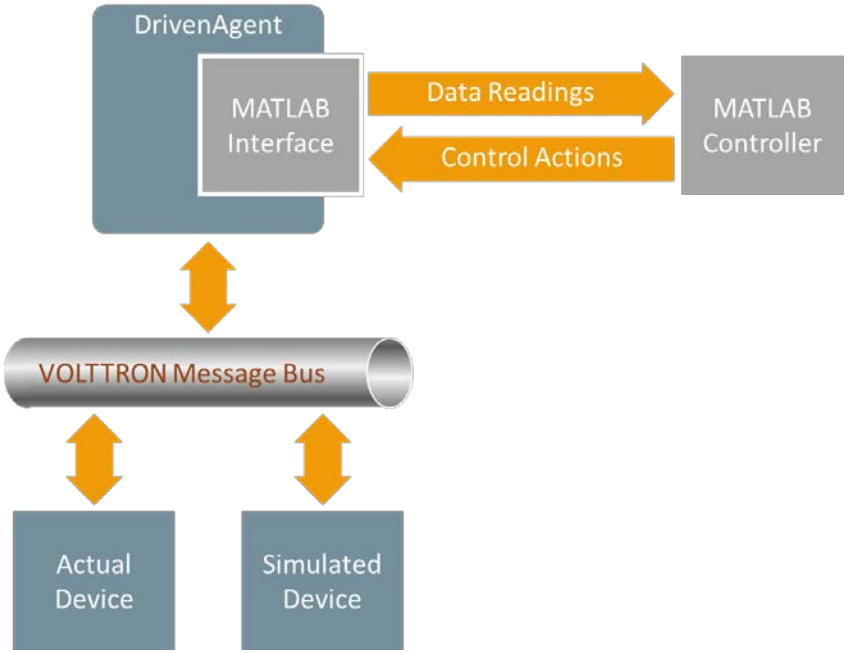
- Improve the modularity, flexibility and manageability of the VOLTTRON™ platform
  - Lets people use whatever technology they want
  - Makes it easier to contribute back new drivers, storage/historian strategies, other services
- Message Bus Refactor – VOLTTRON Interconnect Protocol
  - Increase Security
  - Simplify multi-node communication
- Bring VOLTTRON™ closer to acceptance by vendor community and for commercial deployments
  - Need to gain visibility into system
  - Upgrade remotely
  - Easy way of seeing the status/resources of the platform especially when managing multiple systems
  - Address feedback from FY14 User and Vendor engagements

VOLTTRON™ 4.0

- VOLTTRON™ 3.5 released as a preview of VOLTTRON™ 4.0
- VOLTTRON™ Management Central enhancement
  - Web API to enable visualizations
  - Simplify UI for managing instances
- Continue to enhance VOLTTRON™ security
  - Authorize agents' access to capabilities
  - Containerization
- Utilize VOLTTRON™ as a way to increase security of underlying platform
  - Cyber Operations
- Community priorities
  - Common capability needs expressed by community

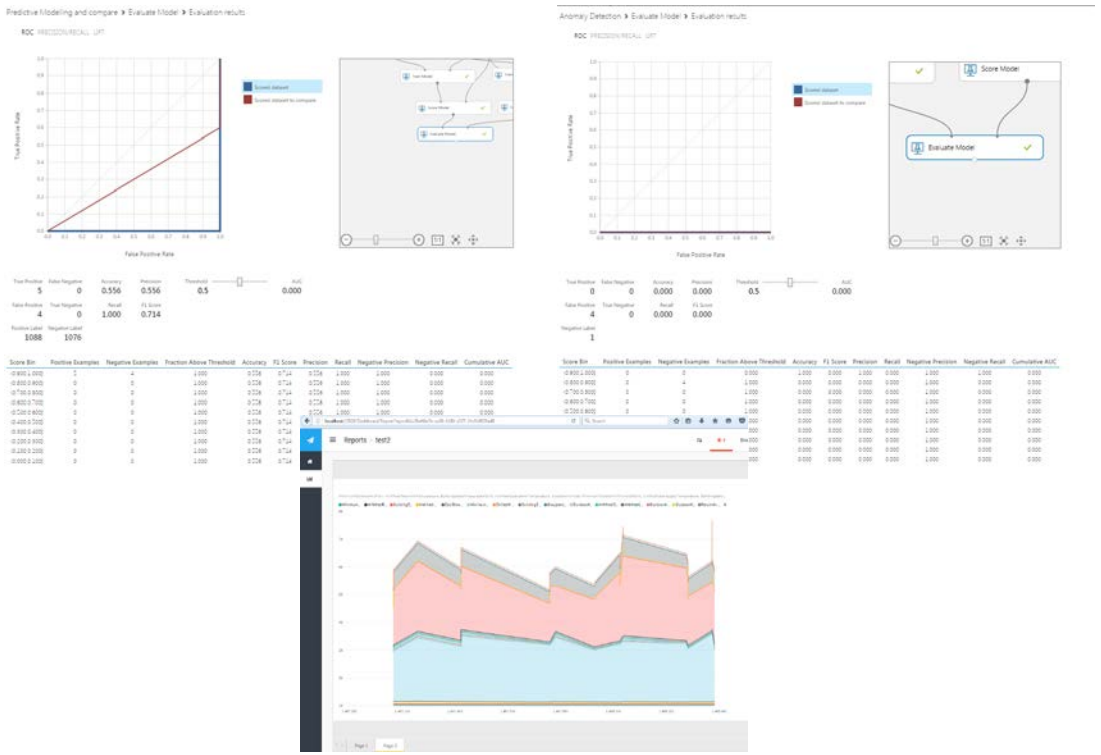
Integration with Simulations

- Allow for development and validations of algorithms working against simulated buildings
- Allow applications to work against real buildings with no code changes
- Some researchers more familiar with MATLAB
  - Develop and test application before paying cost to move to another language (Python)



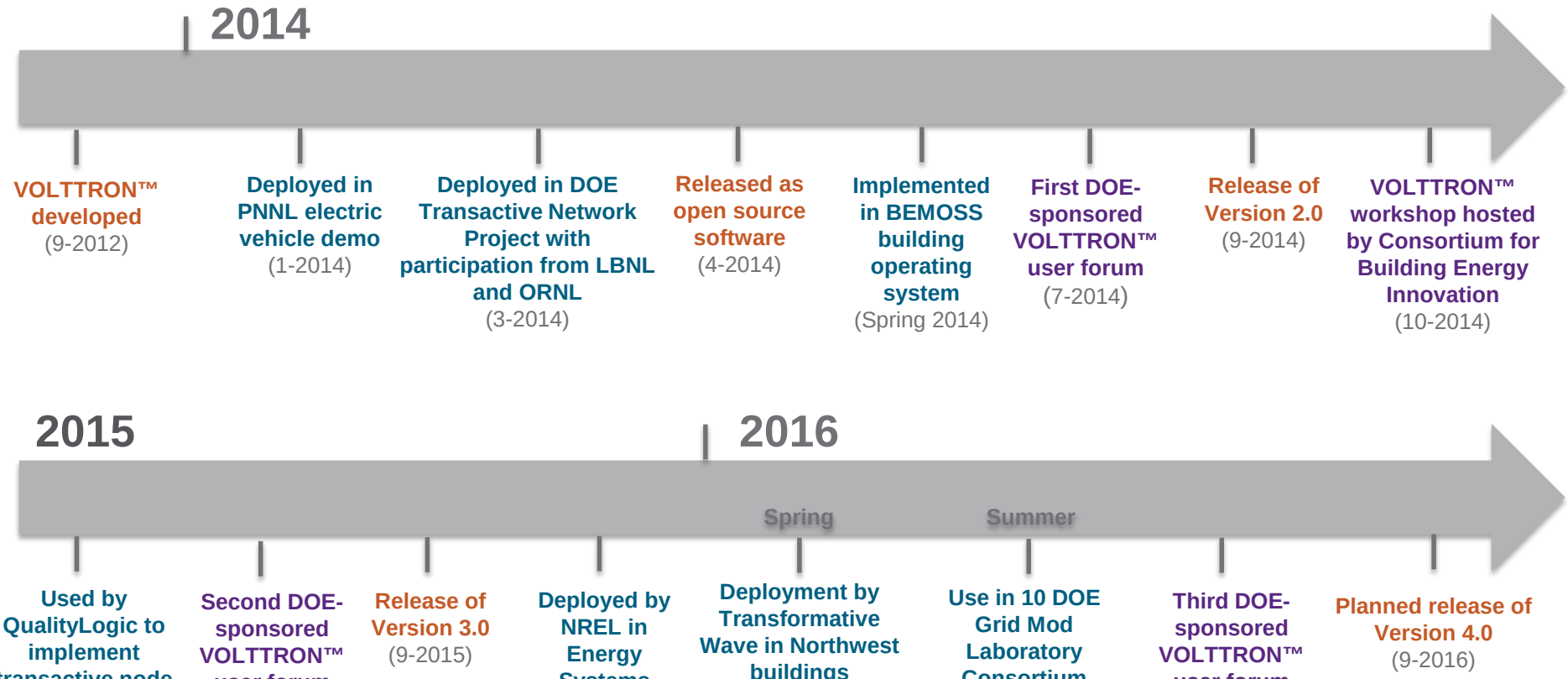
VOLTTRON™ in the Cloud

- VOLTTRON™ can integrate with/leverage cloud based services
- VOLTTRON™ instances collect data from devices/buildings
- Special historians send data to cloud services
  - MS Azure and Amazon AWS
- Researchers use the cloud services to analyze the data



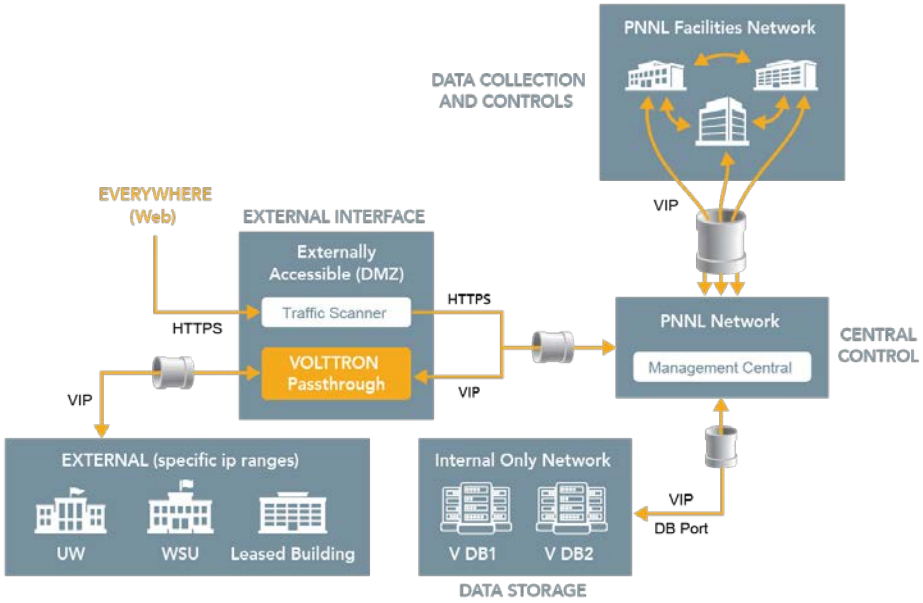
VOLTTRON™ Timeline Highlights

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



VOLTTRON™ in Use

- Clean Energy Transactive Campus
  - Collecting data from multiple buildings on campus
  - Making data available to external partners
- BIRD-IP
  - 14 student teams using VOLTTRON in research projects
- Commercial Companies deploying VOLTTRON™
- Grid Modernization Lab Consortium
- Connected Buildings Challenge
- Portland State University Course



VOLTTRON™ Future

- Focus on increasing readiness for campus wide and commercial deployments
  - Data Assurance
- Increase ease of managing VOLTTRON™ deployment
- Implementation of Data Model
  - Reference topics by meta data to enable dynamic discovery
- Continued IoT integration (Azure and AWS)
- Technical Support and Outreach
  - Office Hours
  - Library of tutorial videos

VOLTTRON™ Resources

- GitHub
  - https://github.com/VOLTTRON/volttron.git
- Email: volttron@pnnl.gov
- Bi-weekly office hours, email to be added
  - http://bgintegration.pnnl.gov/volttronofficehours.asp