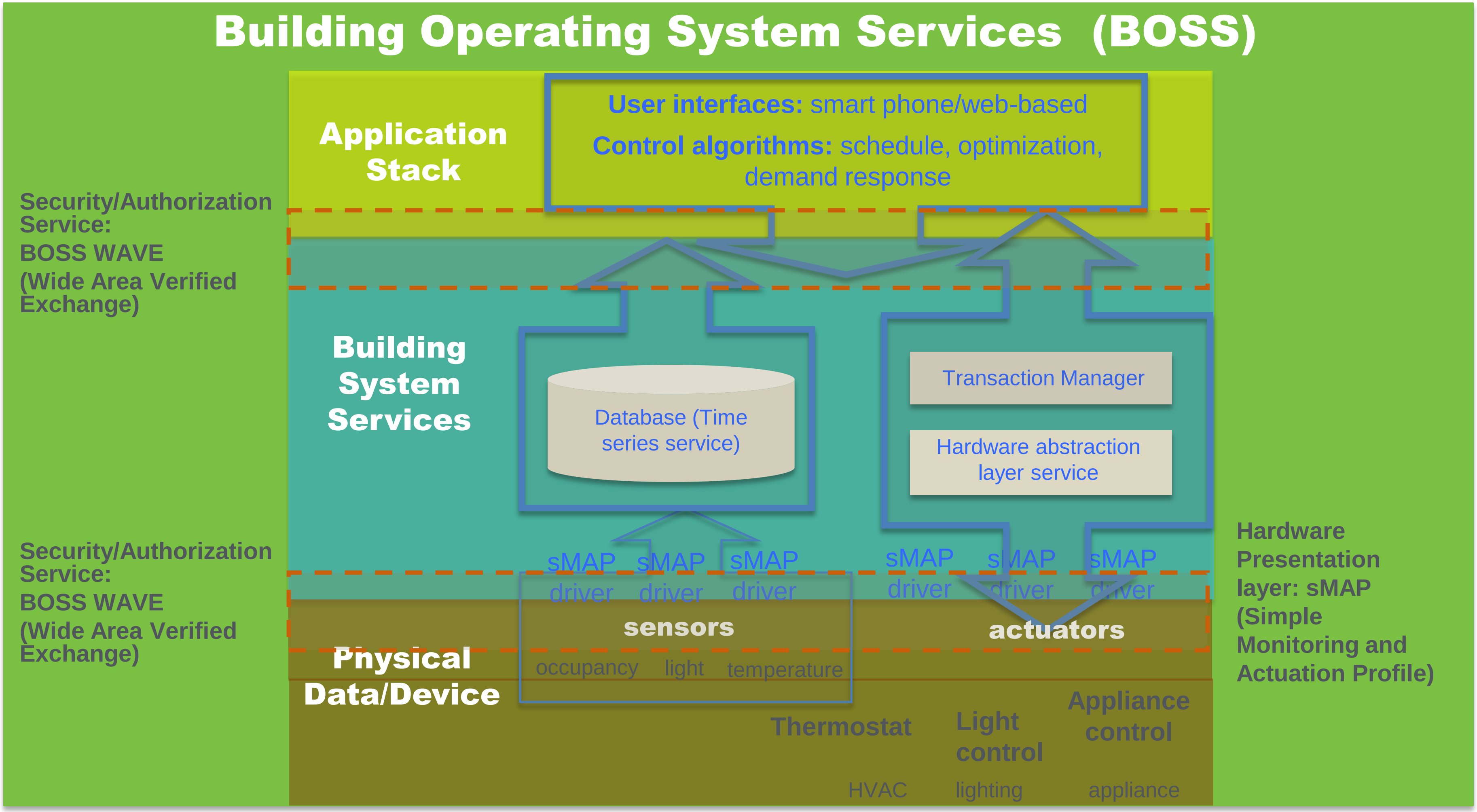
Software-Defined Solutions for Managing Energy Use in Small to Medium Sized Commercial Buildings

2014 Building Technologies Office Peer Review



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

Therese Peffer, therese.peffer@uc-ciee.org
California Institute for Energy & Environment, UC Berkeley

Project Summary

Timeline:

Start date: **December 09, 2013 (New Project)**

Planned end date: **October 31, 2014**

Key Milestones:

1. Successful operation of thermostat, lighting controller & general load controller, Oct 31, 2014
2. Successful integration of hardware with BOSS software platform, Oct 31, 2014
3. Software apps display sufficient maturity to allow full evaluation of BOSS system, Oct 31, 2014

Budget:

Total DOE $ to date: $60,710

Total future DOE $: $440,561

Target Market/Audience:

Small and medium commercial building owners/tenants, manufacturers of equipment and suppliers of services.

Key Partners:

California Institute for Energy & Environment
Software Defined Buildings/EECS/UC Berkeley
Western Cooling Efficiency Center/UC Davis
Lawrence Berkeley National Laboratory
Building Robotics

Project Goal:

Develop a working prototype of an open software-architecture, open source Building Automation System (BAS) for small commercial buildings, based on Building Operating System Services (BOSS). The prototype includes a plug-and-play thermostat, lighting and general controllers, user interface with display, system set-up and auto-mapping.

Purpose and Objectives

Problem Statement: Light commercial buildings (5k-50k sf) account for 42% of the floor area of US commercial buildings, yet do not benefit from Building Automation Systems. These buildings have extremely varied usage and different ownership, operation, and bill payment; BAS operators' skills are likely limited.

Target Market and Audience:
- 43 billion sf, ~700 billion kWh/year, ~2 billion MMBtu/year fuels
- Stage 1—Energy Efficiency Application (App) Developers, Thermostat Vendors, Lighting Controls Vendors, Commercial Equipment Vendors (e.g., copiers)
- Stage 2—RTU Vendors, Lighting System Vendors
- Primary Vendors to Small Commercial Buildings (e.g., security/alarm companies)

Impact of Project:
- 1st R&D Year—Open architecture shows potential for vendor access to market
- 2nd&3rd R&D Years through 1 year after project—enables app development, stage 1 energy efficiency apps offered by vendors, service offered by initial primary vendors - 15% energy savings in 1% of market.
- Years 2-3 Post—Stage 2 apps offered by vendors - 25% savings in 5% of market.
- Years 3+ Post—Other primary vendors - 25% savings in 25+% of market - **$5B/yr.**

Approach

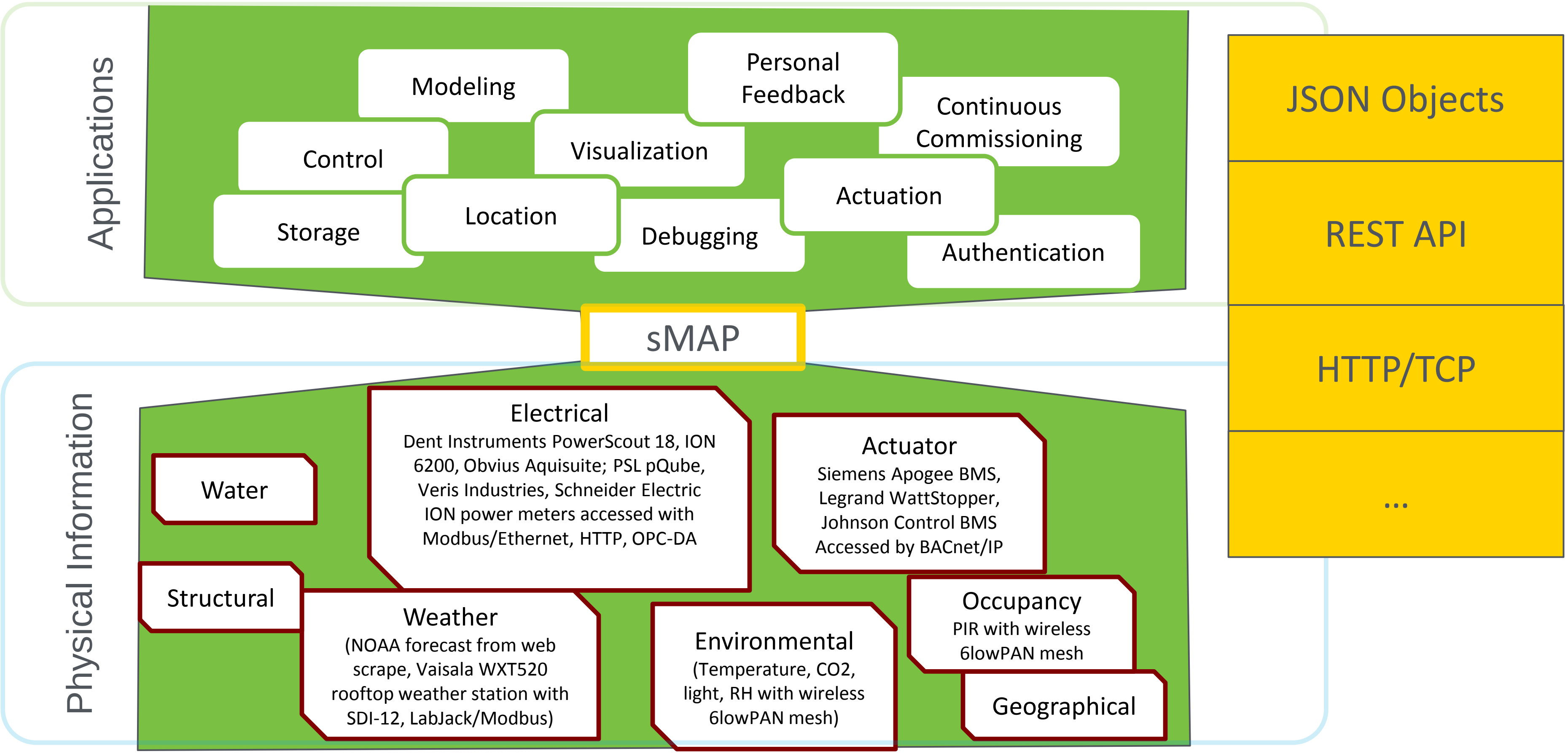
Approach: Because the BOSS platform is built on a RESTful web services integration of heterogeneous data, the architecture is inherently *scalable* to adapt the size of the network (e.g., of sensors or other nodes) to suit smaller or larger buildings or provide greater or fewer data points.

Key Issues: All communication (e.g. commands sent, sensor data published, subscription requests) are secure (BOSS Wide Area Verified Exchange (BOSSwave)). Simple Monitoring and Actuation Profile (sMAP) drivers provide agnostic physical access to sensors, actuators, or data streams—can be WiFi, ZigBEE, Ethernet, BACnet/IP etc.

Distinctive Characteristics: The key innovations are a ***layered open software architecture***, and the data aggregator and archiver **sMAP**. The modular architecture is the disruptive technology to the market as a means for third parties to easily create new applications (control algorithms, diagnostics, visualization) or add new devices (occupancy sensors, actuator/monitor for specific load), while radically reducing cost of implementation.

sMAP – simple Monitoring and Actuation Profile

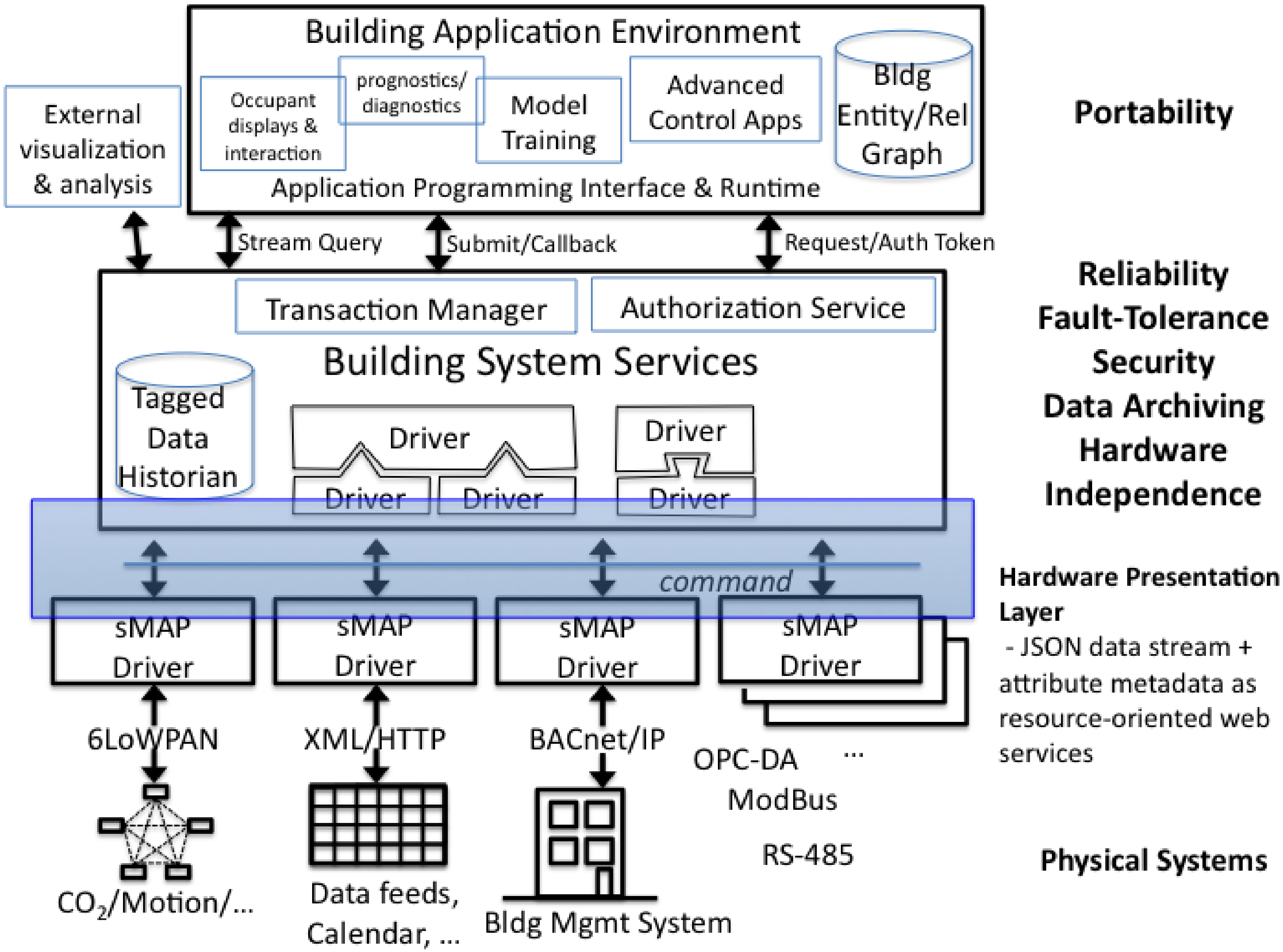
Uniform Access to Diverse Physical Information



www.openbms.org

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

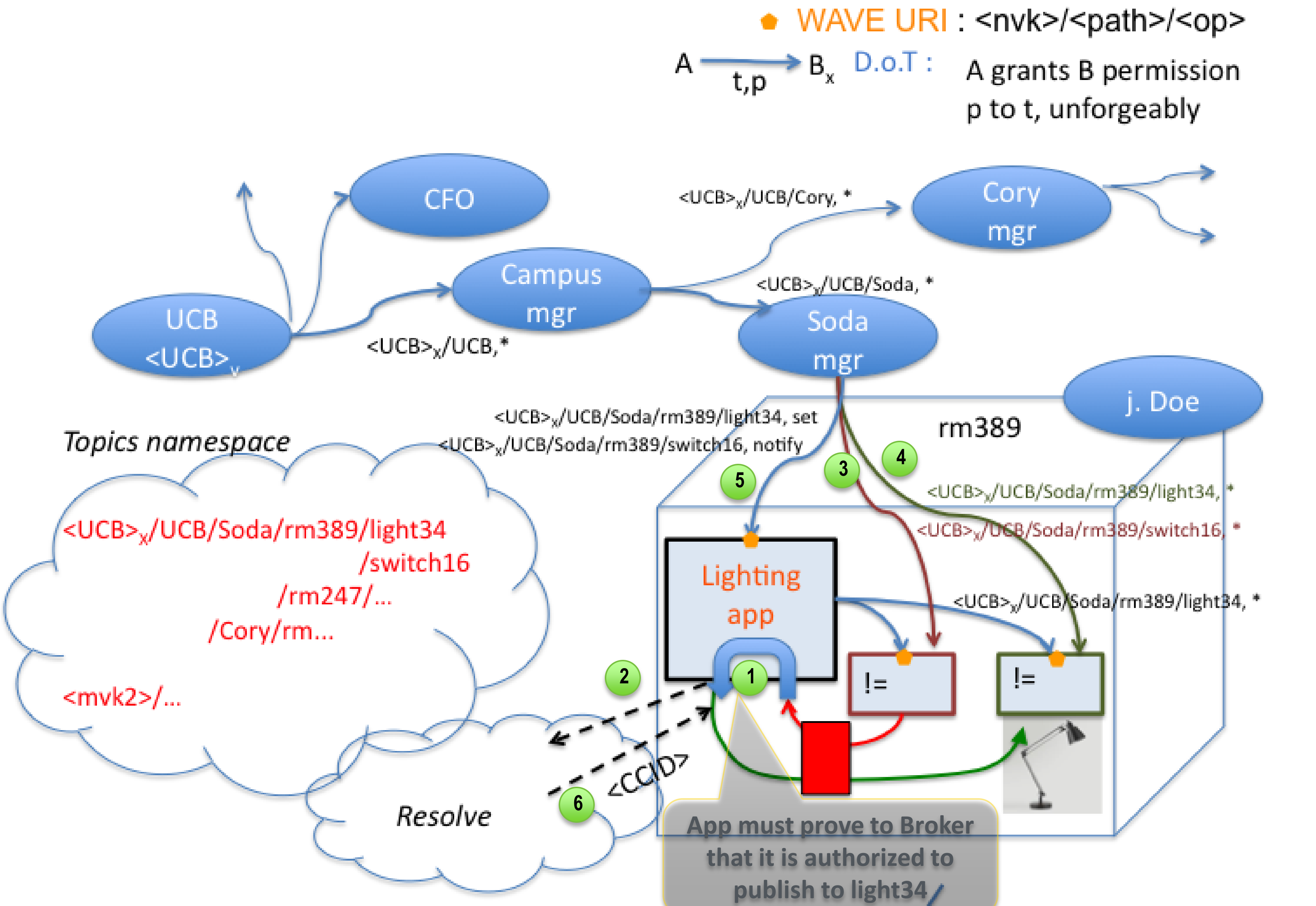
Building Operating System Services (BOSS)



Security: BOSS Wide Area Verified Exchange (BOSSwave)

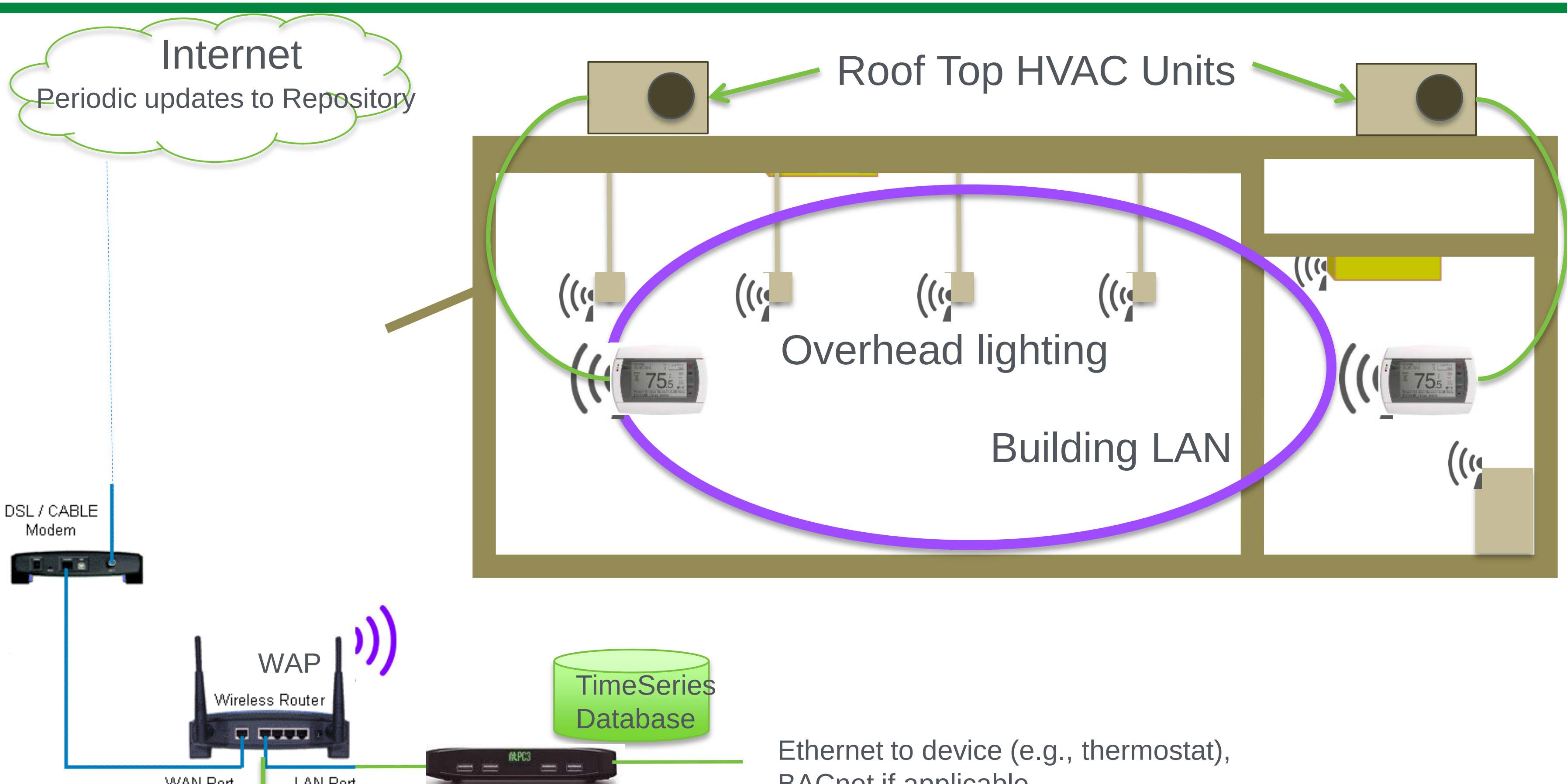
- Web of trust model
- Decentralized
- Push to (multiple) subscribers – not poll
- Revocation
- Verify
  - Origin, Authorization of Operation, Target
- Limit
  - Processing of unauthorized ops, bandwidth of fanout
- Tolerate
  - Intermittent connection

BOSSwave



WAVE URI : <nvk>/<path>/<op>
A t,p B x
D.o.T :
A grants B permission p to t, unforgeably
CFO
Cory mgr
UCB <UCB>x
Campus mgr
Soda mgr
j. Doe
rm389
<UCB>x/UCB/Cory, *
<UCB>x/UCB/Soda, *
<UCB>x/UCB,*
<UCB>x/UCB/Soda/rm389/light34, set
<UCB>x/UCB/Soda/rm389/switch16, notify
<UCB>x/UCB/Soda/rm389/light34, *
<UCB>x/UCB/Soda/rm389/switch16, *
<UCB>x/UCB/Soda/rm389/light34, *
Topics namespace
<UCB>x/UCB/Soda/rm389/light34
/switch16
/rm247/…
/Cory/rm…
<mvk2>/…
Resolve
<CCID>
Lighting app
!=
!=
1
2
3
4
5
6
App must prove to Broker that it is authorized to publish to light34

Proposed openBAS



BOSS server

FITPC with openBAS platform including:

- sMAP sources (instances of drivers for particular devices)
- Discovery
- Repository:
  - TimeSeries Archiver/database
  - sMAP drivers
  - Config
  - Discovery registry

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

Progress and Accomplishments

Lessons Learned: Some commercially available controllers more easily integrated into platform than others (e.g., reliability, open Application Programming Interface (APIs))

Accomplishments: Wrote several device interfaces (sMAP drivers). Implemented Auto-discovery (PlugNPlay) of device (e.g., find device on network, discover type of device, autoload appropriate driver). Developed communication and data security (BOSSwave). Demonstrated the implementation of two different thermostats, two different lighting control devices, and a general controller.

Market Impact:
- Efforts—Including robust authentication and authorization capability, see Project Integration (p.11) for collaboration and coordination regarding APIs and accepted standards.
- Actual impact—On track for end of year 1 architecture to be compelling for potential equipment vendors to open APIs to monitoring and actuation requests, and energy efficiency vendors to develop applications.

Awards/Recognition:

Project Integration and Collaboration

Project Integration:

- Initiated conversations with key equipment vendors (e.g., lighting controls) regarding opening API to monitoring and actuation access.
- Software architecture builds upon accepted standards (E.g., WiFi, MQTT-3)

Partners, Subcontractors, and Collaborators:

California Institute for Energy & Environment, UC Berkeley: *Project management and administration, market delivery strategy plan*

Software Defined Buildings, Electrical Engineering Computer Science, UC Berkeley: *System integration, software platform, user interface, apps*

Western Cooling Efficiency Center, UC Davis: *HVAC controller and apps, demos*

Lawrence Berkeley National Laboratory: *Lighting controller and apps, FLEXLAB*

Building Robotics: *Software platform and applications*

Communications: EPRI's Power Delivery & Utilization Program, Software Defined Buildings Summer and Winter retreats (UC Berkeley/industry), Green Tech Center/ITU/SDU (Denmark), Centre for Sustainable Communications in KTH (Sweden), Saga University (Japan), Daikin Konwakai (St. Michael's, MD)

Next Steps and Future Plans

Next Steps and Future Plans:

Year 1:

- Implement user interfaces for different types of users (occupant, building manager, installer/app vendor)
- Develop market delivery strategy plan
- Integrate the software with hardware and user interface
- Test increasingly sophisticated control algorithms
- Demonstrate BOSS capabilities

Year 2:

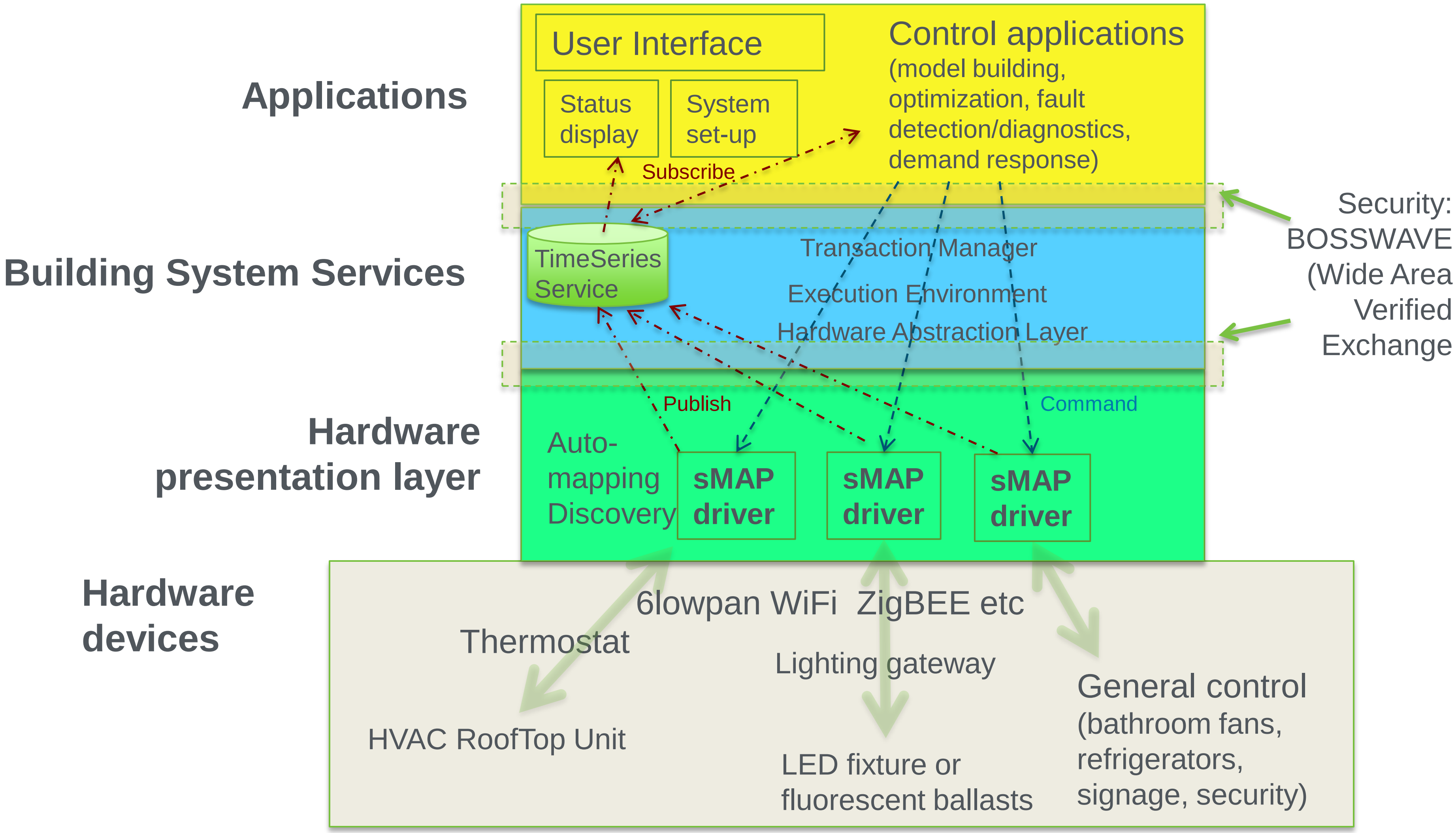
- Test-bed implementation in LBNL's FLEXLAB
- Refine/expand controller capabilities, sensors, and user interface

Year 3:

- Deployment in three buildings
- Refine/expand controller capabilities (e.g., DR) and user interface
- Evaluate, measure, and verify

REFERENCE SLIDES

BOSS Software platform = backbone of OpenBAS



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

Project Budget

Project Budget: $501,271 project budget
Variances: More travel than anticipated (participation at BTO review and CMU workshop)
Cost to Date: $60,710 spent (12% budget), $0 cost share recorded of $12,500 project budget (0% budget).
Additional Funding: None

Budget History			
December 9, 2013– FY2013 (past)		FY2014—October 31, 2014 (current)	
DOE	Cost-share	DOE	Cost-share
$0	$0	$60,710	$0

Project Plan and Schedule

Project Schedule												
Project Start: Dec 9, 2014		Completed Work										
Projected End: Oct 31, 2014		Active Task (in progress work)										
Go-No go decision point Oct 31, 2014		Milestone/Deliverable (Originally Planned)										
		Milestone/Deliverable (Actual)										
	FY2013				FY2014				FY2015			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Current/Future Work												
Q3 Task: Functioning OpenBAS Software Platform												
Q3 Task: Integrated three hardware devices												
Q4 Task: Developed software tools (display, setup, automapping)												
Q4 Task: Developed user interface												
Q1 Task: Market delivery strategy plan												
Q1 Milestone: Demonstration of operation of hardware devices												
Q1 Milestone: Demonstration of integration of hardware with software platform												
Q1 Milestone: Demonstration of software applications												