



The VOLTTRON™ Platform—A Secure Capability for Coordination and Control

VOLTTRON™ is an open source distributed control and sensing software platform. Cost-effective, scalable and secure, this technology improves the control of heating, ventilation and air conditioning (HVAC) systems, electric vehicle chargers, distributed energy resources such as renewables and batteries, entire building power loads and more. VOLTTRON™ also offers powerful data management capabilities for a broad range of potential applications.

The following pages of this brochure provide an overview of the VOLTTRON™ platform's components and features, and include:

- » A color-coded perspective of the platform
- » Descriptions of VOLTTRON™ features
- » Other open source software incorporated in the platform
- » Examples of how this technology can enable solutions in multiple use areas.



Devices | Data | Decisions

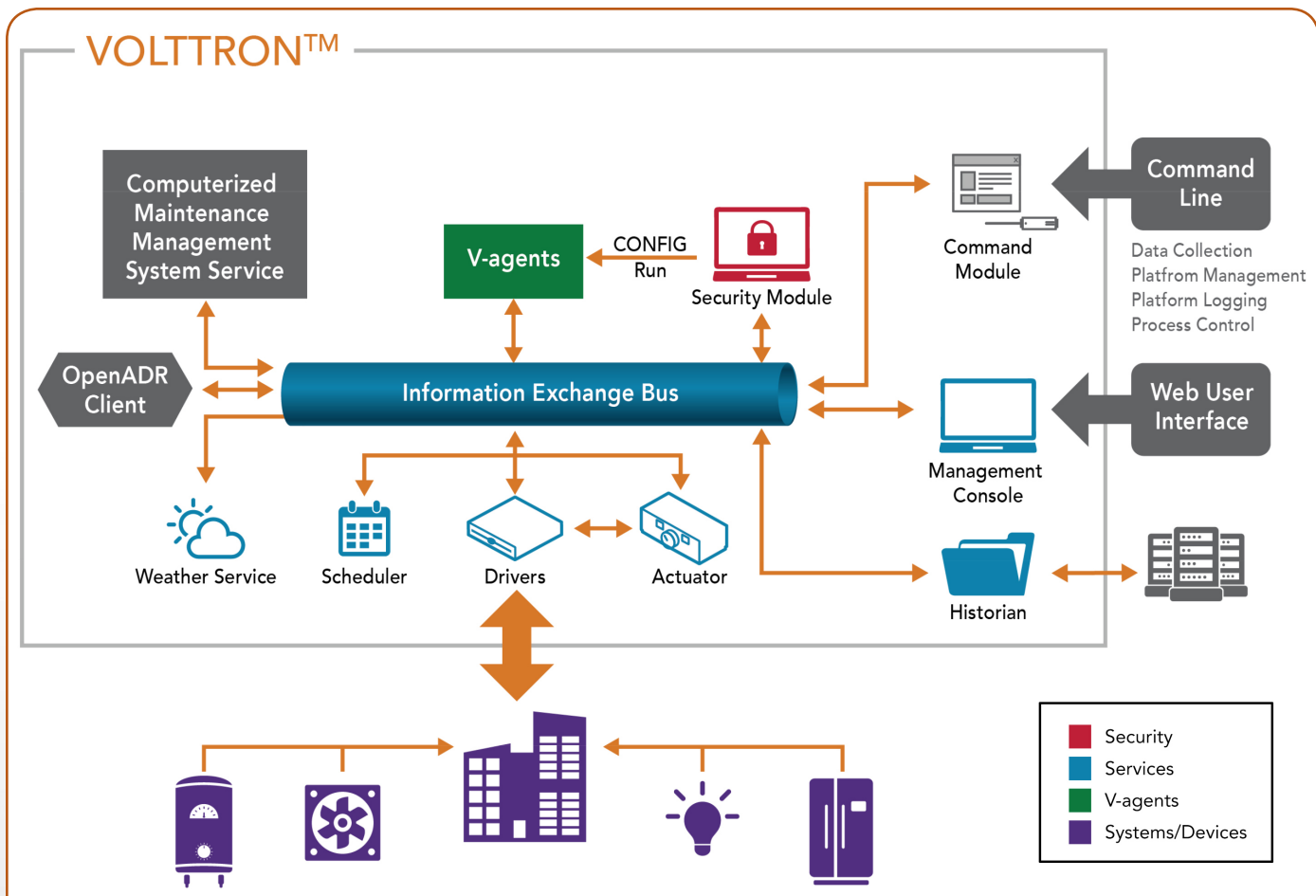
Pacific Northwest National Laboratory (PNNL) created VOLTTRON™, and with funding from the U.S. Department of Energy, continues to develop the technology and its capabilities.

Key Benefits

- » **Cost-Effective** – Open source software (free to users) and can be hosted on inexpensive computing resources
- » **Scalable** – Can be used in one building or a fleet of buildings
- » **Interoperable** – Provides the ability to interact and connect with a wide variety of systems and subsystems, both in and outside of the energy sector
- » **Secure** – Underpinned with a robust security foundation to combat today's cyber vulnerabilities and attacks.

Primary Use Areas

- » **Building Efficiency** – To help control building energy system performance
- » **Building-Grid Integration** – To support “beyond demand response” approach and integration of distributed energy resources into the grid
- » **Transactive Control** – To support a scalable, distributed control mechanism for transacting information about systems, loads, and constraints to deliver user specified services.



The VOLTRON™ Platform: A Color-Coded Overview

Security Module—Capabilities that protect against cyberattacks and other vulnerabilities, ensuring safe communication between the platform and buildings/devices, and the greatest possible level of security.

V-agents—Individually tailored VOLTRON™ operatives for specific tasks. Enabled by platform **Services**, V-agents interrogate systems, collect data, identify issues (e.g., temperature set point errors) and take actions to resolve issues. More details can be found in the V-agents section of this brochure on page 3.

Services—Functions that manage and coordinate platform activities, including the operation of V-agents. The Information Exchange Bus serves as a central location where data/information comes in and is published, and where processed data/information and corrective actions are picked up and communicated back to building systems and devices. The Historian facilitates data storage. More details can be found in the Services section of this brochure on page 3.

Buildings, building automation systems and devices—Primary focuses of VOLTRON™ capabilities and interactions, though the technology’s versatility extends capabilities to other types of devices. Data collected from these entities lead to development of actionable information—and efficiency solutions.

VOLTTRON™ Services

Service	Function
Actuator Agent	Helps enable the control of external devices by V-agents within VOLTTRON™; acts as a gatekeeper for messages that go to the drivers, which interact with devices. The actuator agent also prevents multiple V-agents from controlling the same device at the same time.
Drivers	Communicate with devices being controlled by the platform. They isolate device-specific protocols from the rest of the platform, and access the message bus to publish device data and receive commands. Currently supports Modbus- and BACnet-compatible device communication.
Historian	Enables storage of device data and application analysis results in a database (currently MongoDB, SQLite and MySQL).
Management Console	Allows administration of nodes running VOLTTRON™ on one or more networks.
Information Exchange Bus	Provides a conduit for V-agents and Services to publish and subscribe to topics, abstracting device and V-agent details from each other. At the most basic level, V-agents and Services running in the platform produce and consume messages and/or events.
Multi-Node Communication	Enables V-agents to publish and subscribe to the message bus of a remote VOLTTRON™ platform; communication can be encrypted with ZeroMQ Curve.
VOLTTRON™ Interconnect Protocol	Increases the security of communications within and between VOLTTRON™ platforms, allowing for message attribution and access restriction. VIP makes it easier to address messages to V-agents on other platforms.
Weather Information	Retrieves data from the Weather Underground site and reformats and publishes it to the platform, allowing access by other V-agents.

V-agents

V-agents deployed on the platform leverage VOLTTRON™ Services and execute specific tasks, such as building system fault detection and demand response.

V-agent categories include:

- » **Platform**—Providing services to other V-agents on the platform
- » **Proxy**—Acting as a bridge to remote applications that need access to platform messages and data
- » **Control**—Using data from buildings and other V-agents to make decisions and interact with devices and other resources
- » **Passive**—Subscribing to certain data from systems and performing specific actions to surface operational issues.

The VOLTTRON™ platform is designed to efficiently facilitate V-agent development and deployment.

Other Open Source Software Strengthens Platform

VOLTTRON™ incorporates a number of open source projects to build a flexible and powerful platform, including:

- » **ZeroMQ**—acts as message bus, allowing data exchange
- » **BACPytes**—allows BACnet driver to interact with devices supporting BACnet protocol
- » **PyModbus**—enables Python code to easily interact with Modbus devices
- » **SQLite**—serves as local data cache
- » **MySQL and MongoDB**—serve as additional historian options for archiving data
- » Other open-source Python modules being used are:
 - avro, configobj, gevent, flexible-jsonrpc, numpy, posix-clock, pyopenssl, python-dateutil, requests, setuptools, simplejson, zope.interface, pandas, tornado, ply.

VOLTTRON™ Provides Secure Solutions for Buildings, Grid and More

Buildings efficiency: Although most buildings are designed to support energy efficiency features, often these features are not fully deployed. VOLTTRON™ enables enhanced supervisory control for the automation systems that manage heating, cooling, lights and other functions in buildings. V-agents, via automation systems, gain access to HVAC and other data, identifying and diagnosing problems, such as erroneous temperature settings. The technology offers passive capabilities that report a problem, as well as active approaches that actually fix the problem. By addressing these deficiencies, buildings can be made significantly more energy efficient without impacting functionality or occupant comfort.

Integration of distributed energy resources (DERs) at the grid's edge: In addition to building systems, VOLTTRON™ can support the integration of distributed energy resources (DERs), such as wind and solar generation, into the power supply. For example, V-agents, detecting grid imbalances caused by a lack of wind power, can marshal temporary efficiency actions in buildings to reduce power consumption, initiate virtual storage options, rapidly respond to grid requests to immediately increase or decrease building power usage, and manage demand response approaches. Such actions at the “edge” of the grid can ultimately improve grid performance and reliability.

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Other Potential Uses

VOLTTRON™ offers a wide range of prospective applications. The technology's ability to gather data—and then disposition the data to improve an operation or process—provides use opportunities in many areas, including:

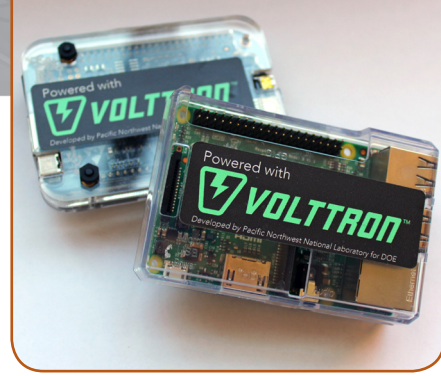
- » Data management and analytics for building operations (controllers, meters, occupancy sensors, etc.)
- » Improved interoperability between utility systems and proprietary home energy technologies
- » Cybersecurity
- » Energy efficiency in non-building disciplines, such as irrigation.

VOLTTRON™'s adaptability has significantly expanded its potential. Users are applying the platform in ways not originally envisioned.

ABOUT PNNL

Interdisciplinary teams at Pacific Northwest National Laboratory address many of America's most pressing issues in energy, the environment and national security through advances in basic and applied science. Founded in 1965, PNNL employs more than 4,000 staff and has an annual budget of approximately \$1 billion. It is managed by Battelle for the U.S. Department of Energy's Office of Science.

VOLTTRON™ is available to the public for download. Visit <https://github.com/VOLTTRON/volttron> to learn more.



VOLTTRON™ can be hosted on inexpensive computing devices.



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