Controlling Actuation in Central HVAC Systems in Buildings

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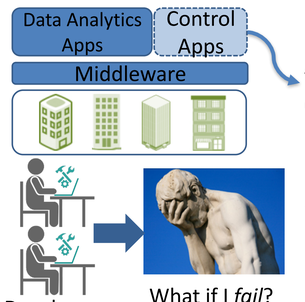
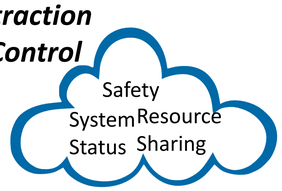
Need for Control Platform



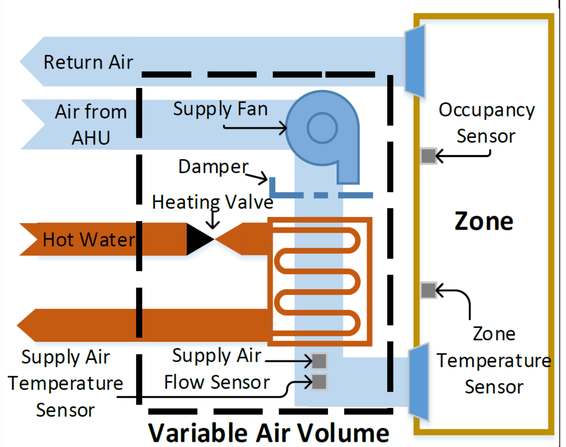
Apps with fine-grained ***control*** are missing

Need Abstraction of Control

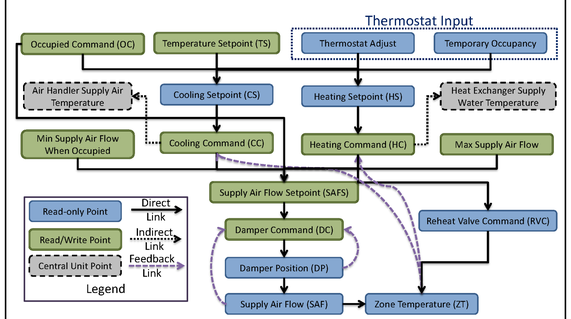


We propose
"Building Control Engine"
to provide high level view of control.

HVAC Background

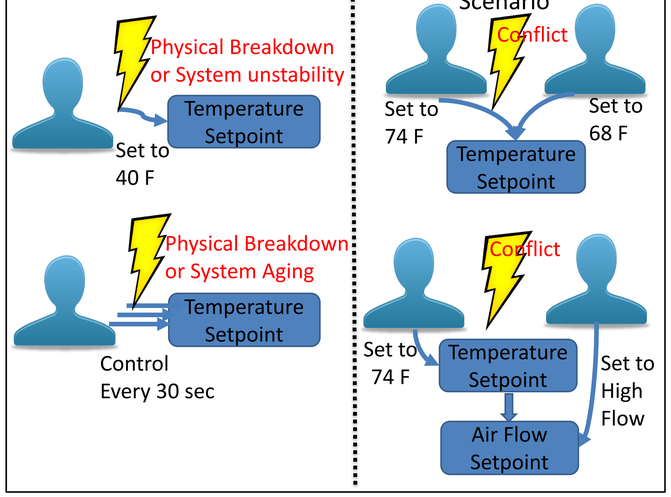


Sensor/Actuator Dependency Graph



- Impact on control stability
- Impact on safety

Challenging Scenarios



Building Control Engine (BCE)

Design Goal

1. Provide a library as API

2. Reject *unsafe operation*
- Should not exceed operating range.
  e.g., Temperature Setpoint to 40˚F
- Should not operate too frequently.
  e.g., Damper command change in every 30 seconds.

3. Status of operation per a sensor/actuator is stored/managed
- Points are dependent on others.
- Need to track status of each resource, and its dependency information.

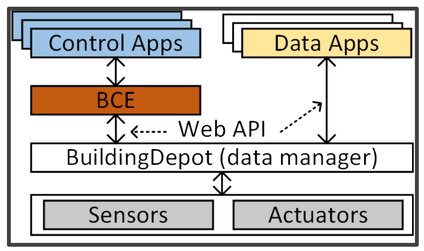
4. Logging entire history of control
- Logging history of all system status
- Need for both data analysis and system management

4. Rollback
- In case of system down or user interrupt.

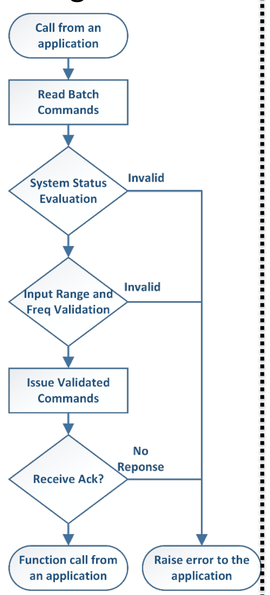
Unsafe operation

1. Definition of unsafe operation
   - Exceeding normal operating range.
   - Too frequent operation.
2. Each actuator has its own definition of unsafety.
3. Each operation affects dependent points.

System Architecture



Validation Algorithm



Application Suggestion

1. System Diagnosis
   - Active fault diagnosis
   - System estimation for security
2. System Identification
   - *Sensor/actuator colocation*
   - Type identification
   - Finding control function
   - Finding dependency graph
3. Personalized Control

Example Application: Sensor/Actuator Co-location

Problem: Co-location of sensor/actuators when location metadata is unavailable.
Assumption: Sensor and actuator types are known.
Hypothesis: Co-located points will be distinguishable if unique control signal is applied. The signal is unique in terms of *amplitude*, *frequency,* and *phase*.
Method: Use control to make information more observable.

Algorithm for Co-location

Apply large pulses to a Temperature Setpoint

Extract time-series features from each point over all zones

Pick a point with most abnormal features

Result: 68 % recall with 98.6 % precision over 8 zones.

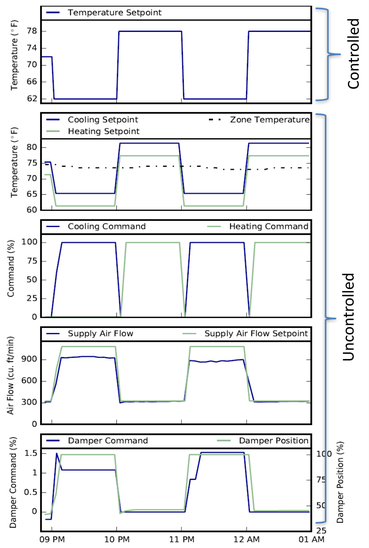


Fig. Example of control experiment for co-location