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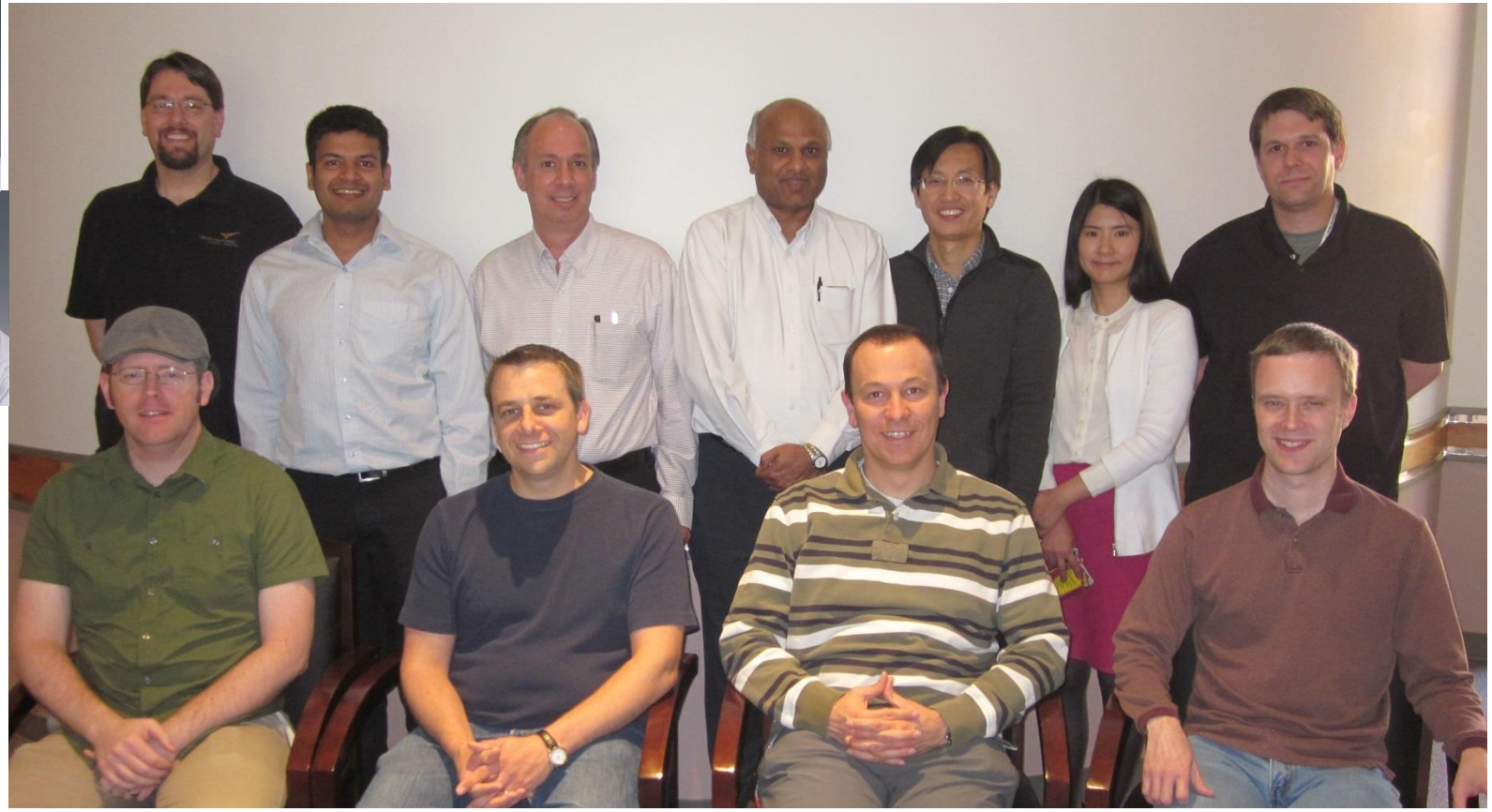
VOLTTRON™ 0 to 3.0 History

JEREME HAACK

Pacific Northwest National Laboratory

Software Framework for Transactive Energy: VOLTTRON™, VTARI, Arlington, VA

VOLTTRON Team



VOLTTRON Team

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Software Development Team

- Srinivas Katipamula
- Bora Akyol
- Jereme Haack
- Brandon Carpenter
- Kyle Monson
- Craig Allwardt
- Poorva Sharma
- Tim Kang
- Casey Neubauer
- Robert Lutes
- Dan Johnson

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

The Challenge

- Improving operating efficiency of buildings
- Providing grid services across buildings and the grid
  - Smart loads in homes, offices, industry
  - Millions of electric vehicles
  - Distributed renewable energy
  - Reliability and security





Application Challenges

- Managing and “optimizing” end-use loads
  - Residential, commercial and industrial
- Increasing end-use efficiencies
- Integrating storage at multiple layers
- Enabling energy coordination and trading between buildings and between buildings and grid

Technology Challenges

- In some buildings, there is too much data, not enough information
  - Rapid deployment of networked, affordable sensors and controllers
- Lack of scalable and fault tolerant control and diagnostics
- Lack of secure and reliable communication
- Tight, vertical integration of single vendor products
- Lack of a cross-vendor “App Store” for best-of-breed energy application solutions
- Evolving standards landscape for transactive energy
- Lack of a reference platform for R&D use

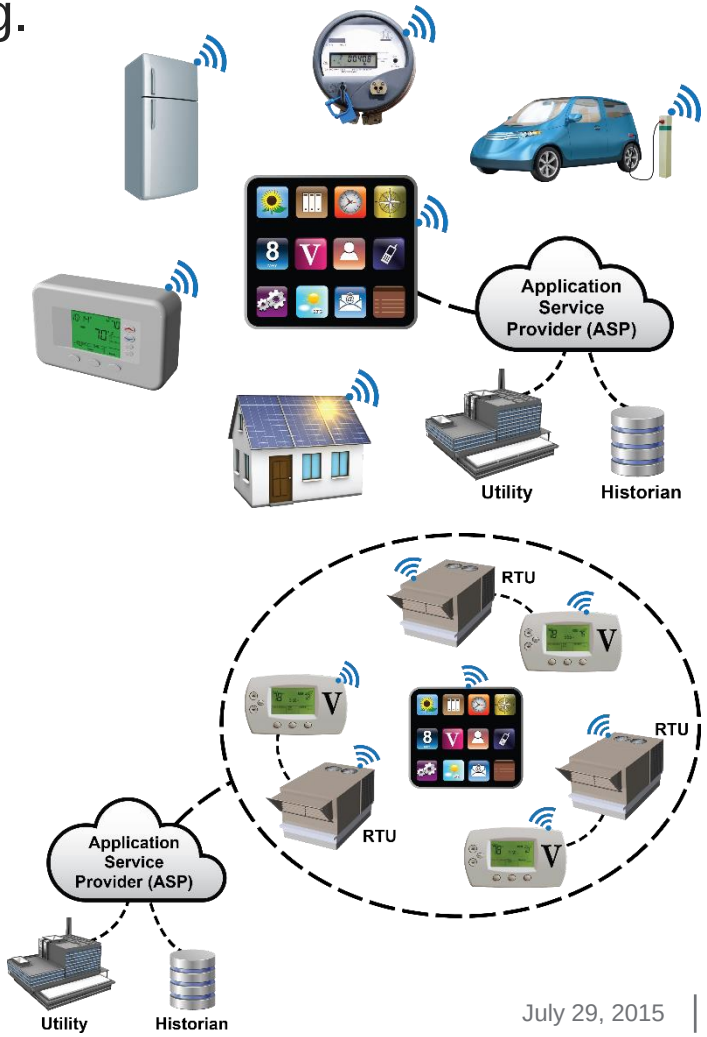
A Distributed System Solution

- Building systems that operate at peak efficiency because they are self aware and self correcting and mitigate:
  - Cloud cover in a neighborhood filled with rooftop solar panels
  - A neighborhood where everyone owns an EV and comes home at the same time on a hot day and starts to charge
  - Household appliances that communicate directly to coordinate energy use and shift load
- Benefits
  - Lower bills for consumers
  - More predictable and even loads for utilities
  - Quicker response to mitigate variable distributed power generation

- VOLTTRON is one such platform that addresses many of these challenges

What is VOLTTRON?

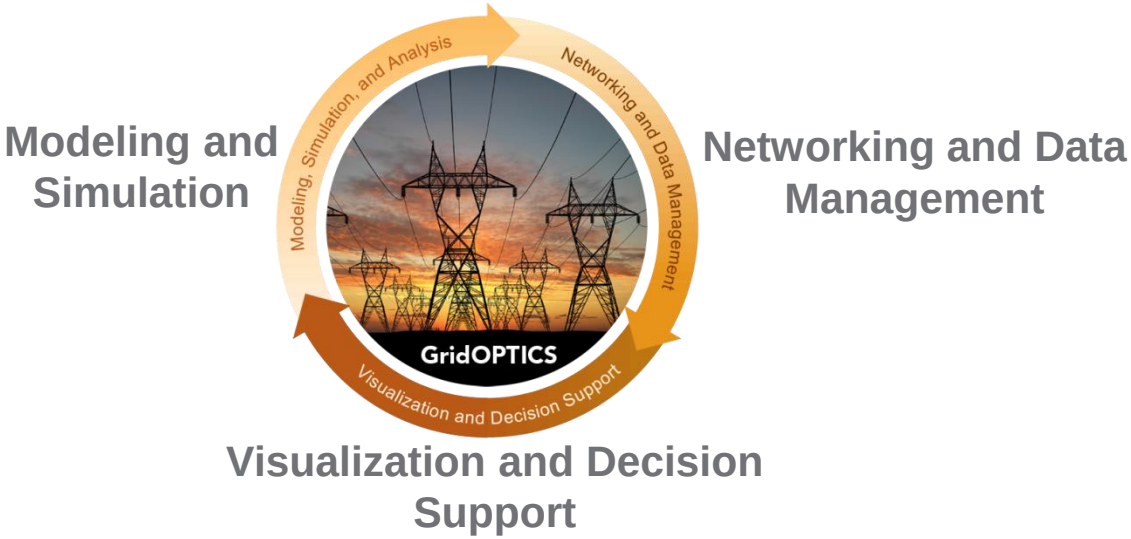
- VOLTTRON is an application platform (e.g. Android, iOS) for distributed sensing and control applications
- VOLTTRON is not a protocol
  - A protocol, such as SEP2.0. or OpenADR, are implemented as applications
- VOLTTRON is not an application such as demand response
  - Demand response can be implemented as an application on top of VOLTTRON
- VOLTTRON is open, flexible and already benefits from community support and development



VOLTTRON Attributes

- Provides a single point of contact between applications, devices, and external resources
  - Isolates applications from the details of devices being controlled
  - Additional resources can easily be added and utilized through the message bus without requiring changes to existing resources/agents
  - Applications can specify data of interest
  - Applications can publish their own events/data for use by other agents or for storage
- Device communication
  - Drivers for communicating with Modbus and BACnet enabled devices
  - Custom communication schemes can be supported
- Platform Features
  - Scheduler – Handles locking control of devices (reading does not require a lock)
    - Application reserves a timeslot
  - Ease of application development
  - Collection of utilities and base applications to simplify development
  - Goal is to allow researchers to focus on implementing their algorithm, not dealing with the specifics of the platform
  - Data archiver – devices readings and application results stored to a historian

PNNL Internal Development



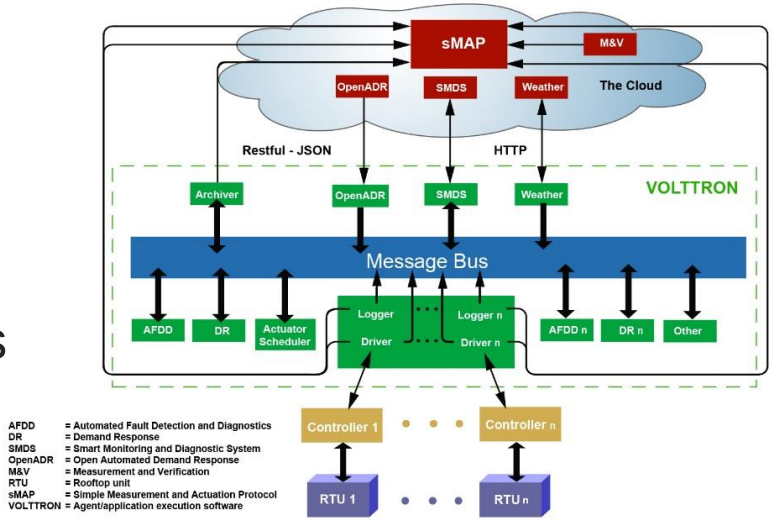
- 2010 PNNL started a Future Power Grid Initiative
- VOLTTRON proposed to deploy intelligence into the Smart Grid
- Identified gap in agent platforms which meet security and resource management requirements of the domain

VOLTTRON LDRD

- Requirements gathering
- Initial simulations
- Build and deploy platform on demonstration testbed
- Deploy into instrumented home

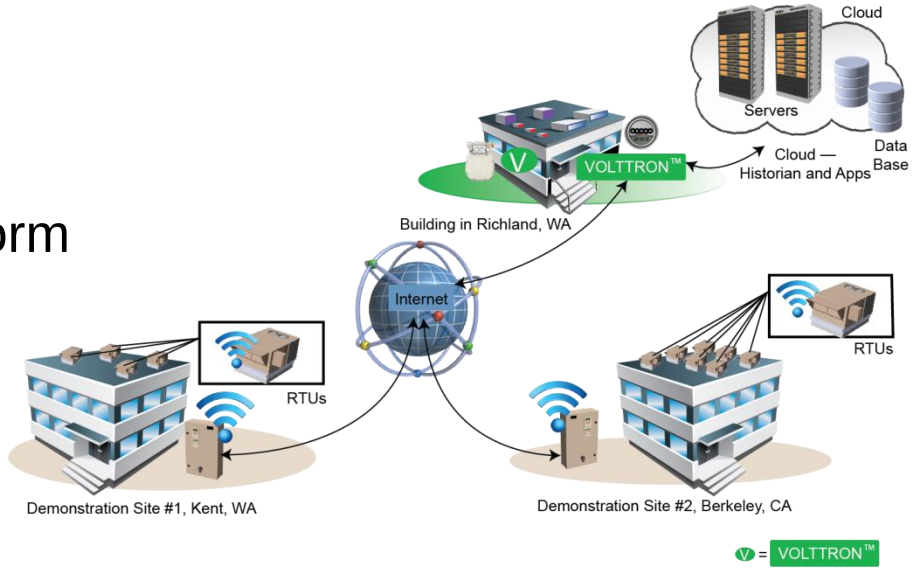
RTU Network Project

- 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 omitting 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

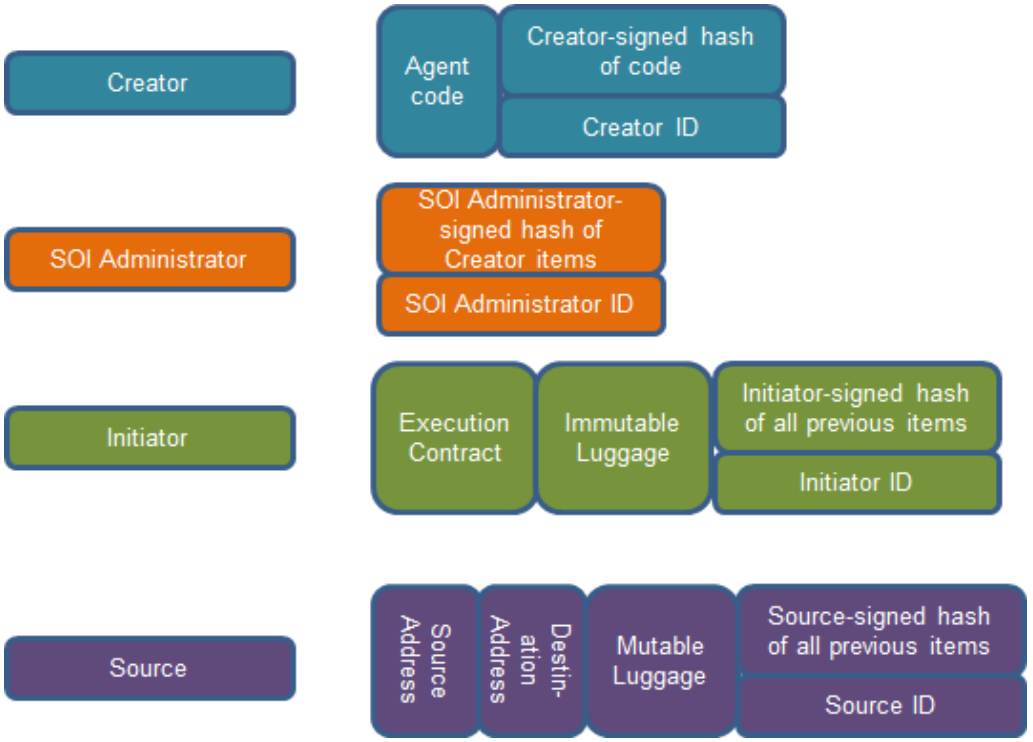


VOLTTRON 2.0

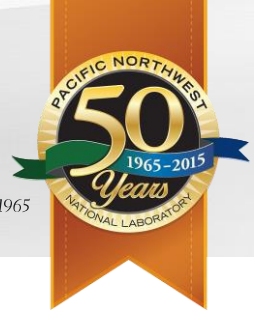
- 2.0 Incorporated PNNL IP from the original research
  - Different license: Free for buildings domain
- Resource monitoring
  - Agents must present an execution contract to the platform stating their resource requirements
  - Platform rejects agents which it cannot support
  - Expandable framework for specify additional resources
- Agent signing and verification (next slide)
- 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

Agent Transport Payload

- Agent package contains multiple layers which can be signed by different entities
  - Creator of code
  - Administrator of 'Scope of Influence'/Deployment
  - Instantiator of agent
  - Most recent platform (for mobile agents)
- Each level verified before agent is allowed to run
- Entities cannot change content of other layers



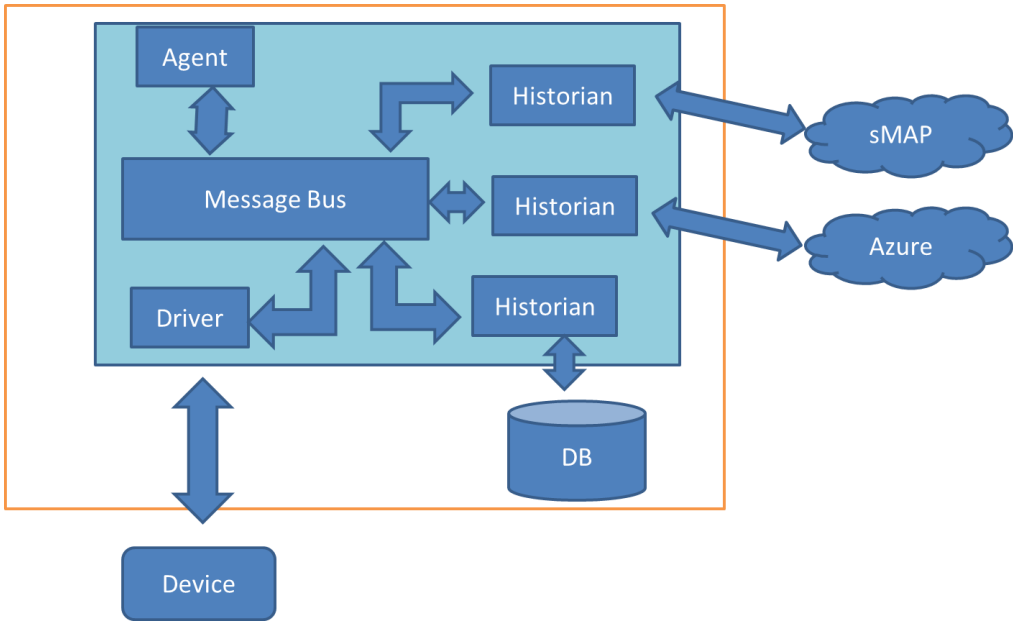
VOLTTRON 3.0



- 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
- 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

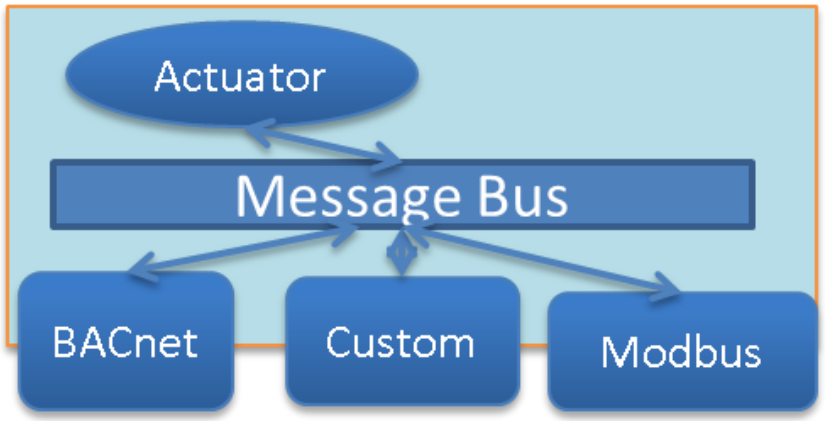
Modularized Historian

- Historians can be built for any storage solution
- Previous versions did not have option for local storage
- BaseHistorian
  - Can be extended for any solution
  - Handles subscribing to Bus
  - Local cache



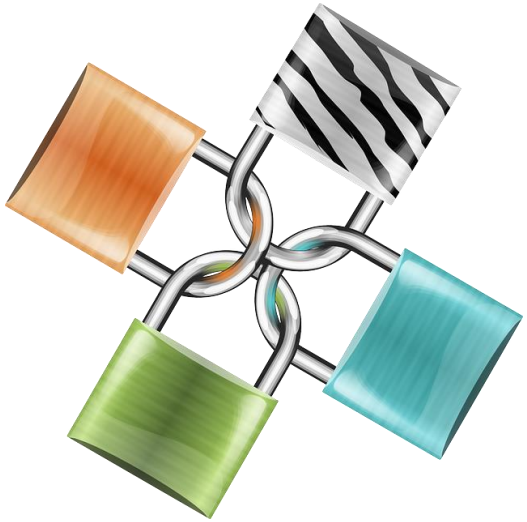
Modularized Drivers

- Standardized creating custom drivers to scrape data and publish to the message bus
- Simplify developing drivers and contributing new capabilities back to VOLTTRON
- Abstracted out driver interfaces allowing Actuator Agent to handle controlling devices via any protocol



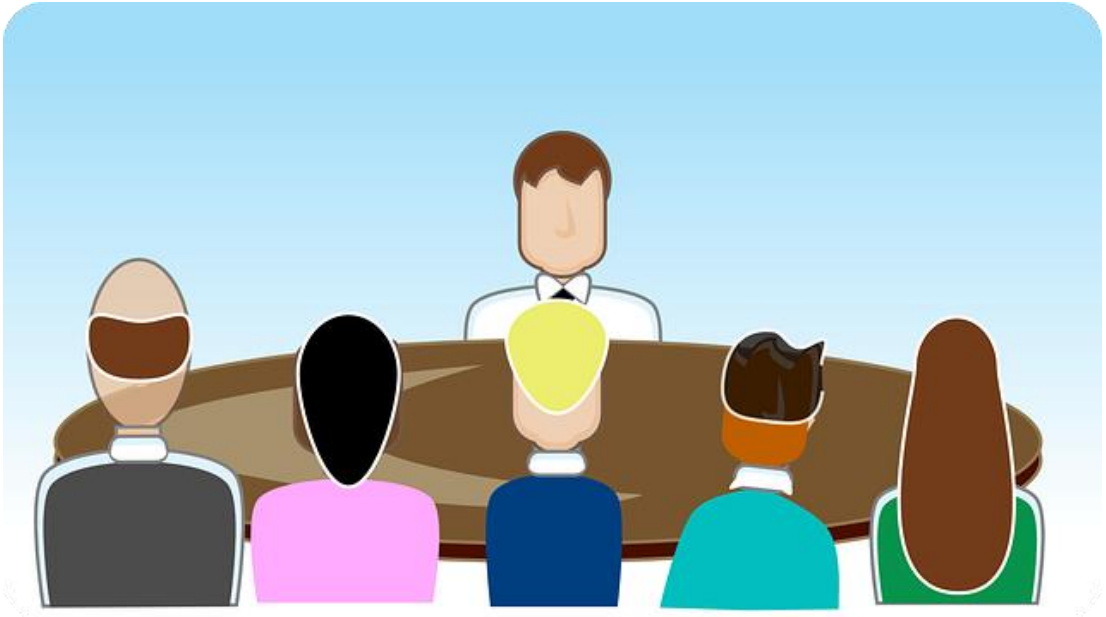
VOLTTRON Interconnect Protocol

- Increase security of the message bus and allow direct communication where appropriate
  - Platform – service
  - Agent – service
  - Agent – Agent large transfer
- New communication model underneath VOLTTRON Message Bus
  - Compatibility layer so changes are transparent to existing agents
- VOLTTRON now requires only a single socket
- Message Bus can be secured
  - Authenticated publishers
  - Publishers can limit subscribers



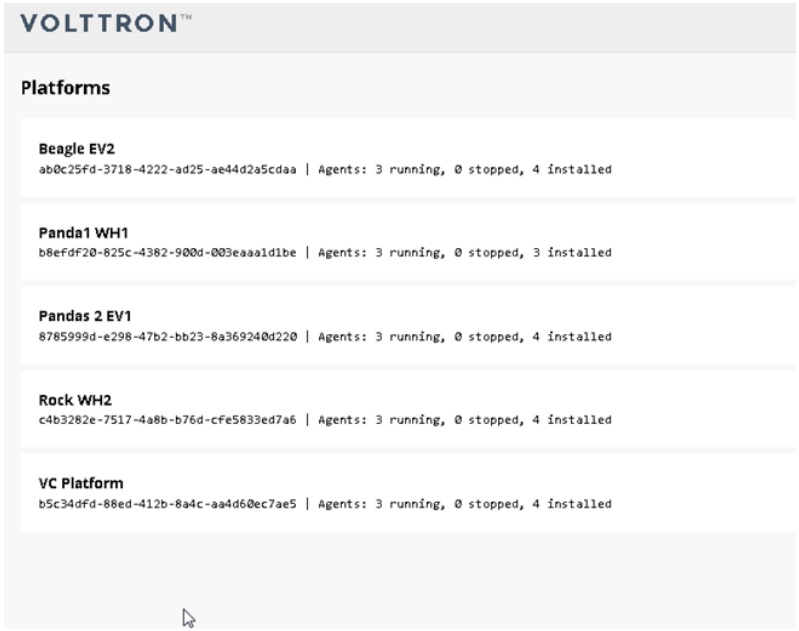
Management Agent

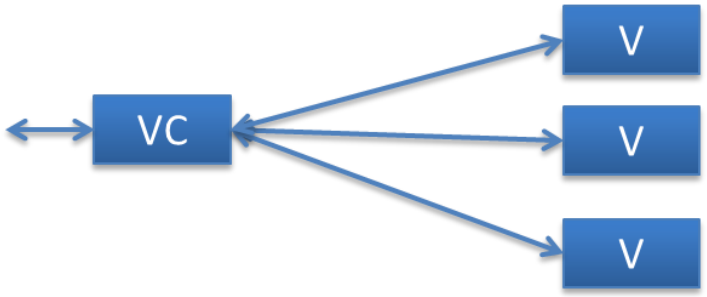
- PlatformAgent acts as manager for the platform
  - Send commands to agents
  - Enables monitoring of health of agents and platform
  - Exposes status to other platforms/web console
  - Support for applications which analyze data and issue alerts (behavior out of norm)



VOLTTRON Management Central

- Improve Visibility of Deployed Platforms
- Previous interface to the platform “admin centric”
- Makes use of the service exposed by the Management Agent
- VOLTTRON Management Dashboard
  - Allow for better insight into the state of the platform and agents
  - Does not require expert user
  - Quickly see overview of platforms being monitored





Proposed VOLTTRON 4.0

- Exploiting existing capabilities for more complex demonstrations
  - Distributed Multi-Agent Energy Efficiency application
- VOLTTRON Management Central enhancement
  - Closer integration with VOLTTRON Central Analytics
  - Real-time analytics
- Continue to enhance VOLTTRON security
- Utilize VOLTTRON as a way to increase security of underlying platform
  - Cybersecurity agent application
- Community priorities
  - Common capability needs expressed by community
- VOLTTRON Hackathon
  - Activity to spur outside use of VOLTTRON for new applications

Future Goals

- Compelling VOLTTRON functionality and interoperability demonstrations with major partners to serve as an acceptance and marketing tool
- VOLTTRON Community Portal with third party applications store
- Expand capabilities of VOLTTRON as the foundational controls operating system over which third party applications can be deployed
- Continue to build VOLTTRON Community with industry, federal laboratories and academic institutions

VOLTTRON Resources

- GitHub
  - https://github.com/VOLTTRON/volttron.git
  - https://github.com/VOLTTRON/volttron/wiki
- Email: volttron@pnnl.gov
- Bi-weekly office hours, email to be added
  - Planning to start a series of webinars for 3.0 features