Task 2: Methods and Infrastructure

Technical Objectives, Progress, and Plans

IBPSA Project 2

Expert Meeting
DTU, Denmark

November 20, 2024

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Task 2: Methods and Infrastructure

Technical Objectives, Progress, and Plans

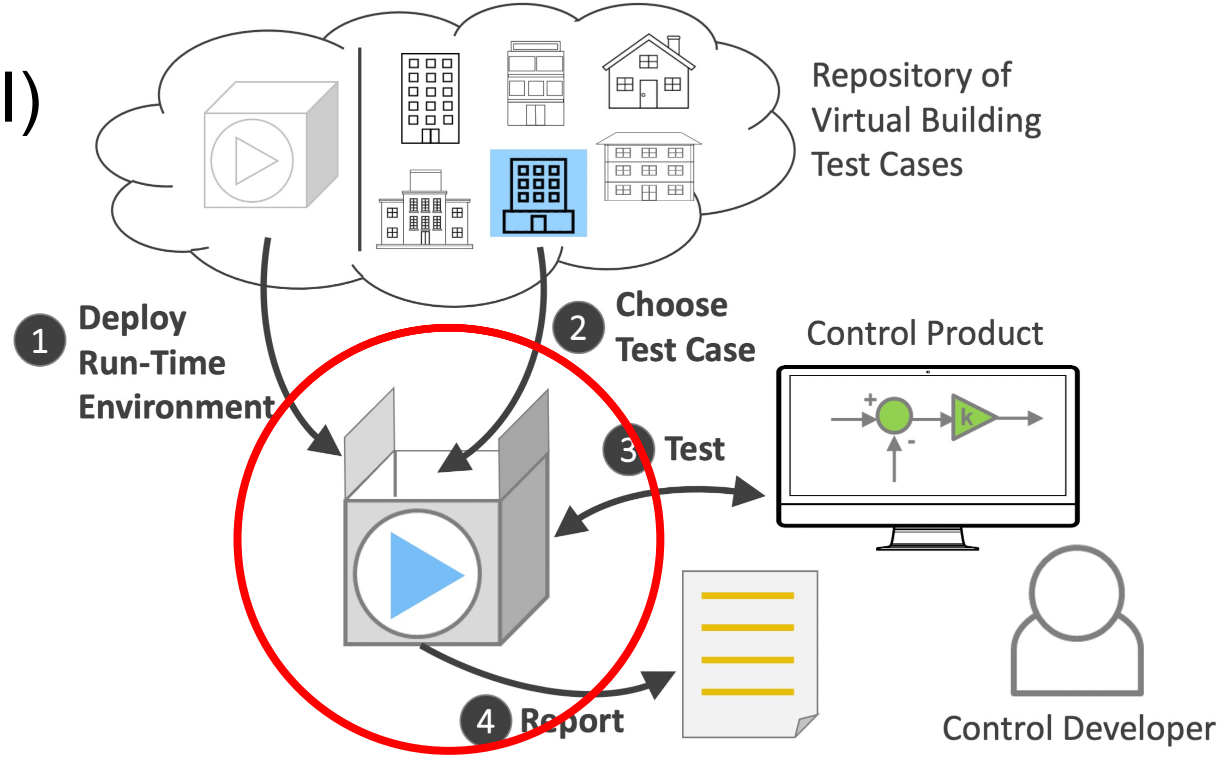
IBPSA Project 2

- Technical Objectives
- Activities, Progress, and Plans
- Ideas for New Features
- Breakout Session Topics

Technical Objectives

Development and maintenance of core software and closely related extensions, including:

- Deployment architecture
- Application programming interface (API)
- Simulation and data management
- KPI calculation
- Forecast delivery
- Online dashboard
- Public web-service
- Interface extensions
- Continuous integration and unit testing
- GitHub repository management


Repository of Virtual Building Test Cases
1 Deploy Run-Time Environment
2 Choose Test Case
Control Product
3 Test
4 Report
Control Developer
k

Activities, Progress, and Plans

Work Structure

- Since February 2024, 6 virtual meetings
- “Offline” exchanges through email and smaller group discussions

Significant Contributors, So Far…

BERKELEY LAB
Lawrence Berkeley National Laboratory

Pacific Northwest
NATIONAL LABORATORY

TUM Technical University of Munich

KU LEUVEN

R2M
RESEARCH TO MARKET
SOLUTION

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

SINTEF

wedoco
we do control

Activities, Progress, and Plans

Ongoing Activities

- Public Web-Service and Online Dashboard
- Repository Refactor
- Weather Forecast Uncertainty
- New KPI – Actuator Travel
- DOPTEST
- OpenModelica Test Case Compilation (Discussed in Task 3)
- Semantic Modeling

Activities, Progress, and Plans

Public Web-Service and Online Dashboard (Kyle Benne, David Blum)

Web-Service

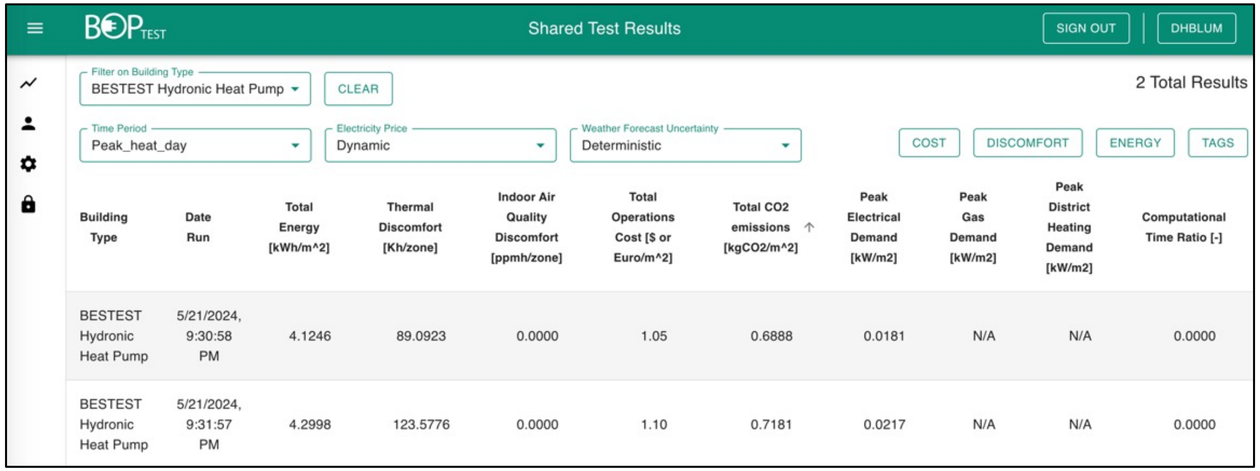
NREL developed web-service deployment architecture (BOPTEST-Service) at https://github.com/NREL/boptest-service

- Maintains publicly available instance on AWS (https://api.boptest.net) and associated helm chart for Kubernetes based deployment
- Recently merged to master branch of https://github.com/ibpsa/project1-boptest
- Continue coordination with NREL's Alfalfa project, including work towards API alignment

Online Dashboard

NREL developed prototype **online dashboard** via subcontractor for user registration and results collection at https://github.com/NREL/boptest-dashboard

- Utilization not encouraged yet, needs updating to be flexible for future BOPTEST development (e.g new test cases, KPIs) and user registration data collection



Filter on Building Type: BESTEST Hydronic Heat Pump

2 Total Results

Time Period: Peak_heat_day

Electricity Price: Dynamic

Weather Forecast Uncertainty: Deterministic

Building Type	Date Run	Total Energy [kWh/m^2]	Thermal Discomfort [Kh/zone]	Indoor Air Quality Discomfort [ppmh/zone]	Total Operations Cost [$ or Euro/m^2]	Total CO2 emissions [kgCO2/m^2]	Peak Electrical Demand [kW/m2]	Peak Gas Demand [kW/m2]	Peak District Heating Demand [kW/m2]	Computational Time Ratio [-]
BESTEST Hydronic Heat Pump	5/21/2024, 9:30:58 PM	4.1246	89.0923	0.0000	1.05	0.6888	0.0181	N/A	N/A	0.0000
BESTEST Hydronic Heat Pump	5/21/2024, 9:31:57 PM	4.2998	123.5776	0.0000	1.10	0.7181	0.0217	N/A	N/A	0.0000

Activities, Progress, and Plans

Repository Refactor (David Blum, Kyle Benne)

Problems presented in November 2023 meeting:

- BOPTEST-Service API slightly different than original BOPTEST API
  - Updates to ibpsa/project1-boptest need to be tested and aligned in nrel/boptest-service
  - Interfaces need to maintain two slightly APIs
- ibpsa/project1-boptest is overloaded
- DOPTEST is far-removed

Proposed solutions and ongoing work:

- Merge nrel/boptest-service into ibpsa/project1-boptest to be only deployment architecture and API ✅
- Planning to separate ibpsa/project1-boptest into multiple repositories

BOPTEST (ibpsa/project1-boptest)

- Software (Framework Python modules, Dockerfile)
- Test Cases (FMUs, Modelica models, docs, resources)
- Documentation (User Guide, Design Guide)
- Flask API for local deployment
- BACnet Interface
- Website content (branch ***gh-pages-custom***)
- DOPTEST (fork branch **JavierArroyoBastida/project1-boptest *doptest***)
- Tutorials/workshops

Gym Interface (ibpsa/project1-boptest-gym)

- Gym environment for BOPTEST
- Gym environment for BOPTEST-Service (branch ***boptest-gym-service***)

BOPTEST-Service (NREL/boptest-service)

- Extend BOPTEST into web-service
- Web API for web-service usage (needs “/select” and “testid”)
- Helm chart for Kubernetes deployment

BOPTEST (ibpsa/boptest)

- Software (Framework Python modules, Dockerfile)
- Documentation Source Code (User Guide, Design Guide)
- Deployment and API as web-service (can be local too)
- DOPTEST functionality

Test Cases (ibpsa/boptest-testcases)

- Test Cases (FMUs, Modelica models, docs, resources)

Gym Interface (ibpsa/boptest-gym)

- Gym environment interface for BOPTEST

BACnet Interface (ibpsa/boptest-bacnet)

- BACnet interface for BOPTEST

Website (ibpsa/boptest-website)

- Website content
- Tutorials/workshops?
- Meeting presentations/minutes?

Activities, Progress, and Plans

Weather Forecast Uncertainty (Laura Zabala, Zhe Wang, Wanfu Zheng)

Objective:

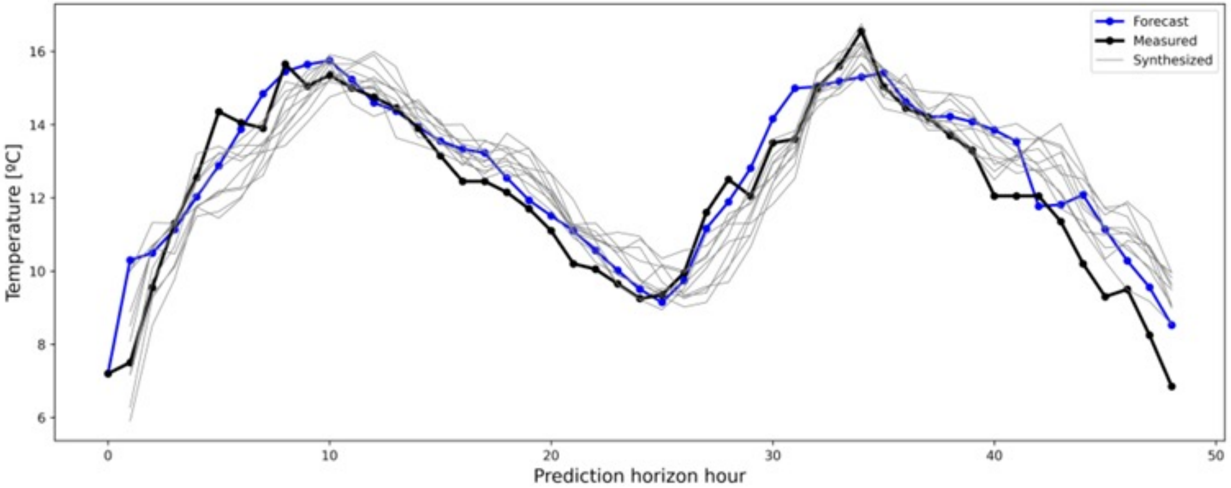
- Develop weather forecast uncertainty emulator to be implemented as part of BOPTEST
- Add error to TMY weather data to emulate real forecasts for weather variables
- Initial focus on outdoor temperature (OAT) and solar radiation (SR)

Work done:

- Characterized error in historic forecasts from USA, Norway, Belgium, Germany, and Italy.
- Forecast error models: autoregressive with a distribution for residuals
  - OAT: Normal, SR: Laplace
- User to choose from 4 uncertainty levels: none, low, medium, and high, and "seed" for "deterministic stochasticity"

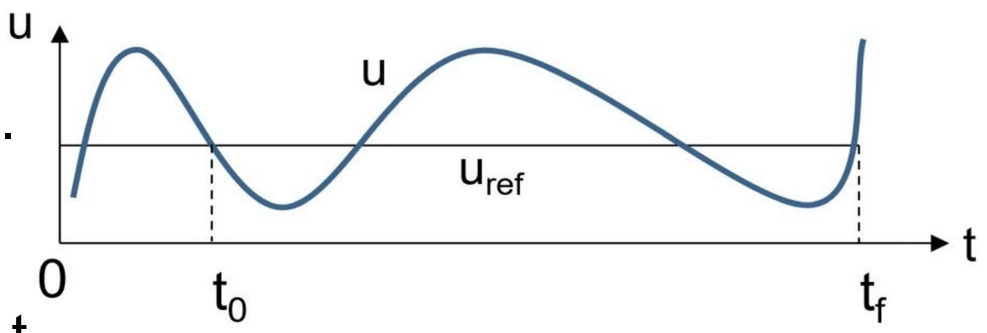
Ongoing work:

- Software for BOPTEST developed and PR. First review done, working on changes.
- Submission of work to a Journal for peer review and publishing before software release



Activities, Progress, and Plans

New KPI – Actuator Travel (Xing Lu, Jan Marco Ruiz de Vargas, Ettore Zanetti)



Objective: Quantify frequency of equipment and actuator switching (e.g., cycling, hunting) over the evaluation period.

Proposed Normalization: Consistency across signals and scenarios

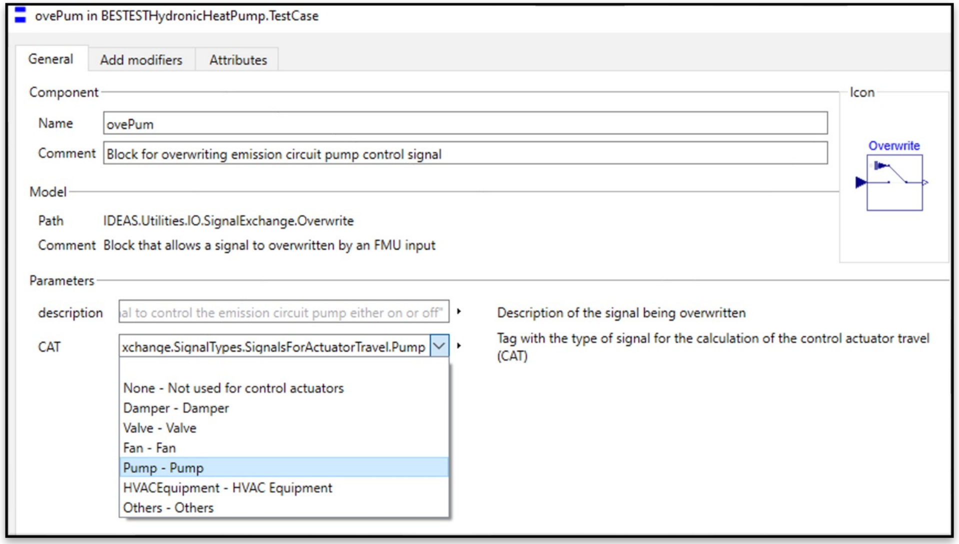
- **Time:** Time interval $[t_0,t_f]$ is scaled to [0,1] by dividing by t_f
- **Signal**: Actuator signal u(t) normalized to [0,1] using range $[u_{min}, u_{max}]$
- **KPI equation:**

$$AT(\tilde{u}) = \int_0^1 \sqrt{1 + \left(\frac{d\tilde{u}(\tilde{t})}{d\tilde{t}}\right)^2}\, d\tilde{t}$$

Aggregation: Calculated for all signals and then averaged

Actuator Signal Tagging:

- **Existing Test Cases**: Manual tagging of actuator signals
- **New Test Cases**: Automated tagging via updates to the signal exchange (overwrite) block.



ovePum in BESTESTHydronicHeatPump.TestCase

General | Add modifiers | Attributes

Component

Name: ovePum

Comment: Block for overwriting emission circuit pump control signal

Model

Path: IDEAS.Utilities.IO.SignalExchange.Overwrite

Comment: Block that allows a signal to overwritten by an FMU input

Parameters

description: al to control the emission circuit pump either on or off" — Description of the signal being overwritten

CAT: xchange.SignalTypes.SignalsForActuatorTravel.Pump — Tag with the type of signal for the calculation of the control actuator travel (CAT)

None - Not used for control actuators
Damper - Damper
Valve - Valve
Fan - Fan
Pump - Pump
HVACEquipment - HVAC Equipment
Others - Others

Ongoing Work: PR made with initial implementation and under review, particularly normalization scheme to consider “integration by substitution” rule

Activities, Progress, and Plans

DOPTEST (Javier Arroyo, Cas Bex)

Objective:

- Evaluation and benchmarking of system integration strategies in Districts through simulation
- Focused on aggregators and grid operators
- Test cases contain multiple buildings + system, overwrite price signals to buildings, aggregator profit KPI

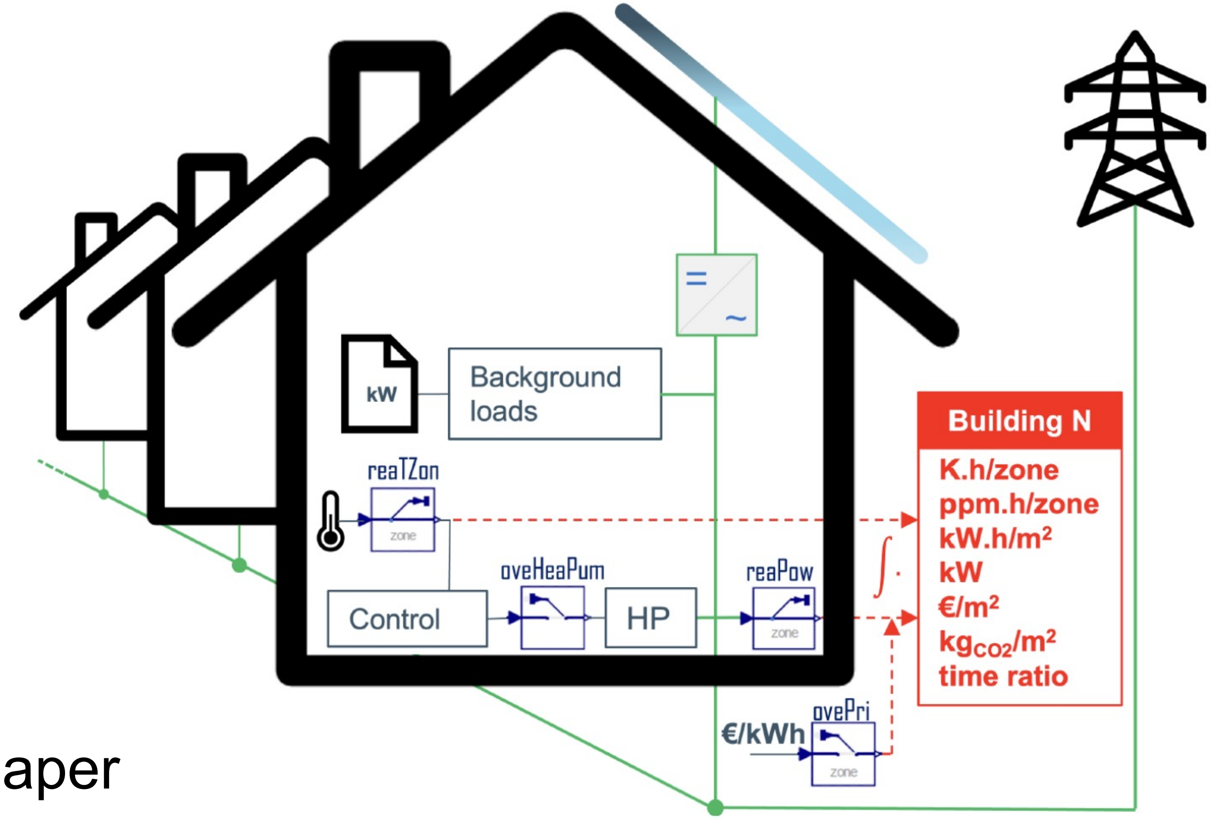
Work done:

- Created MoPED Modelica Library (Models for Positive Energy Districts)
- Created "DOPTEST Factory" GitHub actions to compile test case FMUs with OpenModelica
- Initial simulation case study and IBPSA BS23 Paper

Ongoing work:

- New API request for Disaggregated KPIs in PR
- Functionality alignments with BOPTEST repository

TECHPED
Technically feasible positive energy districts



Arroyo et al. (2023). "Prototyping the DOPTEST Framework for Simulation-Based Testing of System Integration Strategies in Districts." In Proceedings of Building Simulation 2023: 18th Conference of IBPSA. https://doi.org/10.26868/25222708.2023.1493

Activities, Progress, and Plans

Semantic Modeling (Ettore Zanetti, David Blum)

Project Haystack

Brick Ontology ASHRAE 223p

Objective:

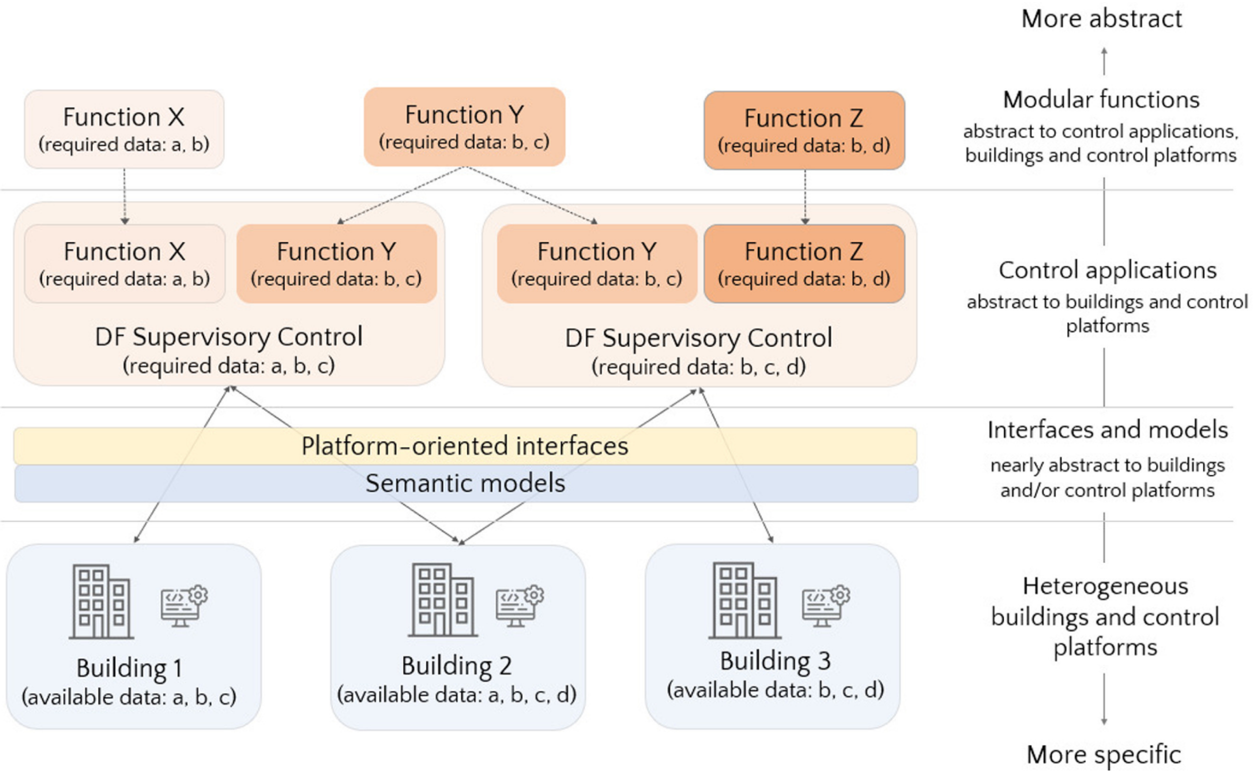
- Provide semantic models with BOPTEST test cases
- Develop workflow to annotate in and extract semantic models from Modelica models

Work done:

- Coordinate with semantic model and associated tool development within DOE
- Initial semantic models implemented for bestest_air and multizone_office_simple_air test cases

Ongoing work:

- Finalize post-processing needed to complete semantic model extraction process
- Issues to be addressed in related tools (i.e. modelica-json)


More abstract
Function X (required data: a, b)
Function Y (required data: b, c)
Function Z (required data: b, d)
Modular functions
abstract to control applications, buildings and control platforms
Function X (required data: a, b)
Function Y (required data: b, c)
DF Supervisory Control (required data: a, b, c)
Function Y (required data: b, c)
Function Z (required data: b, d)
DF Supervisory Control (required data: b, c, d)
Control applications
abstract to buildings and control platforms
Platform-oriented interfaces
Semantic models
Interfaces and models
nearly abstract to buildings and/or control platforms
Building 1 (available data: a, b, c)
Building 2 (available data: a, b, c, d)
Building 3 (available data: b, c, d)
Heterogeneous buildings and control platforms
More specific

Pereira et al. (2024). "Enabling portable demand flexibility control applications in virtual and real buildings." Journal of Building Engineering, 86, 108645. https://doi.org/10.1016/j.jobe.2024.108645

Ideas for New Features

Sensor uncertainty: Noisy, missing, inaccurate data

System faults: Stuck actuators, leaky valves dampers, coil degradation

Internal Load Scenarios: Optionality for level of internal loads such as design, medium, low

Stochastic Occupancy Scenarios: Occupancy profiles generated stochastically upon run-time

Multiple Years of Weather Data: Statistically similar but different years of weather data

Climate Scenarios: Be able to run test cases from different climates - Spawn will soon have auto-sizing capabilities (via EnergyPlus)

Tracking Used Points: Keep track of input, measurement, and forecast points that are used by controllers and report as KPI

Breakout Session Topics (Task 2 on Day 2)

Ongoing Activities

- Public Web-Service and Online Dashboard
- **Repository Refactor [~15 min]**
- Weather forecast uncertainty
- **New KPI – Actuator Travel [~15 min]**
- **DOPTEST [~15 min]**
- OpenModelica Test Case Compilation (Discussed in Task 3)
- Semantic Modeling

New Ideas

- **Sensor Uncertainty [~15 min]**
- **Others or even newer [~15 min]**