VOLTTRON™ as an Open Source Platform for Energy Management Applications

Software Framework for Transactive Energy
Case Western Reserve University
Cleveland, OH

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History

May 2013  Attended AAMAS conference 2013 in MN, which had a VOLTTRON™ demonstration

July 2013  Visited PNNL and was formally introduced to VOLTTRON™

Aug 2013  Started VOLTTRON™ installation for home energy management research

Sept 2013  Started discussion with PNNL regarding VOLTTRON™ issues and applications

Oct 2013  Started participating in VOLTTRON™ twice-monthly calls

May 2014  Submitted a conference paper using VOLTTRON™ as an energy management platform for buildings (ISGT 2014 Turkey)

Today   Have a working energy management platform developed on VOLTTRON™
Problem Statement

- Buildings consume over 40% of the total energy consumption in the U.S. Over 90% of the buildings in the U.S. are either small-sized (<5,000 square feet) or medium-sized (between 5,000 sf and 50,000 sf).
- These buildings typically do not use Building Automation Systems (BAS) to monitor and control their building systems from a central location.
Develop an open source, low cost, low power consumption platform that can monitor and control majority of loads in buildings to **improve energy efficiency** and **facilitate demand response** implementation.

Electricity use in buildings:
- **HVAC**: 30%
- **Lighting load**: 38%
- **Plug load**: 6%
- **Others**: 26%

Three major loads in buildings:
- HVAC
- Lighting loads
- Plug loads

Source: EIA - Commercial Building Energy Consumption Survey (CBECS)
[http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=consumption#e1a](http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=consumption#e1a)
Solution Approach

VOLTTRON™ was used as a platform to host our software. It is open-source and not hardware specific.

VOLTTRON™ Features:
- Open-source platform
- Built-in security module
- Built-in resource management capability
- Distributed and decentralized control based on a multi-agent system
- Can be installed in a low-cost, low-power embedded system
- Sensitive to CA Title 24 requirements
Solutions for Small Buildings

- **Plug Load Controllers**
  - ZigBee mesh

- **Power Meters**

- **HVAC Controllers**

- **Lighting Load Controllers**
  - ZigBee mesh

- **Energy Efficiency & Renewable Energy**
Solutions for Larger Buildings

- ZigBee mesh
- Power Meters
- HVAC Controllers
- Plug Load Controllers
- Lighting Load Controllers
- Light Switches
BEMOSS on Various Embedded Devices

**CPU:** 700 MHz ARM processor  
**RAM:** 512MB SD  
**Ethernet:** 10/100 RJ45  
**USB 2.0:** Available  
**Price:** $35  
**Size:** 3.4”x2.2”

**CPU:** 1GHz ARM Cortex-A8  
**RAM:** 512MB SD  
**Ethernet:** 10/100 RJ45  
**USB 2.0:** Available  
**Price:** $55  
**Size:** 3.4”x2.1”

**CPU:** Dual core 1.2GHz ARM Cortex-A9  
**RAM:** 1GB SD  
**Ethernet:** 10/100 RJ45  
**USB 2.0:** Available  
**Price:** $220  
**Size:** 4.5”x4.0”
Virginia Tech’s Agent Development on VOLTTRON™
Software Used

Agent coding
• Python
• C++

Database
• sMAP
• PostgreSQL

User Interface
• Django
• jQuery
• ZeroMQ
• Java script
• Twitter Bootstrap
VOLTTRON™: Beneficial Features

- Scalability
- Open architecture
- Ease of deployment
- Built-in security module
- Interoperability (through IEB)
- Resource guarantee for agents
- Can be installed in a low-cost, low-power embedded system
- Distributed and decentralized control based on a multi-agent system
- Language-agnostic environment (supports development in Python, Java, JADE, Binary, etc.)
- Have community support
VOLTTRON™: Room for Improvement

- GUI tool may be added for agent management and debugging.
- VOLTTRON™ 1.2 does not support agent mobility and cloning service.
- VOLTTRON™ 1.2 does not follow any agent communication standards (e.g., Foundation of Intelligent Physical Agents - FIPA).
- VOLTTRON™ 1.2 does not address interaction of multi-agent systems.
- VOLTTRON™ 1.2 does not provide an easy database interface (e.g., MySQL, PostgreSQL, Oracle, etc.)
- Additional security features, may be available in VOLTTRON™ 2.0.
In-house BAS Operating System

<table>
<thead>
<tr>
<th></th>
<th>PC</th>
<th>PandaBoard</th>
<th>BeagleBone</th>
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</thead>
<tbody>
<tr>
<td>VOLTTRON</td>
<td>20 minutes</td>
<td>1 hours 20 minutes</td>
<td>2 hours 15 minutes</td>
</tr>
<tr>
<td>UI</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Database (PostgreSQL)</td>
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Thank You

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Professor and Director
Virginia Tech – Advanced Research Institute
Extra slides
Electricity Use in Office Buildings

Three major loads in buildings:
- HVAC
- Lighting loads
- Plug loads

Electricity use in buildings

Source: EIA - Commercial Building Energy Consumption Survey (CBECS)
http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=consumption#e1a