Case Study: Transactive Concepts for a Network of Rooftop HVAC Units

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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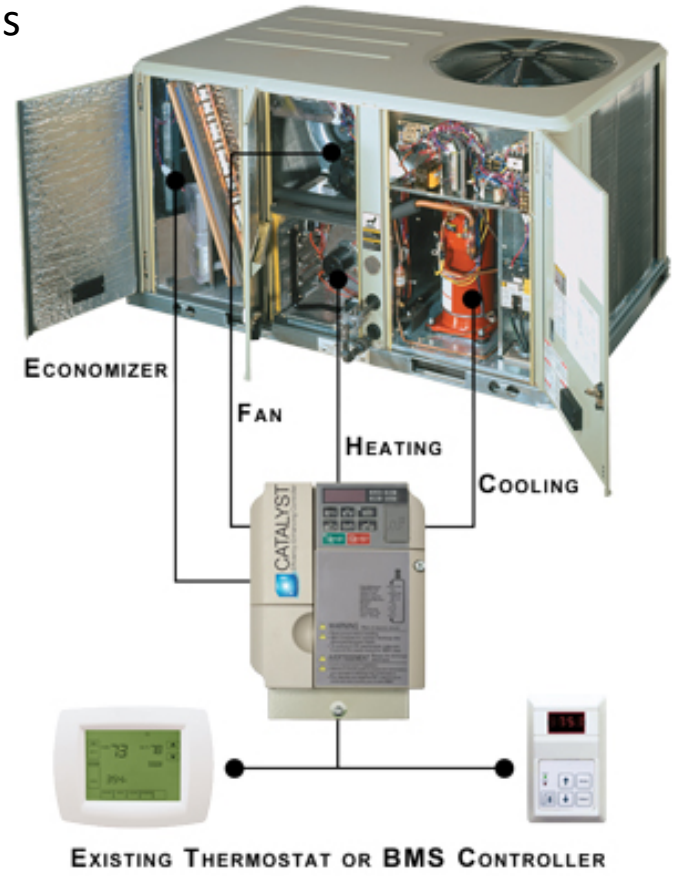
Rooftop Unit (RTU) Network Project

What:

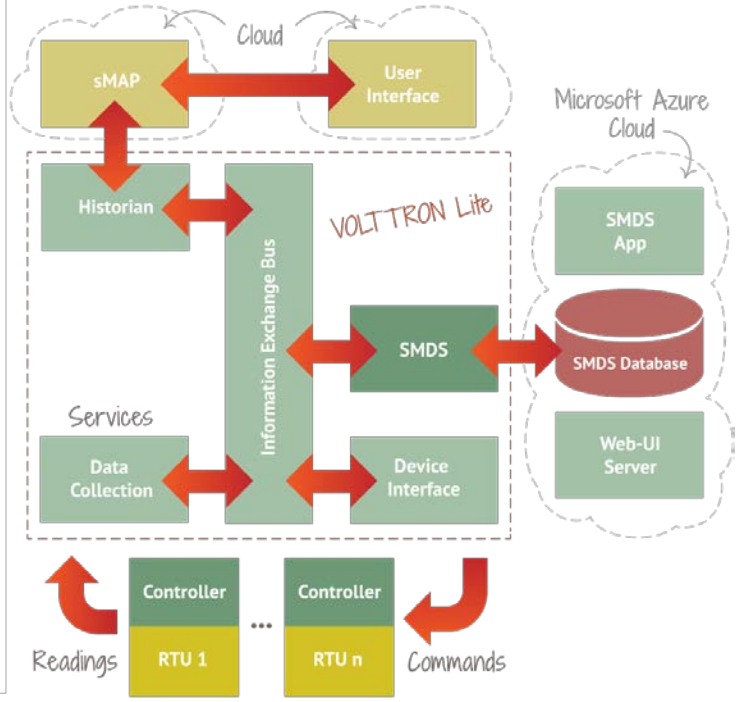
- Demonstration project for networked commercial bldg. RTUs to provide advanced controls and energy services
- Open-source, agent-based platform runs local & remote apps, enables networking & transactions
- Applications (current scope):
  - Advanced control for var. speed drive RTUs
  - Automated fault detection & diagnostics (equip. & schedule)
  - Wireless sensor interoperability
  - Demand response (event-driven, OpenADR, baseline load shape, M&V, cost savings)
  - Match consumption to peak PV output
  - Optimize consumption across multiple RTUs
  - Optimize energy & peak demand (supermarket refrigeration)



Rooftop Unit (RTU) Network Project

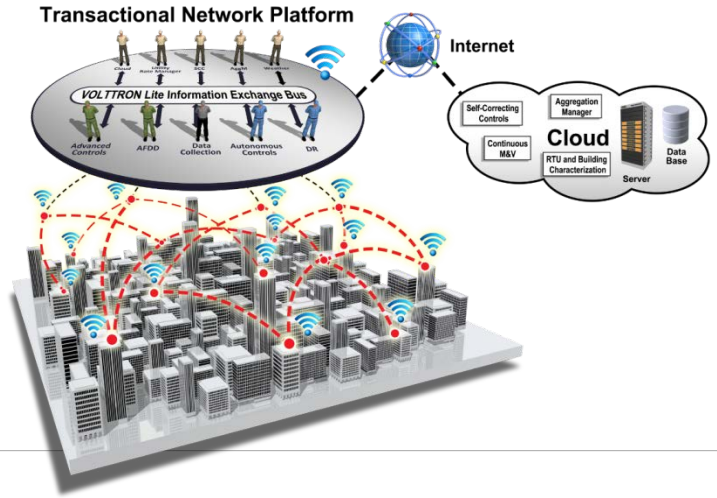
Why:

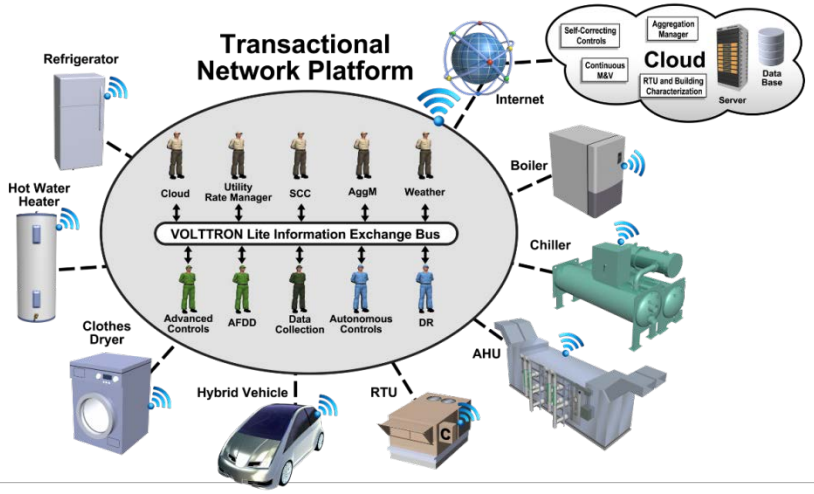
- Operating efficiency of RTUs low due to lack of:
  - Advanced controls to improve part-load efficiency
  - Equipment maintenance
- RTUs cannot easily interact with the grid
- Goals:
  - Develop & validate advanced, control strategies
  - Demonstrate platform for agent-based applications, networking, & transactions
- Transaction-capable network platform enables:
  - Self-correcting controls & automated diagnostics
  - Applications providing continuous M&V, automated energy management, etc.
  - Interactions among networked systems (RTUs with each other, w/ bldg. systems & grid)
  - Applications run in "the Cloud" where the local platform resources are inadequate



Architecture

- Architecture is distributed (current project)
  - Each RTU uses an independent “VOLTTRON” platform
  - Some applications are purely autonomous, others interact across RTU platforms
  - In some future developments:
    - A platform may run applications that control multiple devices within a premises
    - Platforms may be hierarchical, not simply peer-to-peer (e.g., could operate a market and participant applications)





Transactions

The vision for the platform and network involve a variety of possible transactions

- Current effort involves RTU control automation, but is not transactive beyond simple DR
- This presentation focuses on two future use cases under consideration

Example 1: Trading Capacity Rights Within a Facility

- Building (or facility) has commitment that limits peak load (capacity)
- Share of capacity limit assigned to each RTU, based on it's diversified share of peak load
- RTU's exchange capacity rights in real-time to optimize comfort while meeting constraint
- ***Note:*** *transaction-based control within bldg., serves grid objective (no direct interaction)*

Example 2: Diagnostic Services

- Building (or facility) transacts with 3rd-party provider for monitoring & diagnostic analyses, conducted remotely over the network
- Fees may be based on
  - Continual services over a subscription period
  - Fee-for-fault: number and/or magnitude of faults detected or fixed
- ***Note:*** *contract for bldg. energy service (unrelated to grid) promoted by network capability, transactional in sense of real-time fee for service (2nd case)*

Extent

Current work involving intra-building coordination of multiple RTUs

- Includes deployments on buildings at three locations: PNNL, LBNL, and ORNL

Example 1: Trading Capacity Rights Within a Facility

- Limited to a building (or facility) as described
- Concept of managing capacity limit by granting tradable capacity rights can be extended to populations of customers at the level of a feeder, substation, or utility

Example 2: Diagnostic Services

- Extent is defined by the geographic range of the energy service providers target market – could be local, or national

Transacting Parties

In a future transactional network

- Transactions would take place between pairs of automated system nodes acting as agents on behalf of their owner
- E.g., one located at a commercial building and another located at a power systems utility or energy services provider

Example 1: Trading Capacity Rights Within a Facility

- RTU control nodes trade capacity rights with each other based on quantity (kW) and "need" (e.g., excursion from temperature setpoint)
- Asynchronous, bi-lateral, peer-to-peer transactions
- Building/facility acts as market maker
  - Could operate node as an exchange clearing transactions between RTUs

Example 2: Diagnostic Services

- Customer (owner/operator of building or facility) initiates contract
- Third-party service provider

Temporal Variability

Example 1: Trading Capacity Rights Within a Facility

- Trading for relatively short ~5-15 min. capacity relevant for comfort control
- Trading for long-term capacity rights could also take place irregularly over various time scales

Example 2: Diagnostic Services

- Contracts would take the form of a service contract over a specified time period such as monthly or yearly
- Diagnostic evaluations would take place over short time frequencies such as daily (while considering historic base lines over longer periods) to identify equipment performance malfunctions and degradations

Interoperability

Example 1: Trading Capacity Rights Within a Facility

- No implementation to date
- Interoperability required between node platforms within the facility or building could be assured with single-vendor approach
- Extending concept to populations of customers would require more formal interoperability approach between nodes to be defined

Example 2: Diagnostic Services

- If services are Cloud-based:
  - Likely to use proprietary monitoring, diagnostic analysis, & reporting
  - Transfer of measurements from bldg. via node, and any corrective control actions back to building, will require use of a standard protocol
  - Results may be transmitted in report form (e-mail) or in work-order format to a maintenance management system (translate to a proprietary protocol)
- If services are local application based, conformance with node software platform standards are required

Value Discovery Mechanisms and Value Assignment

Example 1: Trading Capacity Rights Within a Facility

- Discovery mechanisms
  - Building or facility level node discovers value of comfort/consumption tradeoff by receiving buy/sell bids from RTU nodes
- Value assignment
  - RTU nodes assign value for capacity to buy or sell by combining forecasted load requirements and comfort objectives resulting from user-set preferences & configurations

Example 2: Diagnostic Services

- Value of discovered through experiential market information regarding what customers are willing to pay to avoided energy costs
- Note: Value discovery & assignment are not as separable for energy service transactions as they are for control transactions

Alignment of Objectives

Example 1: Trading Capacity Rights Within a Facility

- Objectives of utility met through customer attempting to reduce costs by managing peak demand
- Objectives of customer met by optimized distribution of capacity rights across RTU units through the intra-building trading of capacity rights

Example 2: Diagnostic Services

- Customer objectives are addressed through improved performance and efficient use of operational and capital expenditures
- Societal objectives are addressed through more efficient use of energy (through better performing equipment)

Stability Assurance

Example 1: Trading Capacity Rights Within a Facility

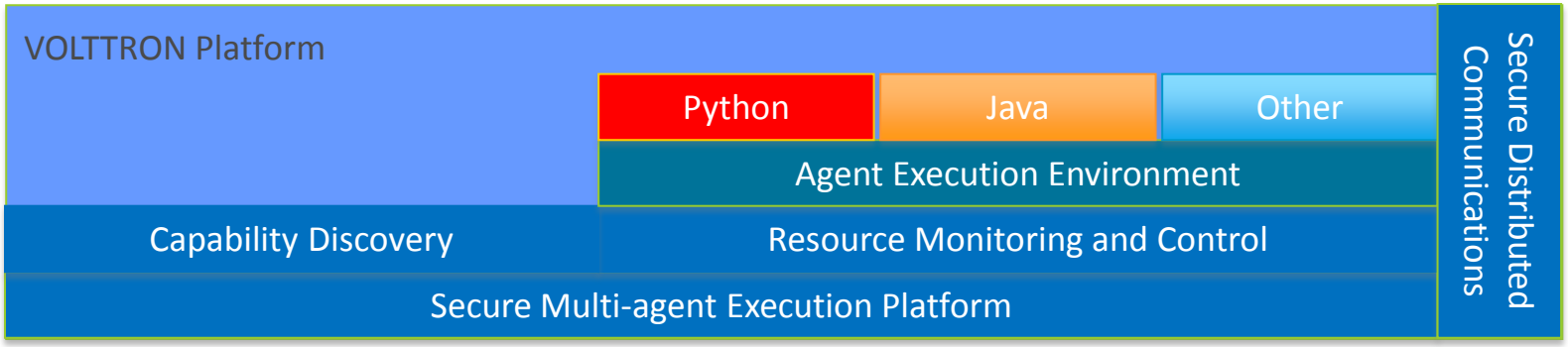
- System of capacity rights (with aggregated RTU capacity limits operating under the total capacity limits of the building/facility) ensures stability with respect to peak load management objective

Example 2: Diagnostic Services

- Not a control objective; stability is not an issue

VOLTTRON™ Platform

- VOLTTRON is a software platform for next generation distributed control applications for integrating buildings and power grid
- Proven through simulation, prototypes and field deployments
- Flexible, modular and language-agnostic
- Open-source*, easy to extend, already being used by external collaborators
- Maintain security and manage platform resources
- Services for applications to find each other



*Some parts of the VOLTTRON platform currently need a license from PNNL; PNNL is considering making those freely available

Participating Agencies and Organizations

- Funded by DOE EERE Building Technologies Office, FY13 – FY14
- PNNL previously developed VOLTTRON platform
- PNNL, ORNL, LBNL developing applications
- PNNL performing RTU control demonstrations
- ORNL and LBNL involved in other related RD&D work

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