OpenMortar.io: An Extensible Sensing and Control Platform for Building Energy Management

2014 Building Technologies Office Peer Review

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

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Project Summary

Timeline:

Start date: November 2013 **(New Project)**

Planned end date: November 2016

Key Milestones

1. Functional Requirement Analysis; 03/14
2. First Version of Mortar.io; 04/14
3. Benchtop HVAC, Lighting, CMEL Integration; 10/14
4. Deploy in Scaife Hall Building at CMU;

Key Partners:

Bosch RTC	
Lutron Electronics	

Budget:

Total DOE $ to date: $232,670

Total future DOE $: $1,925,976

Project Goal:

This project will develop and test an open-source software platform for enabling seamless integration of systems in small and medium-sized commercial buildings, in a way that is secure, scalable and simple to configure/install. The target systems will include HVAC, lighting and miscellaneous electrical loads (CMELs).

Target Market/Audience:

Small and medium sized building owners / managers.

Purpose and Objectives

Problem Statement: Sensing and control systems for small and medium-sized buildings rely on proprietary communication protocols and vendor-specific solutions, thus making integration of different systems difficult and preventing us from treating buildings as computing platforms for which applications can be developed without detailed knowledge of the underlying hardware.

Target Market and Audience: Our market is small and medium-sized commercial buildings in the US (3,700 BTU in 2003). The audience are the owners and building managers of these facilities.

Impact of Project: This project plans to transform the building automation industry in the small/medium sized building sector by presenting an open-source platform integrate different building components. Expected milestones:

a. 1st year: open source platform tested on benchtop demonstration

b. 3rd year: platform tested on three buildings and integrated into one or more commercial platforms

c. After 3rd year: wide community and industry adoption of platform

Approach

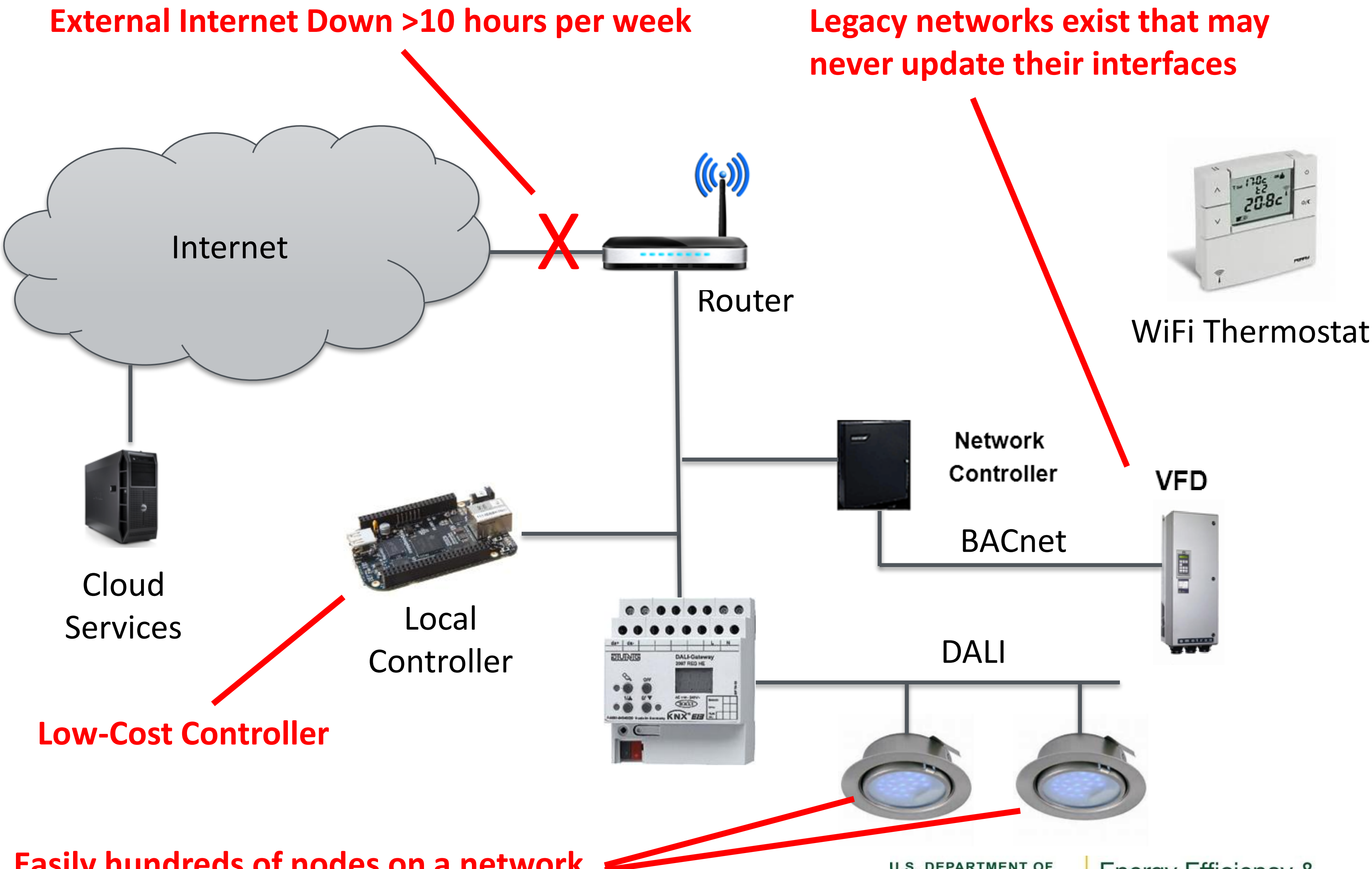
Approach: The team has followed a functional requirements elicitation process by interviewing key stakeholders (facility managers and building owners) in order to better guide the software development. The software development project was then divided into five components: the adaptor library, the viewer, the executive and the composer. Specific sensing and control devices were selected for testing the platform and a spiral development process is being followed using the results of these tests.

Key Issues:

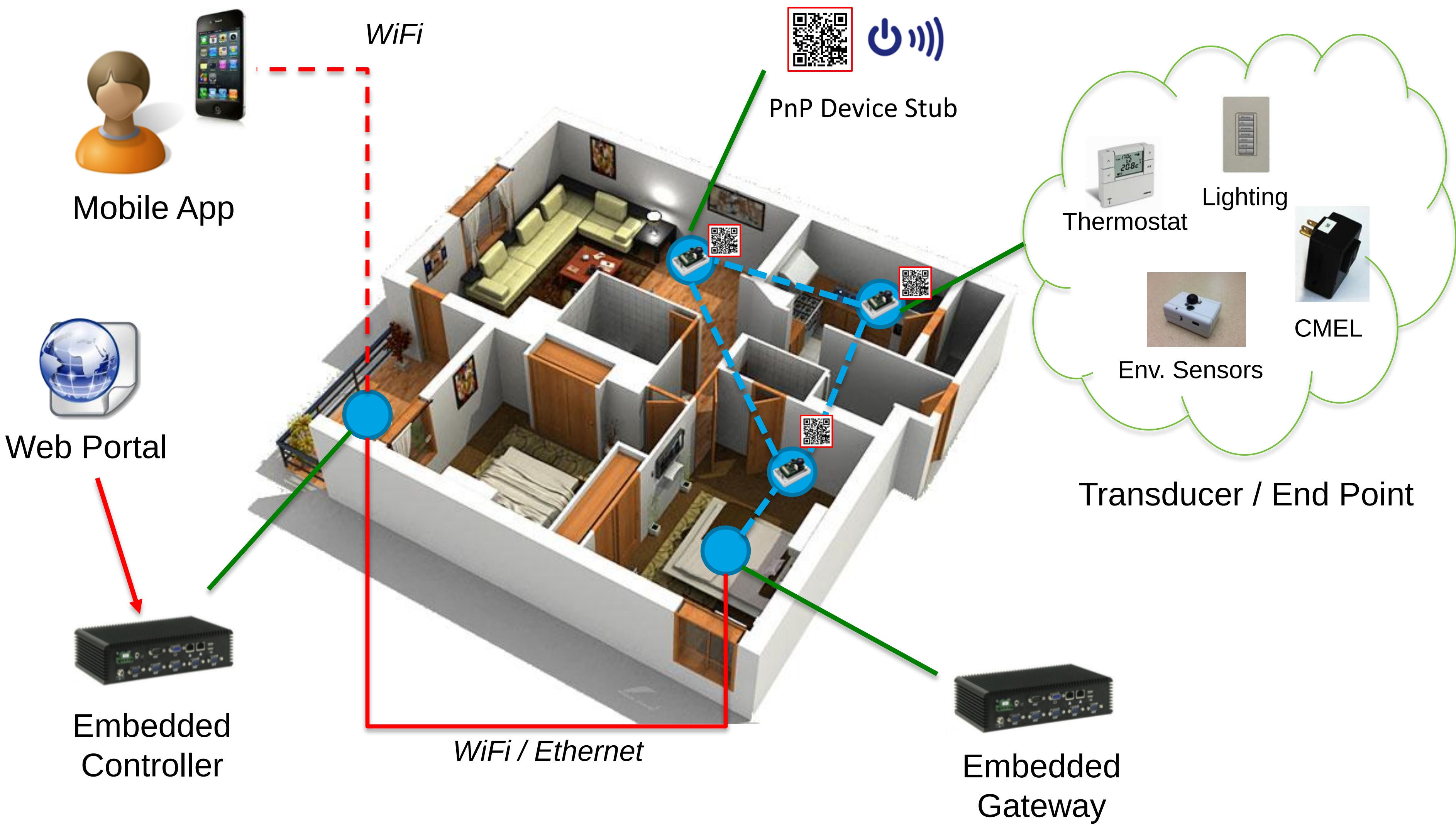
- Designing a secure and scalable plug-and-play process for building components.
- Designing and implement an architecture and supporting meta-data schema for building sensors and controls.

Distinctive Characteristics: Secure and scalable Publish-Subscribe software architecture. Simple plug-and-play device management. Fine-grained access-control models. Clear separation between data and meta-data. Minimalistic data schemas.

Typical Building Scenario



Mortar.io Components



TCP/IP Network

Fieldbus Network

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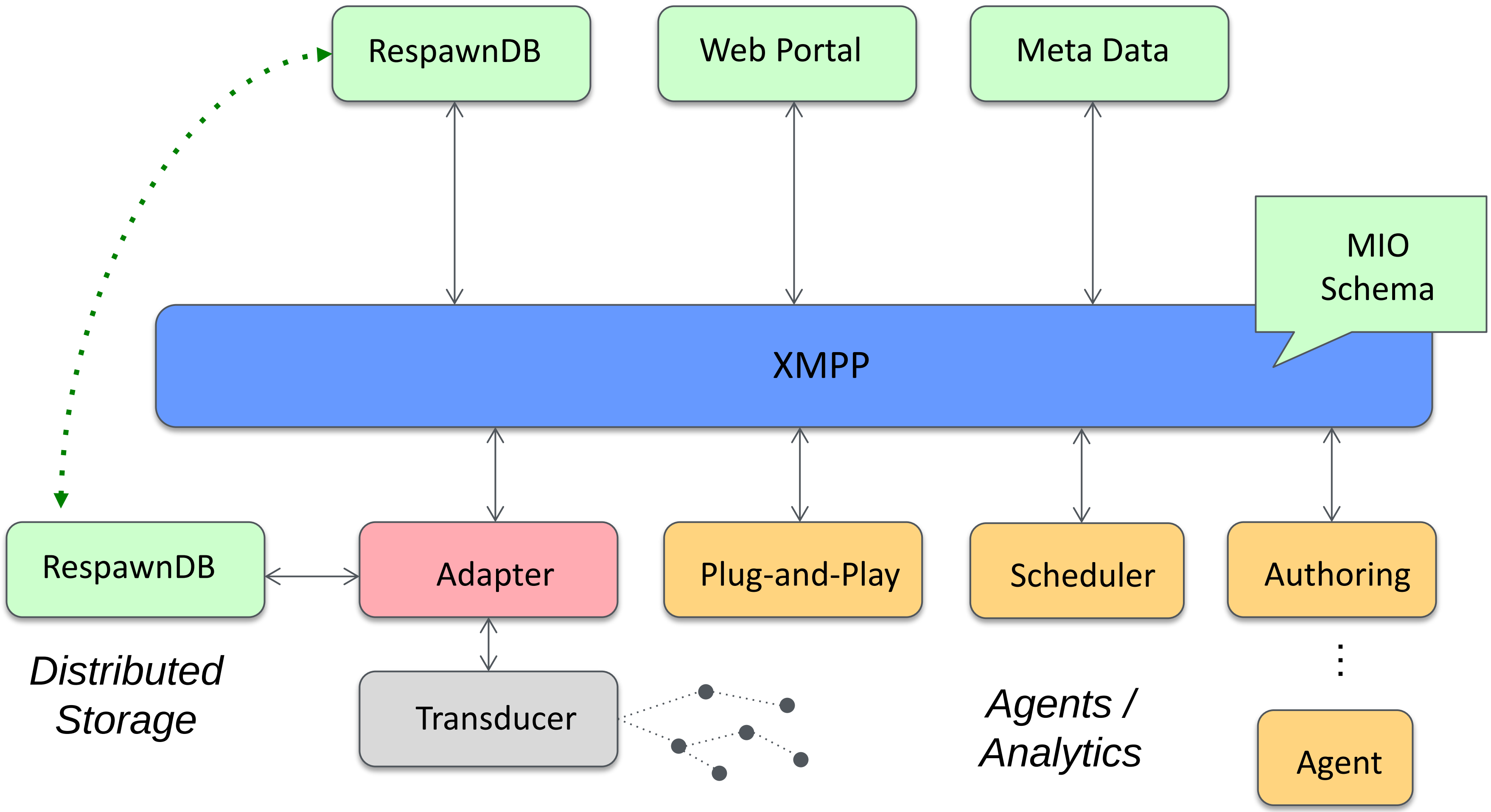
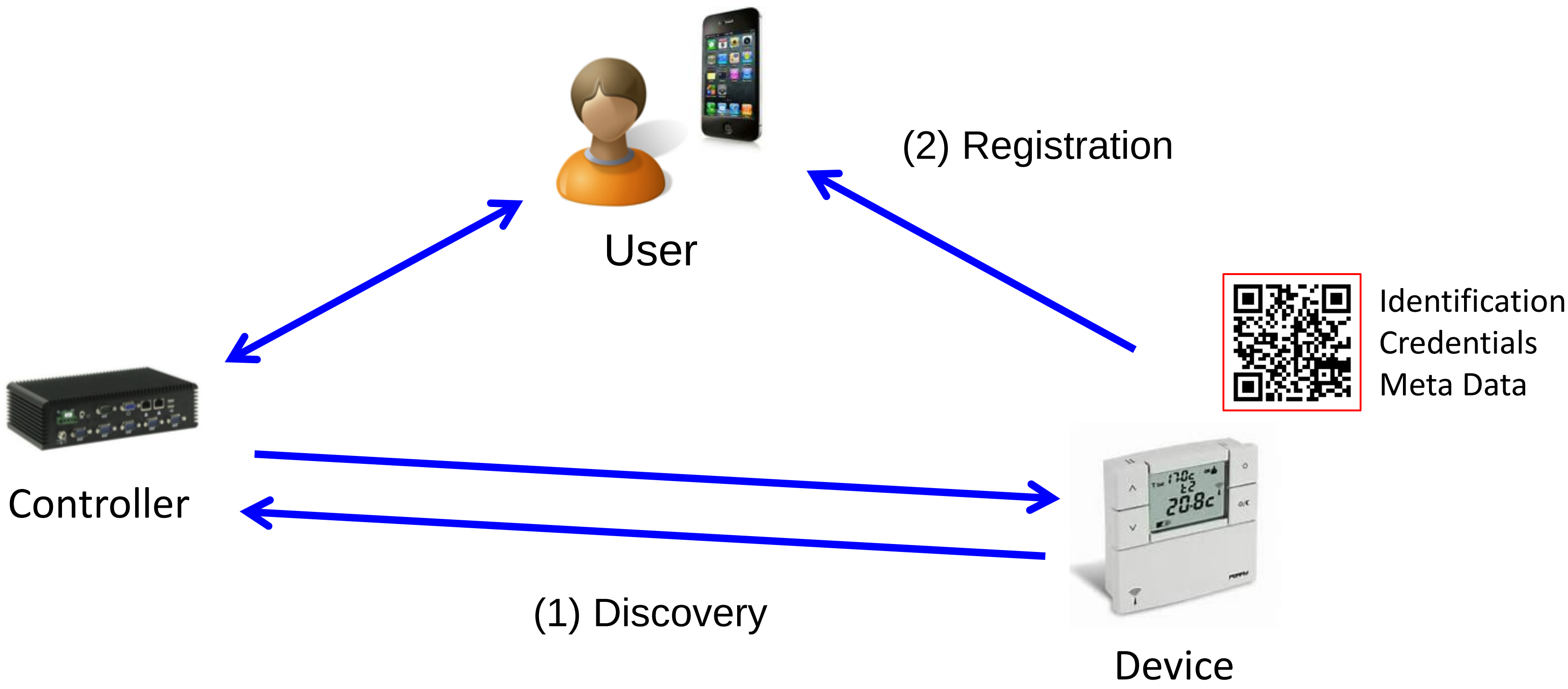
Mortar.io Highlights

- **Networking**
  - Publish-Subscribe Architecture
  - Device-Level Access Control
  - Automatic Discovery / Plug-and-Play
- **Storage**
  - Multi-Resolution Time Series Database
  - Cloud-to-Edge Data Storage
    - High-resolution data stored at routers
    - Aggregates intelligently pushed to server side
- **Extensible Device Interfaces**
  - FireFly Wireless Sensing Platform, BACnet, Android@Home, NEST thermostat, Web Services, ModBus, PUP, Zigbee, Zwave

Mortar.io Architecture



Plug-and-Play



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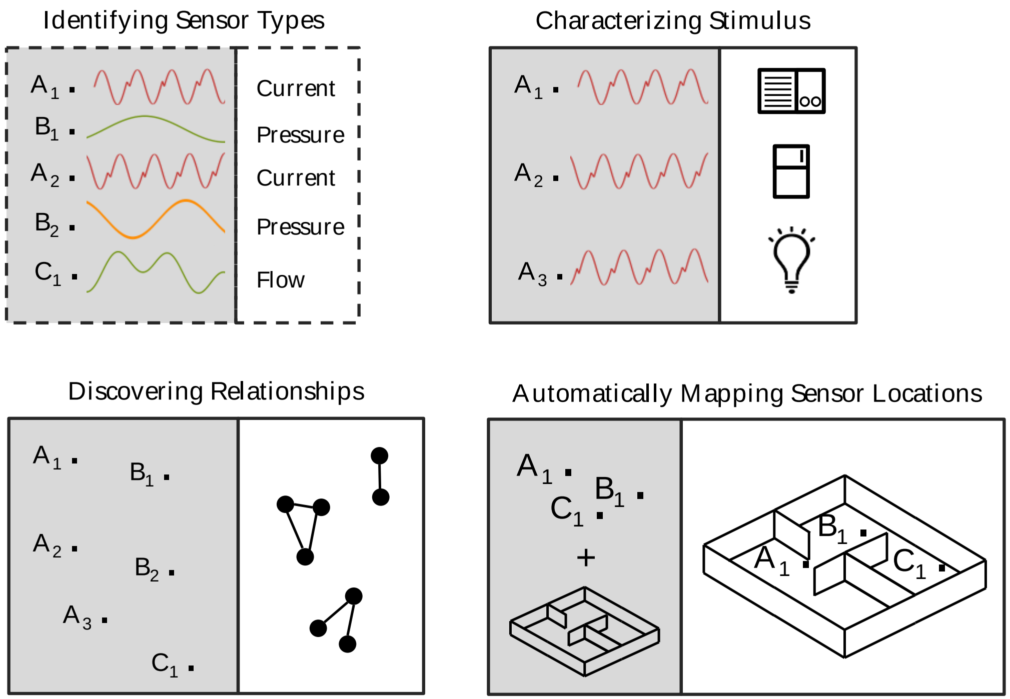
Transducer Auto-Mapping

- How can we locate and validate correct placement of sensors?
  - Classify sensor type
  - Classify sensor stimulus
  - Use context to discover relationships
  - Map relationships into the physical space



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Progress and Accomplishments

Lessons Learned: In our work on plug-and-play, we have learned that current state-of-the-art approaches for secure pairing and authentication of hardware devices is not wide-spread or standardized. Approaches exist, but most of them require an external Internet connection.

Accomplishments:

1) Design of a lightweight meta-data model for building automation systems.
2) Design of a secure plug-and-play protocol that can securely pair a device with our system without an external Internet connection.

Market Impact: We are working closely with our industrial partners to mitigate potential adoption barriers based on cost or complexity of our solution.

Awards/Recognition: N/A

Scaife Hall Deployment

40,000 sq ft, 5 story, 140 room, 8 hallway, academic building built in 1962 with classrooms, auditorium, offices and labs.

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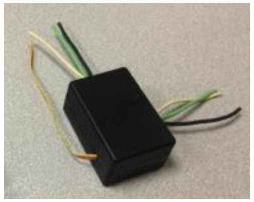
Instrumentation

EnFuse Panel Meters
Electricity usage
11 x 48 = 528 feeds

AutoMatrix PUP Controller
HVAC
30 x 6 (inter-building) x 24 = 4320 feeds

Thermostat
802.15.4 Pneumatic thermostat with branch pressure monitoring
70 feeds



Fan Control Units
802.15.4 units for heat exchangers in each room
Control and power metering
170 feeds

Lutron Lighting Controller
277 VAC lighting control
15 x 2 = 30 feeds

FireFly Environmental
Light, temp, humidity, sound, motion, vibration, pressure
120 feeds

Chilled Water and Steam
Temperature and flow-rate
2 x 2 = 4 feeds

Localization
Mobile Phone / Tag Localization
Feed per person

Project Integration and Collaboration

Project Integration: Personnel from Bosch RTC attends the weekly meetings and contributes to the project regularly. We actively use a wiki and source-code versioning system.

Partners, Subcontractors, and Collaborators:

Bosch RTC (partner/subcontractor),
Lutron Electronics (collaborator)

Communications:

Texas Instruments, February 2014
Intel Corp, March 2014

Next Steps and Future Plans

1) Implement prototype plug-and-play system
2) Complete adapters for target system components
   - benchtop demonstration
3) Deploy in first target building
4) Deploy and evaluate configuration process in two additional buildings
   - Experiment with automated mapping and set point configuration techniques.
5) Evaluate end-to-end system's effectiveness on improving efficiency, maintenance and user comfort.

REFERENCE SLIDES

Project Budget

Project Budget: Total project budget over 3 years is $1.9M
Variances: None to date
Cost to Date: $232,670
Additional Funding: N/A

Budget History					
11/1/13– FY2013 (past)		FY2014 (current)		FY2015 – 11/1/16 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$0	$18,569	$211,417	$30,947	$1,672,130	$253,843

Project Plan and Schedule

Go/no-go decision points

- Year 1: Functional Benchtop Demo
- Year 2: Functional Scaife Deployment

Project Schedule		
Project Start: 11/1/13		Completed Work
Projected End: 11/1/16		Active Task (in progress work)
	◆	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)
Past Work												
Task 1.0: Stakeholder Interviews												
Task 2.0: Code repository and project management framework with wiki access												
Current/Future Work												
Task 3.0 Develop Initial Device Adapters												
Plug-and-Play Agent												
Task 3-6 Working Benchtop demo												
Task 7.0 Scaife Hall Deployment												
Task 11.0 Porter and Smith Deployment												

Project Abstract (<150 Words)

- The objective of this project is to develop, deploy, test and refine an open-source and open architecture software platform for secure building management applications that is easy-to-configure, scalable and robust. The platform will be specifically tailored towards small- and medium-sized buildings to advance opportunities for energy efficiency in these building sectors by enabling easier access to existing Building Automation Systems (BAS) and introducing controls where none might currently exist. The system will include plug-and-play functionality that simplifies the process of adding new devices into the system even for non-experts. This will include auto-mapping and auto-configuration functionality for setting up default configurations. The target systems will include HVAC, lighting and miscellaneous electrical loads (CMELs). By the end of the third year, the system will have been deployed across three test buildings on CMU's campus.