VOLTTRON™

Devices | Data | Decisions

Technical Meeting on the Software Framework for Transactive Energy: VOLTTRON™

Pacific Northwest NATIONAL LABORATORY

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U.S. DEPARTMENT OF ENERGY

Pacific Tower, 1200 12th Ave. South, Seattle, WA 98144

The Department of Energy Building Technologies Office would like to welcome you to the 3rd annual meeting on VOLTTRON™! I would like to thank you for attending and for your active participation today. We have lots of great presentations and an opportunity for questions and answers.

Our first day is focused on a broad overview of VOLTTRON™'s capabilities. More importantly, we want to show, and learn, how VOLTTRON™ is, and can be used to solve problems or create new opportunities. For those of you attending day two, we will take a deep technical dive into the capabilities of VOLTTRON™.

This year's meeting is hosted at the Pacific Tower, home of the Smart Building Center (SBC). The SBC serves anyone within the state of Washington with an interest in better understanding energy efficiency in commercial and institutional buildings. DOE, like the SBC, is supporting a smart buildings ecosystem – including transactive controls, transactive energy, and utilizing buildings as resources – so we can enable buildings to help utilities meet and exceed their clean energy demands and capacity requirements from generation to end-use.

DOE's investments in this area are all built on VOLTTRON™, a transaction based software platform and an open source software environment for developing and deploying a variety of market driven applications.

For the purposes of this meetings, a smart building is a building that communicates with/across the meter and aids in optimization of the electrical system. Transactive controls enable that functionality in smart buildings by allowing energy consuming and generating components to engage across the meter -- exchanging both energy and information across physical, logical, and financial domains. Possibly more importantly, transactive controls make possible the settlement of real transactions across these domains.

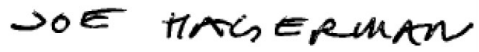
BTO's overarching GOAL for transactive controls R&D is to advance our shared principles across the two different perspectives from which we believe buildings can operate:

- From the Buildings Perspective, our goal is to encourage transactive markets behind the meter to increase energy efficiency (EE) through new means and mechanisms. We express this with the catch phrase, "thinking beyond EE."
- From the Grid Perspective, our goal is to increase and enhance the hosting capacity of both energy efficiency and renewable energy technologies at scale -- beyond simple demand response (DR). We express this opportunity with the catch phrase, "thinking beyond DR."

Over the next two days, we will discuss current and future applications that utilize the VOLTTRON™ platform to demonstrate transactive controls and transactive energy principles in buildings from these two perspectives.

It is my hope that this meeting will inspire stakeholders – including industry members, university and other researchers, software developers and practitioners – to think beyond EE and DR. And I hope everyone understands how our demonstration of transactive energy through VOLTTRON™ shows that buildings can act as dynamic, self-optimizing participants in the power system.

Thanks again for your time. We look forward to a productive and stimulating meeting.



Joe Hagerman
Senior Policy Advisor
DOE/Building Technologies Office

ACRONYMS & ABBREVIATIONS

ACEEE	American Council for an Energy-Efficient Economy
ADMS	Advanced Distribution Management System
AMSE	American Society of Mechanical Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
BAS	Building automation system
BTO	Building Technologies Office
CETC	Clean Energy and Transactive Campus
DDS	Data Distribution Services
DER	Distributed Energy Resources
DOE	Department of Energy
DR	Demand response
EE	Energy efficiency
FAS	Federation of American Scientists
FNCS	Framework for Network Co-Simulation
GMLC	Grid Modernization Laboratory Initiative
HVAC	Heating, ventilation, and air conditioning
IBPSA	International Building Performance Simulation Association
IETF	Internet Engineering Task Force
ISA	International Society of Automation
LBNL	Lawrence Berkeley National Laboratory
NAR	National Association of Realtors
ORNL	Oak Ridge National Laboratory
PNNL	Pacific Northwest National Laboratory
PV	Photovoltaics
RTU	Roof top unit
SBC	Smart Building Center
SMB	Small/medium size buildings
TC	Transactive Controls
UI	User interface

OVERVIEW

Purpose

This meeting will provide an overview of the VOLTTRON™ platform, present new developments and uses, discuss advancement of the Transactional Network concept, and build and expand the user community around this technology.

Presentations at the meeting will provide an overview to describe current and future applications, and development plans for VOLTTRON™. Throughout the two days, we will showcase VOLTTRON™'s potential to address several buildings-related services according to the perspectives from the Building and from the Grid.

DOE-BTO aims to broaden the applications of transactive controls (TC) and foster a community of VOLTTRON™ users, leading to outcomes including the following:

- A catalog of real-world VOLTTRON™ applications related to buildings;
- Discussion on development of VOLTTRON™-based products/services by industry;
- Multiple demonstration facilities to help socialize TC applications for buildings;
- A software repository to store TC applications, the reference platform and test suites, and an associated bug tracking and enhancement request;
- A peer-to-peer technical support forum for fostering discussions and answering questions;
- How-to documents to help build various TC applications on commonly encountered and readily available hardware; and,
- A forum to track and discuss bugs, enhancements of the TC platform, and the various applications.

The community will also contribute to the wider application of TC in buildings by addressing research gaps in the area of sensors, control technology, data mining and modeling standardization.

Background

The term "transactive energy" is used here to refer to techniques for managing the generation, consumption, or flow of electric power within an electric power system through the use of economic or market-based constructs while considering grid reliability constraints, renewables integration, and building energy efficiency. The U.S. Department of Energy's Building Technologies Office (DOE-BTO) is supporting research on transactive energy for buildings as part of its mission to improve energy efficiency and facilitate the integration of renewable energy. The objective of the meeting is to increase awareness and build a community of early adopters in order to further the concept of transactive energy.

VOLTTRON™ is a DOE-BTO funded platform for transactive energy applications that allows sensing activities and control actions to take place as close to devices as possible. VOLTTRON™ is designed to support modern control strategies, including use of agent-based and transaction-based controls. VOLTTRON™ enables mobile and stationary software agents to perform information gathering, processing, and control actions.

VOLTTRON™ is equipped to communicate with building systems (e.g. MODBUS or BACnet devices) and external services, has a built-in data historian and weather service, supports OpenADR 1.2., has a flexible messaging system (publish/subscribe), as well as utility and supporting classes to simplify application development, and logging service for saving application results and logging information. More broadly, it is a highly interoperable reference platform for transactive energy applications, enabling the integration of buildings and the grid.[1]

BTO's goal for the transactive controls R&D program is to advance transactive principles in buildings and to enable 4 of 7 of EERE's strategic goals.[2]

BTO believes that agent-based transactive controls can accomplish BOTH enhancing EE and delivering services beyond DR. However, research is necessary to understand how these are integrated together (e.g. from both perspectives simultaneously) especially across the related domains and users, organizations, and governing bodies to demonstrate the benefits and value transactive controls provides to buildings and campuses.

From the Building Perspective

We need to understand what Building Characteristics can address enhanced EE through application of Transactive Controls (TC) and to which buildings components and devices or whole buildings and campuses they can apply. These are EE related opportunities that include (but are not limited to):

- The movement towards fully automated, self-learning buildings as TC utilizes an agent-based environment that offers/enables control of equipment and buildings as dynamic and responsive to the goals of the building operator (e.g., cost, comfort, O&M, etc.);
- The creation of (regulated and non-regulated) markets (e.g., TC creates a market for EE to drive solutions rather than simply dispatch fixed solutions, thereby incentivizing the most optimal solution to be achieved);
- The incorporation or integration of business objectives within EE strategies (e.g., Intelligent Load Control which encodes business objectives into the classes of solutions to drive EE, and when presented with potential transactions, trigger the evaluation of the business rules to deliver the most optimal solution from the perspective of the business operator);
- The leveraging of characterization results rather than the simple application of annual efficiency measurements (e.g., TC best leverages the characterization results to all controls to drive to various EE solutions).

From the Grid Perspective

We need to understand which Building Characteristics can address the various, and emergent, flexibility needs of the GRID. These needs require us to better understand what electric characteristics and capacities buildings can affect, including (but not limited to):

- Demand Response – as a starting point because it is currently used and understood by the market, and can enabled in our transactive activities,
- Power Quality (e.g. Ancillary Services: Volt, Frequency, etc.),
- Load Shifting (e.g. ramping as a result of cloud coverage or steep declines in the afternoon as per the California ISO's "duck" curve) and PV output, and
- (potentially) Harmonic Distortions.

1 For a 3 minute video on VOLTTRON™'s capabilities, please see http://bgintegration.pnnl.gov/volttron.asp

2 "2016–2020 STRATEGIC PLAN and Implementing Framework" United States Department of Energy Office of Energy Efficiency and Renewable Energy, http://energy.gov/eere/downloads/eere-strategic-plan

In FY16, BTO's research seeks to understand and quantify the role of Buildings in addressing these characteristics, and to increase and enhance the hosting capacity of EE/RE technologies. Our work, therefore, must also answer:

- How much transactive control response do we need?
- How much is provided locally and how much nationally?
- How much can we deliver, and when?
- Through which buildings? Through which devices and equipment?

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Agenda

August 4-5, 2016
Pacific Tower | 1200 12th Ave. South | Seattle, WA 98144

Objectives: Build the User Community, Learn From Each Other, and Ensure VOLTTRON™ Meets the Needs for a Transactive Market

DAY 1 – August 4, 2016 – Panoramic Room (8th Floor), Pacific Tower		
EERE and Grid Integration: Role of Transaction Based Control		
08:00	Welcome	Dennis Stiles, PNNL
	DOE/BTO Purpose and Context	Joseph Hagerman, DOE/BTO
	Motivation for the Transaction-Based Platform	George Hernandez, PNNL
VOLTTRON™ Business Cases		
09:00	VOLTTRON™ Market Assessment	Jim Young, Navigant Consulting Inc
09:30	VOLTTRON™-Based Services for Small and Medium Commercial Buildings	Justin Sipe, Transformative Wave
10:15	VOLTTRON™-based Remote Monitoring and Diagnostics Services for Large Commercial Buildings	Terry Herr, Intellimation
11:00	VOLTTRON™-based Cloud Analytics Services	James Benson, CORASCloud
11:30	Energy Users of the Future - How Consumer Needs Will Impact the Energy Markets	Chad Curry, National Association of Realtors
Future of VOLTTRON™ Working Lunch		
12:00	VOLTTRON™ 1.0 – 4.0 and Beyond Where We've Been, Where We're Going	Bora Akyol/Jereme Haack, PNNL
12:30	Key Requests for VOLTTRON™ Enhancements	Craig Allwardt, PNNL
12:45	Suggestions/Ideas for Applications/Improvements to the VOLTTRON™ Platform	Facilitator
The National Lab Transactive Portfolio (Panel)		
01:30	VOLTTRON™ Use Cases and GMLC Projects	George Hernandez, PNNL
	PNNL VOLTTRON™ Use Cases	Srinivas Katipamula, PNNL
	VOLTTRON™ as a DER Integration Platform	Sila Kiliccote, SLAC National Accelerator Laboratory

	Utilizing VOLTTRON™ Platform for Enabling Energy Efficiency and Grid-Responsiveness of Building Loads	Teja Kuruganti, Oak Ridge National Laboratory
	Transaction-based Control of Workstations using VOLTTRON™	Christian Kohler, Lawrence Berkeley National Laboratory Vishal Garg, IIIT Hyderabad
Wrap-up of Day One		
03:00	Discussion and Wrap-up	Facilitator
03:30	Adjourn	
DAY 2 – August 5, 2016 – Training and Event Center, 1st Floor, Pacific Tower		
08:00	Summary of First Day	Facilitator
EERE and Grid Integration: Role of Transaction Based Control		
08:10	VOLTTRON™ Technical Overview	Jereme Haack, PNNL
08:30	VOLTTRON™ 4.0 Features	Craig Allwardt, PNNL
09:10	VOLTTRON™ Security	Craig Allwardt, PNNL
09:40	Discussion	Facilitator
10:00	Agent Development	Jereme Haack, PNNL
10:30	Historians and Drivers	Chandrika Sivaramakrishnan, PNNL
11:00	VOLTTRON™ Deployment and Scalability	Jereme Haack, PNNL
Hands On VOLTTRON™ Working Lunch		
11:30	Live Deployment Walkthrough	VOLTTRON™ Team, PNNL
VOLTTRON™ Integration with Other Platforms		
01:00	MATLAB, GridLAB-D, FNCS, Energy+	Poorva Sharma, PNNL Chad Corbin, PNNL
02:00	Integrating with NodeRed, DDS, etc.	Michael Roup, PNNL
Open Topics		
02:30	Live Office Hours	VOLTTRON™ Team
03:30	Adjourn	

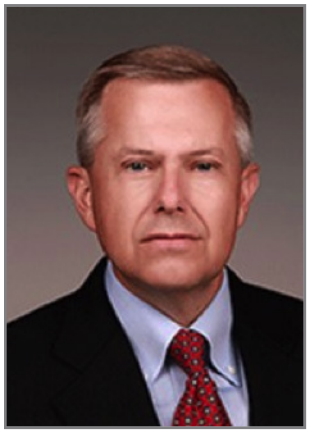
LOGISTICAL INFORMATION

Meeting Location	**Meeting Facilitation**	**Accommodations**
Pacific Tower 1200 12th Ave. South Seattle, WA 98144 206-954-6418	Sean McDonald PlanIt Meetings sean@planitmeetings.com Phone: (410) 507-1660	Crowne Plaza Hotel - Seattle 1113 - 6th Avenue Seattle, WA 98101 Phone: (206) 464-1980
Underground parking at the Pacific Tower $7 up to 10 hours; $10 for 24 hours. Taxi or Uber/Lyft is recommended if you do not have your own transportation. The Smart Building Center is accessible by the City Bus 36 from downtown Seattle along 3rd Avenue southbound to Pacific Tower.		

DAY 1

PNNL WELCOME

Dennis Stiles



Dennis serves as the Building Energy Efficiency & Grid Integration Program Manager, working with the Department of Energy to define research that supports its goals for improving the efficiency of residential and commercial buildings, making buildings fully engaged in the larger energy system, and employing responsive building loads to support integration of renewable energy generation.

Dennis joined PNNL in 1986. During his career at the Laboratory, he has played a role in a number of research areas, most significantly in launching PNNL's biofuels and renewable chemicals research program which resulted in a number of commercial products and national awards. In other prior assignments, He served as a scientific co-director of the Oregon Nanoscience and Micro-Technologies Institute, as a senior project manager, as a technical group manager and in various strategic planning roles.

Dennis has a bachelor's degree in Industrial and Management Engineering from Montana State University and a master's degree in Engineering Management from Washington State University.

DOE/BTO PURPOSE AND CONTEXT

Joseph Hagerman

Joe is a Senior Advisor at the U.S. Department of Energy's (DOE) Energy Efficiency and Renewable Energy Office focusing on building energy efficiency and new building technology development. He is at the forefront of the effort to develop clean, healthy, competitive building technologies for the 21st century – leading the department's smart buildings, transactive controls, and building to grid research. Joe oversees various negotiated federal regulatory and new initiatives for the program – including all activities on connected equipment, cybersecurity in buildings, interoperability, and connected equipment characterization. He Hagerman also directs the Building Innovators program which awards innovative graduate student teams to develop market-based technology solutions as well as VOLTTRON™ applications.

Before joining DOE, Joe was the project manager for the Building Technologies group at the Federation of American Scientists (FAS). At FAS, he conducted research in new building technologies while demonstrating these technologies in the public sector. His efforts helped address environmental and energy injustice in energy efficient, affordable housing.

Joe received his Bachelor of Architecture from Mississippi State University and his Masters in Civil Engineering at the Fu Foundation School of Engineering at Columbia University. His academic work focused on engineering mechanics and construction technology.

Abstract

This session will provide an overview of the BTO portfolio in transactive controls and transactive energy applications in buildings including enhancement of the VOLTTRON™ platform.

Over the last three years, BTO has supported research on using transactive controls and transactive energy applications to lower buildings' energy use, raise building's efficiency, and provide wider benefits to the power system. Transactive controls in buildings will rely on robust control software that enables automatic, market-based intra-building efficiency optimizations. BTO believes that the best way to further the development of such software lies in the formation of a broad community of stakeholders that provides technical expertise, develops applications, and a deployment platform supporting transactive principles in buildings.

In BTO's paper, Buildings-to-Grid Technical Opportunities: Introduction and Vision, DOE laid out a vision of transaction based controls that first, and foremost, benefit the owners and operators of buildings through the delivery of energy efficiency. Transaction based controls are controls that respond to information as well as energy – this commingling of energy and information informs, possibly triggers, or transacts the control actions. In addition to the energy efficiency savings, transaction based controls can benefit the system efficiency of the electricity grid by delivering traditional grid services such as Demand Response (or ancillary services such as frequency regulation in the future).

In the report, Transaction-Based Building Controls Framework, Volume 1: Reference Guide, PNNL specified four service classes that transaction based controls could deliver: 1) user services (e.g. energy efficiency); 2) energy market services (e.g. campus or fleet control that take advantage of portfolios of clean energy and load technologies); 3) grid services (e.g. traditional Demand Response and, in the future, other ancillary services or load management), and 4) societal services (e.g. services society have deemed important through policies or regulations).

Transaction based controls require the commingling of energy and information. Because DOE must not "pick a winner" in the selection or award of proprietary solutions and needs to support the larger discipline of transaction based controls, in early 2010 DOE adopted an Office of Electricity Delivery and Energy Reliability related control "platform" (VOLTTRON™) as the flexible open source solution to accelerate the development of its controls program and simplify the tech transfer process. VOLTTRON™ was developed by PNNL using the Laboratory Directed Research and Development funding as part of the Future Power Grid Initiative. In 2010 DOE began the enhancement of the solution to extend the functionality to include buildings specific control strategies and fully released the solution (and future solutions) as open source.

DOE's collection of controls projects and activities has garnered widespread industry support and collaboration because the comprehensive program was built on three key principles defining DOE's role:

- DOE should invest in comprehensive core RD in the fundamentals of sensors and controls in areas like plug and play, large scale complex control methodologies, agent-based control theory, etc. which is bigger than one sole solution or industry entity,
- DOE should continue development of an open source transaction based controls platform and related tools (e.g., VOLTTRON™, so everyone has equal access to the research, findings, and applications (whether or not industry participants ultimately adopt VOLTTRON™ or simply incorporate features and code found in it), and
- DOE should continue to stimulate the market, fund the development of market-based solutions, and promote market successes only after careful scoping studies are completed that flesh out the use cases, business case, and market justification with the industry.

VOLTTRON™ is a key, open source enabler to that goal and comes with it DOE's past investment and history in the controls space.

MOTIVATION FOR THE TRANSACTION-BASED REFERENCE PLATFORM

George Hernandez

George joined PNNL in 2009 and works in the Advanced Building Controls group. He is a Staff Scientist and senior demand side management professional. Working under the support of Joe Hagerman, he has co-authored the High Performance RTU Challenge, the Buildings Performance Database, the Low Cost Wireless Metering Challenge, Energy Information Handbook, the Portable Sensor Suitcase, Open Source Small Building Control System, and the Transactional Network project. Most recently, he has championed development and commercialization of an open source software platform called VOLTTRON™, used to deploy Transactional Control strategies for buildings to grid integration. He has extensive knowledge, skills, and capabilities derived from a substantial career in demand side utility management across a wide variety of commercial and industrial sectors and utilities as both a corporate employee and an independent consultant. George received his B.S. in Mechanical Engineering from California State University and his Masters in Mechanical Engineering from The University of California at Berkeley. He is a Licensed Professional Engineer by the State of California.

Abstract

Fundamentally, transaction based controls require the commingling of energy data and information. In the 'controls' market today, there are several vendors who claim to provide this type of solution, but they are proprietary, expensive and narrowly focused on one or two systems (typically only HVAC or HVAC and lighting). Because DOE is technology neutral in the selection or award of proprietary solutions and needs to support the larger discipline of transaction-based controls, in 2011 DOE adopted PNNL's innovative distributed control and sensing software 'platform' (VOLTTRON™) as the flexible open source solution to accelerate the development of its controls program and simplify the technology transfer process. VOLTTRON™ was developed by PNNL as part of the Future Power Grid Initiative using Lab Directed Research and Development funding, a five-year project established in 2011 that is designed to deliver next-generation concepts and tools for grid operation and planning and ensure a more secure, efficient and reliable future grid. However, the initial VOLTTRON™ platform was distribution grid focused, so in 2012 DOE began the enhancement of the solution to extend the functionality to include buildings specific control strategies and fully released the solution (and future solutions) as open source. The solution has been tested at utility scale, being certified in PNNL's PowerNET Testbed and includes cyber security features that have been tested through various events.

VOLTTRON™ MARKET ASSESSMENT

Jim Young

Jim is a Managing Consultant in the Energy Practice of Navigant Consulting, Inc. His expertise focuses on energy-related issues for building systems, particularly HVAC, including evaluation of emerging technologies, market assessments, developing R&D roadmaps, and providing support to energy efficiency programs. Clients include government agencies, gas and electric utilities, appliance manufacturers, technology developers, investors, and other clients. Prior to Navigant, Jim spent many summers working alongside HVAC technicians on residential and commercial projects. He serves on the board of the local Young Professionals in Energy chapter and is an associate ASHRAE member. He holds a M.S. in Sustainable Engineering from Villanova University, and a B.S. in Aerospace Engineering from the University of Notre Dame.

Abstract

Navigant conducted a series of stakeholder interviews to help DOE and PNNL understand the key capabilities, challenges, and opportunities for VOLTTRON™-based products and services in the marketplace. Each interviewee articulated their understanding of the market needs for transaction-based control systems based on their specific role and connections in the value chain. The set of 23 interviews captured perspectives from a wide range of organizations, industries, and company sizes, including building owners, manufacturers, service providers, software platform developers, and utilities. This presentation will discuss many of the key findings from these interviews and provide meeting participants insight into the market needs and challenges for VOLTTRON™-based products and services.

VOLTTRON™-BASED SERVICES FOR SMALL AND MEDIUM COMMERCIAL BUILDINGS

Justin Sipe

Justin is the Senior VP of Technology for Transformative Wave Technologies. He is a co-inventor of the CATALYST Efficiency Enhancing Solution, and he holds five patents around rooftop unit efficiency. Justin has been involved in the controls industry for 18 years. During his time in the industry he has designed, serviced, installed, and trained on control systems for commercial buildings and industrial process control. In addition, he leads the development efforts at Transformative Wave that are focused on finding innovative solutions to reduce HVAC energy use. He has certifications in Tridium, Honeywell, Johnson Controls, Distech, Magnetrol, Belimo, and Fireye. He is also a Tridium Certified Developer and a Honeywell Authorized Trainer.

Abstract

Transformative Wave has been working to launch a VOLTTRON™ based control system targeted for small and medium buildings. This has included both hardware and software development focused on lowering the deployment cost and layering in technologies to create financially attractive scenario. This discussion will focus on lesson learned, an update to VOLTTRON™-based services, and a discussion of future development targets. The VOLTTRON™-based services are six agents designed specifically for small and medium buildings. They are air side economization FDD, RTU performance testing (benchmarking), afterhours tenant billing, demand response, coordination of multiple RTUs, and automated measurement and verification.

VOLTTRON™-BASED REMOTE MONITORING AND DIAGNOSTICS SERVICES FOR LARGE COMMERCIAL BUILDINGS

Terry Herr

Terry Herr is the founder and Principal of Intellimation LLC. He has 30 years of experience in the Building Automation industry. Twenty-six of those years as the owner of a Building Automation / Systems Integration firm. Recently, Intellimation's focus has been exclusively on deploying Automated Fault Detection and Diagnostics / Buildings Analytics software tools. Intellimation uses this new class of software for data driven Retro and Ongoing or Continuous Commissioning. He is a licensed Master Electrician and earned a B.S. in Physics from Lebanon Valley College.

Abstract

In order to extract value from a growing list of automated fault detection and diagnostics (AFDD) or building analytics software tools coming onto the market, one must first connect to, trend, archive, meta tag, and make this building automation system (BAS) & meter data easily available to these new applications. VOLTTRON™ can be this enabling middle ware technology platform. Intellimation is testing the use of VOLTTRON™ for this purpose in the City of DC owned buildings. I will describe this use case in detail and where we are presently in our deployment, and testing of VOLTTRON™.

We understand that the vision for VOLTTRON™ is much broader and includes transactive energy and active control/ actuation. We look forward to these types of uses in the future, but our present use case has immediate and broad application.

VOLTTRON™-BASED CLOUD ANALYTICS SERVICES

James Benson

Jim is the Chief Visionary and Operating Officer of CORASCloud a global applications and platform company delivering solutions to more than 175 customers worldwide. With over 25 years of experience creating, building and sustaining technology businesses, Jim's passion and expertise is both broad and deep. Prior to his role at CORASCloud, he led Booz Allen Hamilton's Energy IT business and implemented dozens of eGovernment, eCommerce, Analytics and B2B solutions worldwide. Jim loves to create and enjoys working and partnering with entrepreneurs worldwide to help them realize their business and technology goals.

Abstract

Powered by VOLTTRON™! CORASCloud is working with PNNL to operationalize the secure transfer of VOLTTRON™ information to the Cloud and enable organizations with a suite of applications to make better decisions around the energy management, control monitoring and decision analytics. In this session you will learn how this was accomplished, challenges they experienced and tour a few of the applications that were built.

ENERGY USERS OF THE FUTURE - HOW CONSUMER NEEDS WILL IMPACT THE ENERGY MARKETS

Chad Curry

As Managing Director for NAR's Center for REALTOR® Technology & CRTLabs, Chad investigates emerging technologies, educates NAR members & the public through presentations, webinars, blogs and podcasts, and manages the development of products for use by members. He's presented to REALTORS® on the national, state and local levels.

Currently, Chad's work is focused on research and development of smart home devices, iBeacons and wearables as well as renewable energies. Specifically, he is investigating how these trends will impact the real estate industry and benefit members. To support this initiative, Chad and his team has started CRTLabs focused on testing and developing devices for the home to help improve quality of life. He is an Advisory Board member of the Internet of Things Council and is leading the Case Studies Group. Chad is also a Board Member for the Real Estate Standards Organization, where he works to streamline real estate transaction technology. He was recently named to Inman News's Top 101 Most Influential People in Real Estate. He currently lives in Chicago with his family where he enjoys music, art, soccer and travel.

Abstract

As the internet of things and connected devices gain adoption in the residential market, energy utilization will shift. Informed consumers will be able to adapt to their usage which may in turn alter the nature of energy usage for utilities. The presentation will speak to which types of actions can be taken to anticipate these future needs and what will impact these trends. Finally, the presentation will address what an integrated solution could contribute to meet this demand.

VOLTTRON™ 1.0 – 4.0 AND BEYOND WHERE WE'VE BEEN, WHERE WE'RE GOING

Bora Akyol

Bora is a senior research scientist in CSMD's Data Intensive Scientific Computing group, conducting research and development in network security, information sharing protocols, and Smart Grid. He also serves as cyber security lead for the Pacific Northwest Smart Grid Demonstration project as well as the Principal Network Engineer in the PNNL's CIO organization. He earned both his M.S. and Ph.D. in electrical engineering from Stanford University.

Before joining PNNL in 2009, Bora was a technical leader at Cisco Systems, where his work involved service blades for the Catalyst 6500 Series switches, 1250 and 1140 Series 802.11n access points, and Internet Key Exchange and Internet Protocol Security protocols, as well as next-generation, identity-based networking products. He has published two Internet Engineering Task Force (IETF) Requests for Comment and holds 15 patents in the areas of wireless and Ethernet networks, network security, congestion control, and software engineering. He is a longtime active member of both IETF and IEEE.

Jereme Haack

Jereme is a Senior Research Scientist at PNNL. For the past 4 years he has been a co-lead for the VOLTTRON™ platform which enables deploying agent-based solutions at the edges of the smart grid and in buildings to improve energy efficiency and load responsiveness. This platform serves as an integration point for devices, remote resources, and agent applications greatly decreasing the amount of effort to move research from simulation to actual deployment. Other agent research is the application of bio-inspired solutions to cyber security as part of the Digital Ants project which has been covered in Scientific American and NPR among others. Jereme has also been researching how computer science solutions can best assist information analysts through evaluating their effect on the information analysis process. As part of this research, he has been involved in the VAST Challenge producing datasets with ground truth and evaluating software used to discover the hidden threat. These datasets have become an open resource for research and university courses in the infoviz field. Jereme holds a B.S. Computer Science and in Mathematics from Doane College, Crete, Nebraska, and a Graduate Level Certificate in Intelligence Studies from Mercyhurst College.

Abstract

With support from EERE Building Technologies Office, the VOLTTRON™ platform's capabilities and security features continue to be enhanced to provide a stronger base for the development of transactional energy and other building efficiency applications. This session will give an overview of the platform from its beginnings as an internally funded PNNL research project to an open source platform with a user base spanning national labs, universities, and commercial companies. The goal of this session is to explain the capabilities of the different versions of the platform and present potential plans for the next release.

KEY REQUESTS FOR VOLTTRON™ ENHANCEMENTS

Craig Allwardt

Craig Allwardt brings over 10 years of experience as a software developer in support of the Software Engineering and Architects group. He helps clients to solve complex problems using software. He specializes in system, web and database designs. He has worked in the ecological, geological, and electoral domains.

Abstract

Community feedback is vital for guiding platform development to address the highest priority needs. Feedback provided through technical meetings, mailing lists, and the bi-weekly VOLTTRON™ office hours have led to many of the new features of the upcoming VOLTTRON™ 4.0 and future 5.0 releases. We will present the feedback collected at last year's technical meeting and throughout the year to discuss how it has been addressed and prompt for additional comments.

VOLTTRON™ USE CASES AND GMLC PROJECTS

George Hernandez

Abstract

The applications of VOLTTRON™ as an enabling technology are only limited by the imagination. However, to demonstrate how VOLTTRON™ can be used for emerging and existing energy-related applications, the Department of Energy has funded several national labs to implement and validate solutions that can be replicated by the private sector. The presentations and follow on discussion in this panel will describe a few of the projects that are either completed, underway or postulated using VOLTTRON™ as the software transaction platform.

PNNL VOLTTRON™ USE CASES

Srinivas Katipamula

Srinivas is a Staff Scientist at PNNL. He joined PNNL in 1994. He has extensive technical experience in the evaluation of advanced design concepts for heating, ventilation and air-conditioning systems, demand response techniques for commercial and residential buildings, development of automated fault detection and diagnostic techniques, building and energy system simulations, analysis and evaluation of new energy efficient technologies, and development and use of analytical modeling techniques. Srinivas recently led a team of PNNL staff that demonstrated transactive (price-based) controls in commercial and industrial sites. He is active in both ASHRAE and AMSE technical committees and is an associate editor of the ASME Journal of Energy Resources Technology. He is a Fellow of ASHRAE. He holds a Ph.D. and M.S. in Mechanical Engineering from Texas A&M University and B.E. in Mechanical Engineering, Osmania University, India, 1983.

Abstract

This presentation will highlight some of the most relevant use cases to deliver energy efficiency and grid services to both commercial and residential buildings. Some of these use cases are being piloted on a number of Pacific Northwest National Laboratory (PNNL) buildings as part of the Clean Energy and Transactive Campus (CETC) project, which is the first of the pioneering regional demonstrations projects funded under the Grid Laboratory Modernization Consortium. The CETC project is a joint research project involving the PNNL, Washington State University, and the University of Washington to form a multi-campus network and conduct research that advances transactive control of distributed energy resources.

The presentation will also highlight relevant open source v-agents (VOLTTRON™ agents) that are available to be deployed on the platform. Some example use cases include: building automation system (BAS) for small/medium size buildings (SMB), deploying energy efficiency and grid services in SMB, secure data collection from BAS in support third party Cloud analytics, VOLTTRON™-based Cloud analytics solution, deploying energy efficiency and grid services for large commercial buildings, supporting “re-tuning” mandates (New York, Seattle, etc.), interoperability platform for commercial buildings, interoperability platform for homes, bi-lateral trading of energy between buildings, and enabling “smart” building for “smart” cities.

VOLTTRON™ AS A DER INTEGRATION PLATFORM

Sila Kiliccote

Sila is the leader of Grid Integration, Systems and Mobility (GISMo) group at SLAC National Accelerator Laboratory and co-leader of research for Stanford University and SLAC's Bits and Watts initiative. Prior to joining SLAC, she held a part-time position as a demand response expert at Google and spent over 10 years at Lawrence Berkeley National Laboratory as a deputy of the Demand Response Research Center and leading the grid integration initiatives. At LBNL, she worked with a team to develop OpenADR, Virtual Grid Integration Laboratory (VirGIL) and the use of micro-PMUs for distribution systems. She holds an Electrical Engineering degree from University of New Hampshire and a Master of Building Science degree from Carnegie Mellon University. Sila served as the Co-Chair of the ACEEE Summer Study on Energy Efficiency in Buildings in 2014. She received the C3E Research Leadership Award in 2014 and Leadership in Smart Grid Acceleration Award in 2010.

Abstract

Over the summer of 2015, SLAC developed a framework to demonstrate a variety of new building systems integration and energy management platforms including VOLTTRON™. The demonstrations included two "households" that use a set of loads (fans and lights), storage (car batteries) and propane generators to demonstrate the integration these systems using VOLTTRON™ and coordination of these systems through price response. A server published prices and based on the thresholds that were set by each "household", the systems delivered different level of services. Given this experience, we identified a set of needs for VOLTTRON™ for its broader adoption, namely: 1) A common data model; and, 2) Test Tool Kit. In this presentation, we describe the demonstrations developed at SLAC's Grid Integration, Systems and Mobility (GISMo) Laboratory and the next steps for VOLTTRON™ as a low-cost behind-the-meter systems integration platform.

UTILIZING VOLTTRON™ PLATFORM FOR ENABLING ENERGY EFFICIENCY AND GRID-RESPONSIVENESS OF BUILDING LOADS

Teja Kuruganti

Teja is Senior R&D staff member in the Computational Sciences and Engineering Division at Oak Ridge National Laboratory (ORNL), where he worked since 2003. He currently leads ORNL activities in developing novel sensors and controls for improving energy efficiency of buildings and novel techniques for enabling grid-responsive building loads. His research interests include wireless sensor networks, communications systems, control systems, and novel sensor development. He won an R&D 100 award in 2012 for co-developing electromagnetic wave propagation simulation engine for harsh environments. He earned M.S. and PhD degrees in Electrical Engineering from University of Tennessee, Knoxville and B.E. in electronics and communication engineering from Osmania University. He is a member of IEEE and ISA. He is currently the director of ISA Test and Measurement Division.

Abstract

In this presentation we describe our ongoing work on using VOLTTRON™ platform for implementing, demonstrating, and testing three key applications that enable grid-responsive behavior of building loads. Firstly, we describe the use of VOLTTRON™ platform to demonstrate a supervisory control strategy for limiting peak power demand through a scheduling algorithm that prioritizes the operation of equipment according to data provided with each request to operate within equipment constraints. Secondly, we describe the use of VOLTTRON™ platform to enable building load control to compensate for variability of solar photovoltaic generation temporally and spatially with in a region using heating, ventilation, and air conditioning (HVAC) units and water heaters. Thirdly, we will describe utilizing VOLTTRON™ as an open source interface to inverters for enabling novel grid services. We will also describe our preliminary efforts on using VOLTTRON™ in utility demonstrations.

TRANSACTION-BASED CONTROL OF WORKSTATIONS USING VOLTTRON™

Christian Kohler

Christian is the deputy department head for Building Technologies at Berkeley Lab. Since 2012 he has been working on the integration of sensors and controls into windows and building facades. For more than 20 years he has been the involved in the experimental work, validation and development of highly insulating and dynamic windows, as well as all aspects of software development in the Windows and Envelope Materials Group for various tools such as THERM, WINDOW, Optics. His activities include the development of embedded controllers as well as algorithm development, user support, and training. Prior to that he was working at the LBNL Infrared Thermography research facility. He received his Master's degree in Building Physics in 1997 from Eindhoven University of Technology in the Netherlands.

Vishal Garg

Vishal graduated in Civil Engineering from MBM Engineering College, Jodhpur and completed his doctorate from Indian Institute of Technology, Delhi. He conceived and established Center for IT in Building Science at IIIT-H in the year 2000. Currently IIIT- H offers Ph.D., M.S. by Research, and five years integrated Building Science & Engineering (BSE) dual degree programmes. He has 16 years of teaching and R&D experience in the areas of building energy simulation, cool roofs, building automation, and illumination engineering. He has conducted several national and international workshops on Intelligent Buildings, Green Buildings and Energy Simulation.

Vishal is actively involved in the green building activities in India, development of tools and educational platforms for advancing energy efficiency in buildings, and energy efficiency building code and its implementation. He has facilitated more than 20 projects for achieving their green and energy efficiency targets. Currently he is a member of task force of Indian Green Building Council for 'Energy Simulation Protocol for Green Buildings'.

He was the founding president of Indian chapter of International Building Performance Simulation Association (IBPSA) and recently was the organizing chair of IBPSA's international conference 'Building Simulation 2015'.

Abstract

Within the Joint U.S./India Building Energy Research project VOLTTRON™ is being used to add transactional controls to workstations. VOLTTRON™ will be used to provide personalized comfort for an individual workstation by controlling HVAC, lighting and plug loads. VOLTTRON™ will be integrated into a smart plug strip that monitors, identifies and controls plug loads. It will also be integrated with a workstation hub that can control a Power-over-Ethernet (PoE) light and fan.

Testbeds will be setup in early FY17, both at LBNL's FLEXLAB facility as well as at the International Institute of Information Technology in Hyderabad, India. This allows us to field-test VOLTTRON™ in a U.S. and Indian office setting. In the U.S. Automated Demand Response (ADR) scenarios can be tested. In India tests will experience a far less reliable grid with routine use of generators, which will impact the price of electricity. This work is building on the DOE/DOD Tropec work that LBNL has done for military microgrids.

DAY 2

VOLTTRON™ TECHNICAL OVERVIEW

Jereme Haack

Abstract

This presentation will provide a high level overview of the components and features of the VOLTTRON™ platform as they exist in 4.0. This will provide context for the rest of the technical presentations and potential topics for the in-person office hours.

VOLTTRON™ 4.0 FEATURES

Craig Allwardt

Abstract

This presentation will present the platform improvements that have been made since the release of 3.0 as well as the features to be introduced in VOLTTRON™ 4.0. These features build on the capabilities introduced in 3.0 with a goal of making them more powerful and easier to use. Topics will include: improvements in handling security keys, agent authorization, platform management in the VOLTTRON™ Central Web UI, and enhancements to current services such as the drivers and historians.

VOLTTRON™ SECURITY

Craig Allwardt

Abstract

Security is a primary goal in the development of VOLTTRON™. This session will provide an overview of the security features and provide examples of setting up a secure deployment (including what can be done to secure the underlying operating system). In addition, we will present VOLTTRON™ Cyber Operations which uses the platform to monitor the system it is deployed on.

AGENT DEVELOPMENT

Jereme Haack

Abstract

The VOLTTRON™ platform provides a set of services for interacting with buildings and devices, but the real work of enabling intelligent and responsive buildings gets done in VOLTTRON™ Agents. In this session, we will walk through the development of a simple agent demonstrating how to utilize base and utility classes.

HISTORIANS AND DRIVERS

Chandrika Sivaramakrishnan

Chandrika is a scientist with the Physical and Computational Sciences division at Pacific Northwest National Laboratory. Her main scientific interests include data management, middleware applications, software architecture, web technologies and mashup, semantic technologies, and scientific workflows. She is a senior developer for the Velo scientific knowledge management framework which is currently being deployed for use in several U.S. Government agencies, including the Department of Energy's Biological and Environmental Research program, Geothermal Technologies Office, the Department of Homeland Security's Seattle Law Enforcement Gang Task Force, and the Environmental Protection Agency. Prior to joining PNNL Chandrika worked as software developer and technical lead in Infosys, India. She has over 15 years of experience in software development specializing in Java, J2EE, and relational databases.

Abstract

Data collection and storage are two of the most essential services of VOLTTRON™ and are enabled through an extensible framework that allows for expanding the capabilities of the platform. This presentation will cover how to setup existing drivers (MODBUS and BACnet) and existing historians (MySQL, SQLite, and MongoDB). It will then demonstrate how to use the framework to develop new historians and drivers which can then become capabilities available to the rest of the community.

VOLTTRON™ DEPLOYMENT AND SCALABILITY

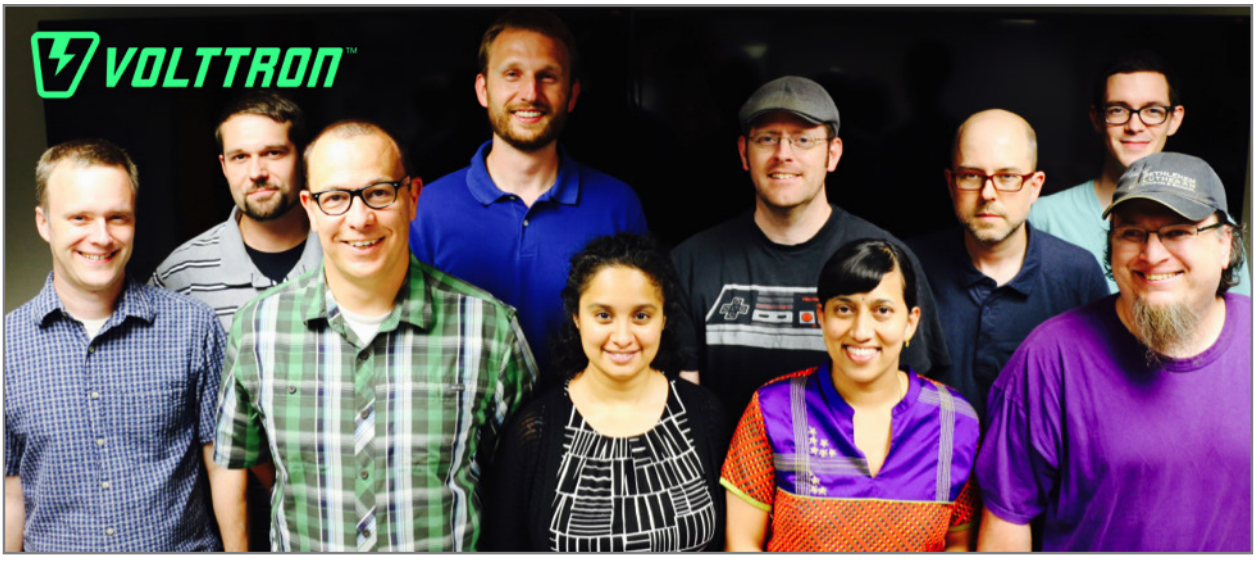
Jereme Haack

Abstract

The VOLTTRON™ platform can support numerous deployment topologies depending on the use case. This session will discuss the relationship between deployment needs, data collection, data storage, and agent operation. Results of scalability testing will also be discussed.

LIVE DEPLOYMENT WALKTHROUGH

PNNL's VOLLTRON™ Team



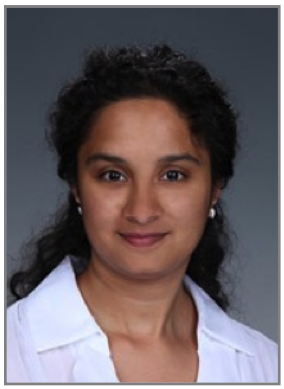
PNNL's VOLTTRON™ development team

Abstract

A live deployment of VOLTTRON™ will show how to go from square one to a working deployment which collects data and executes applications. Participants are invited to follow along, setting up a deployment on their laptops.

MATLAB, GRIDLAB-D, FNCS, ENERGY+

Poorva Sharma



Poorva is a Research Engineer with Data Sciences group at PNNL. She specializes in developing new software tools in the field of knowledge management, distributed systems, integration systems and messaging middleware. Her work focuses on developing middleware solutions for data management and data integration in power grid and building energy research. She worked on OpenEIS and is currently a part of VOLTTRON™ development team. She is also working on DOE funded Grid Modernization Laboratory Consortium for designing and developing open source platform for power grid utilities to deploy ADMS applications in power grid utilities.

Chad Corbin

Chad is an engineer in the Advanced Building Controls group at PNNL. His primary research is focused on the interactions of buildings, distributed energy resources, and electric grid at large scale. Since joining PNNL in 2014, he has been involved in a variety of aspects of transactive energy systems, including valuation, modeling, simulation, and testing. His current work is focused on automated, scalable, transactive energy applications implemented in VOLTTRON™ for managing building electric demand and assisting with electric grid operations. These applications are currently being tested in PNNL's Clean Energy and Transactive Campus project.

Prior to his employment at PNNL, Chad developed residential energy models for estimating retrofit and behavioral energy savings, performed impact analysis of residential energy savings programs, and developed software for model predictive control of commercial buildings.

Chad holds a B.S. in Mechanical Engineering from Cornell University, and a M.S. in Civil Engineering and Ph.D. in Architectural Engineering from the University of Colorado at Boulder.

Abstract

VOLTTRON™ provides a flexible platform for developing and testing building control algorithms. PNNL has created a set of new capabilities to support the development of VOLTTRON™-based control applications against building simulations or simulated devices in MATLAB, the FNCS co-simulation tool, Energy+ building simulation tool and GridLAB-D. These agents enable researchers to quickly study and validate their control applications prior to physical demonstration. This talk will describe how to run these new agents and demonstrate their usage to control simulators.

INTEGRATING WITH NODERED, DDS, ETC.

Michael Roup

Michael Roup is a new PNNL engineer interested in compression, optimization, and programming language design. He has been involved VOLTTRON™ security testing, platform availability, and performance analysis. Before joining PNNL Michael developed methods to virtually unroll ancient scrolls from micro-CT data. The techniques developed were subsequently used to analyze artifacts from Herculaneum, Italy, and from Ein Gedi, Israel. Mr. Roup holds a B.S. in Computer Science from the University of Kentucky.

Abstract

VOLTTRON™ exists within an ecosystem of other messaging systems and platforms for interacting with homes, buildings and devices. In this session, select platforms will be discussed in relation to the VOLTTRON™ community with proof-of-concept demonstrations for DDS and NodeRed showing interaction with agents in VOLTTRON™.

LIVE OFFICE HOURS

PNNL's VOLLTRON™ Team

PNNL's VOLTTRON™ development team

ABOUT THE FACILITATOR

Sean McDonald

Sean has been a meeting planner and facilitator for over twenty years. He has both led and facilitated strategic, multiyear, and program planning efforts for a variety of clients. As an economist, certified network engineer, and technologist, he specializes in complex issues at the intersection of the application of technology and human needs in the built environment. These include automation, communication, and services such as lighting. These abilities are integral to facilitation as he leads clients through the planning process, beginning with classic vision and mission development, through defining objectives and milestones, and finally, performance measurement. Sean has facilitated a variety of open public meetings to gather input and evaluate program direction and progress. These meetings have ranged from as small as a dozen to several hundred participants.

Sean had a B.S. in Economics from Ohio State University and an M.A. in Economics from the University of Virginia. He previously worked for Pacific Northwest Laboratory and the Wharton School, University of Pennsylvania.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