

From Building Simulation Software to Ontology Language: Using a Calibrated HVAC Model as the Core of a Digital Twin Platform

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About

Integrated Environmental Solutions Limited, Glasgow
IES-VE building simulation software commonly used in BIM workflows
Research and Development for Building Operations Research



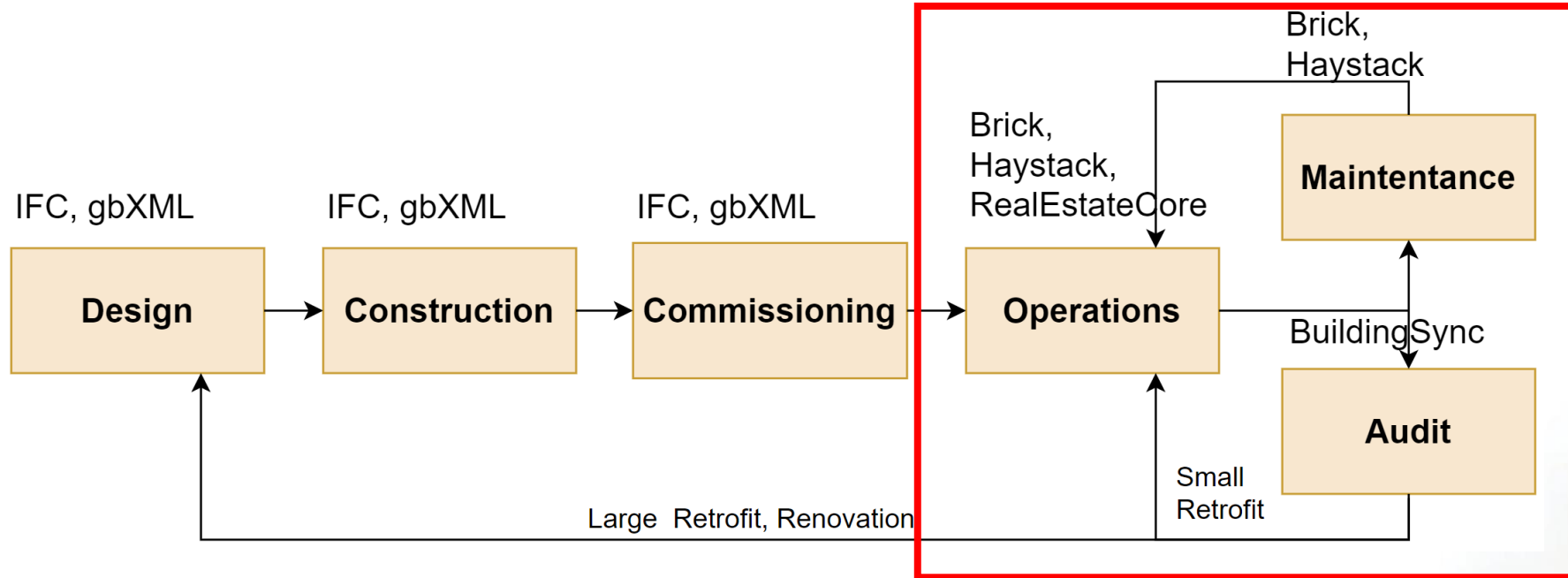
Overview

Building Metadata Life-cycle
Digital Twin Platform & workflow
Apache Data model
Case studies





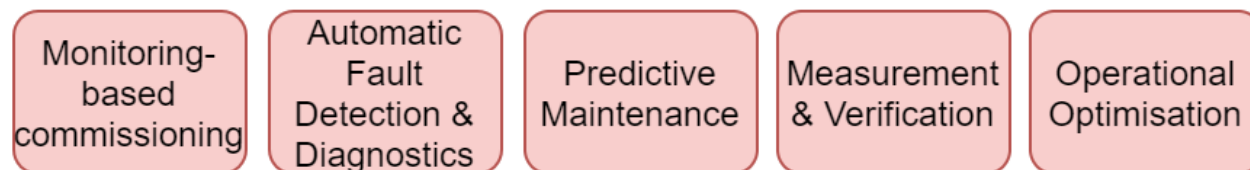
Building Metadata Life-cycle



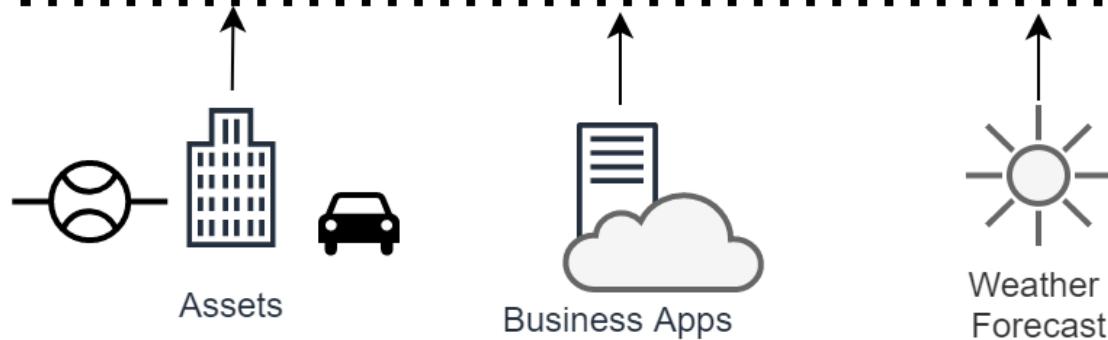
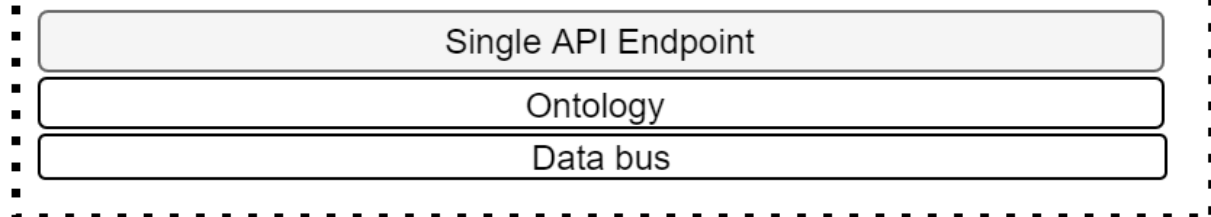


Digital Twin Platform

Application layer

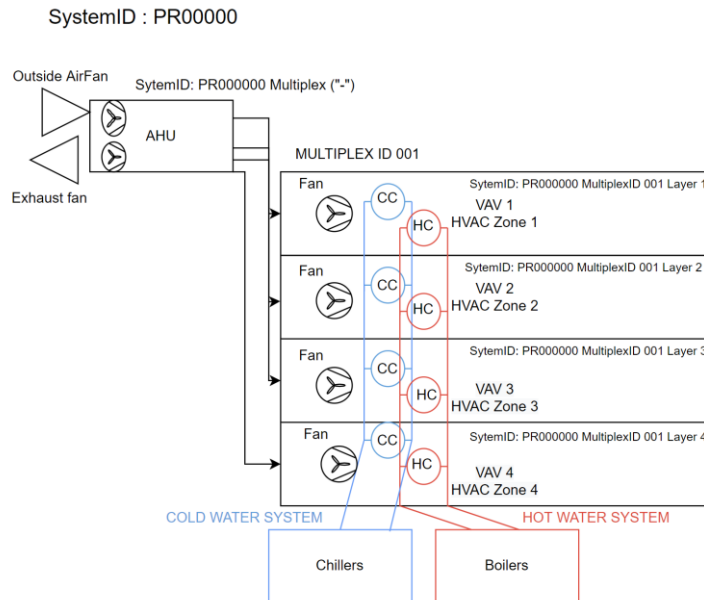


Integration layer



Simulation





Creating a calibrated energy model:

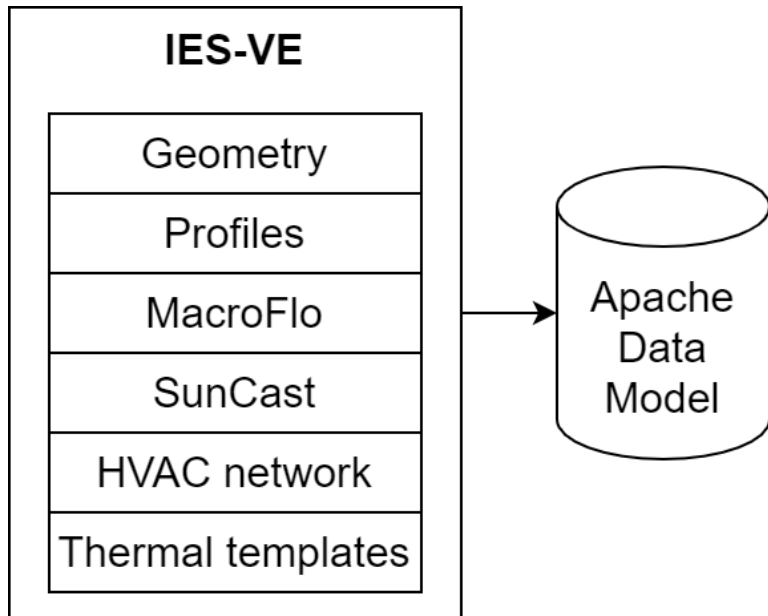
- Collect building information and data
- Model HVAC network
- Identify relevant sensors
- Compare simulated and measured data
- Fine-tune relevant parameters
- **Update as new changes occur**

Creating a BRICK ontology model:

- Discover list of relevant points
- Collect building information and data
- Model HVAC network between relevant points
- Name sensors and actuators with relevant names
- Create BRICK model in TTL file
- **Update as new changes occur**

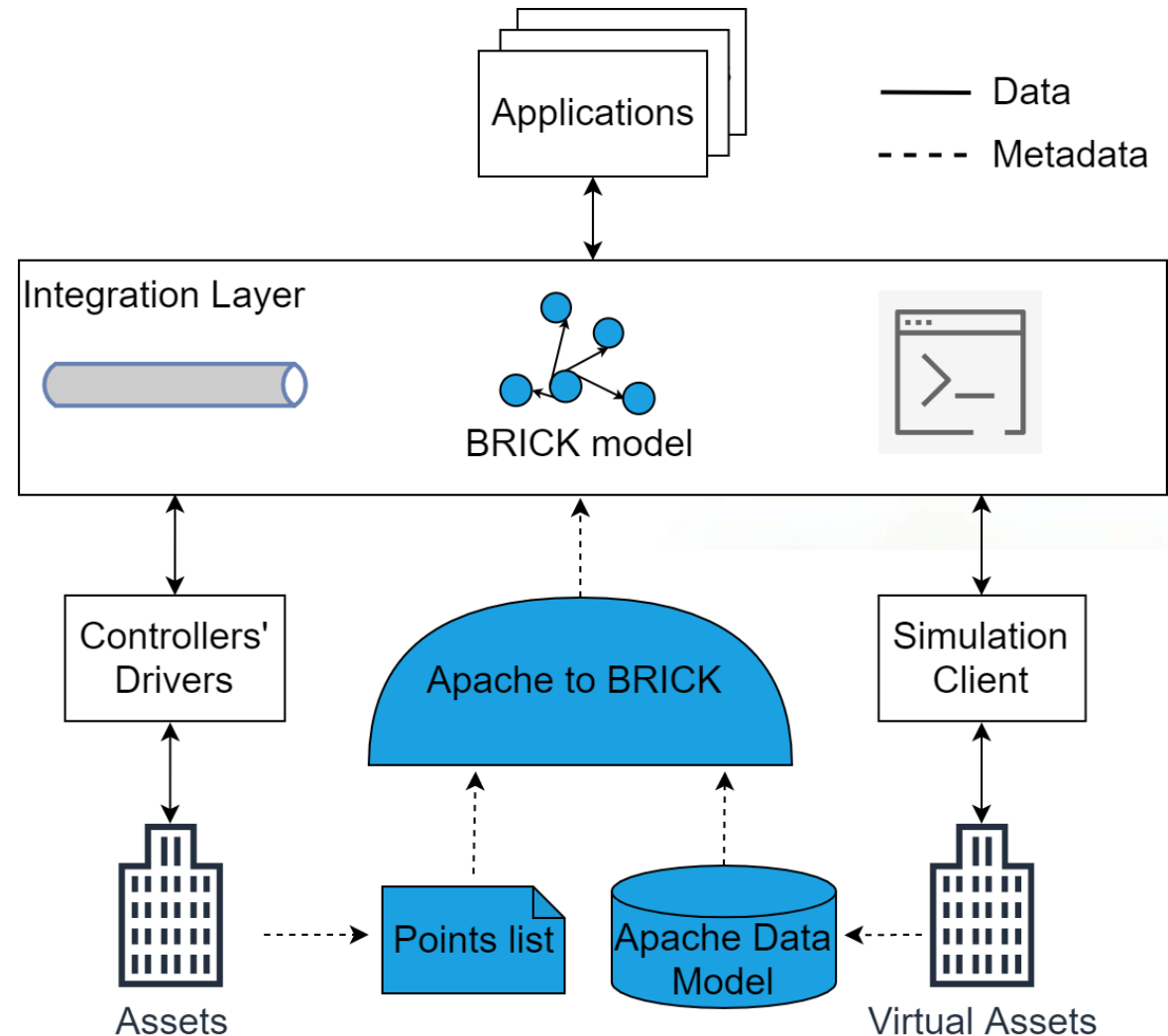


Apache Data Model



Sample Apache Variable Path:
hvac/component/EF001581/power

Digital Twin Platform





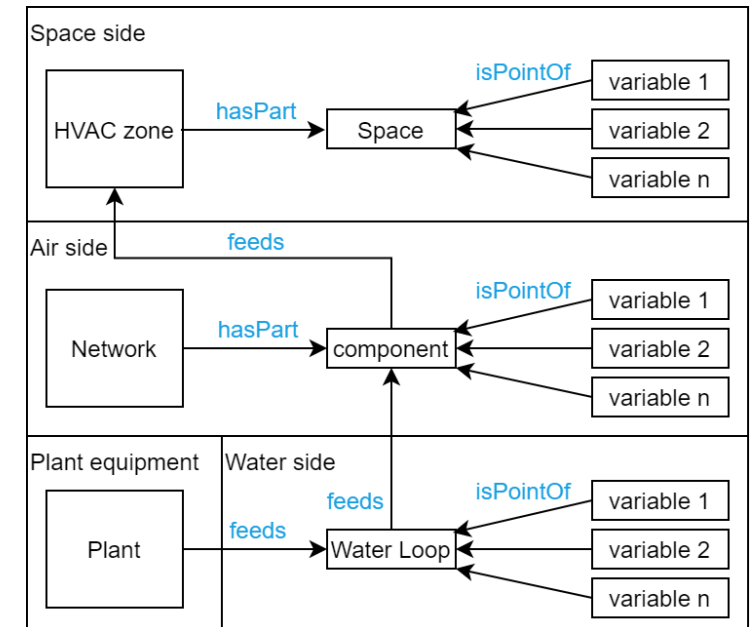
Components (Equipment)

Component ID	BRICK equipment
HC*****	Heating_Coil
CC*****	Cooling_Coil
SF*****	Supply_Fan
HWDL*****	Hot_Water_System
PR*****	AHU
CD*****	Condenser
IN*****	Outside_Air_Damper

Apache Variables (Points)

Apache Variable	BRICK point
airTemperature	Room_Temperature_Sensor
roomCO2Concentration	CO2_Sensor
boilersLeavingTemperature	Leaving_Water_Temperature_Sensor
boilersEnteringTemperature	Entering_Water_Temperature_Sensor
primaryTargetSupplyTemperature	Supply_Water_Temperature_Setpoint

Relationships

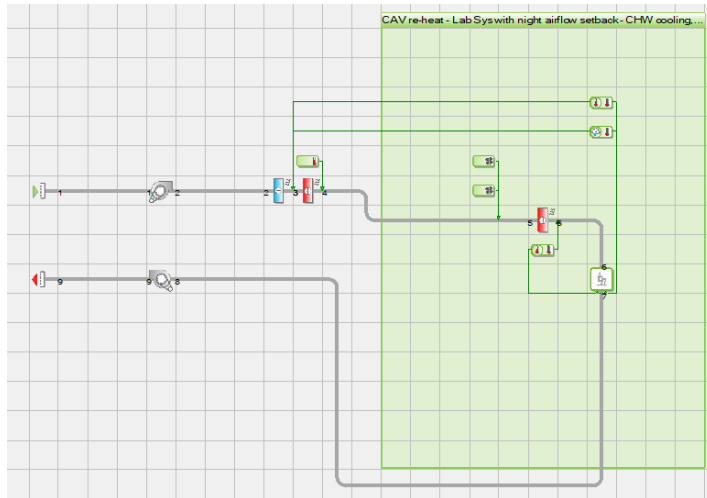




Apache Data Model

Test Case 1: Simple two-zone model

Model with two zones and a CAV HVAC system.



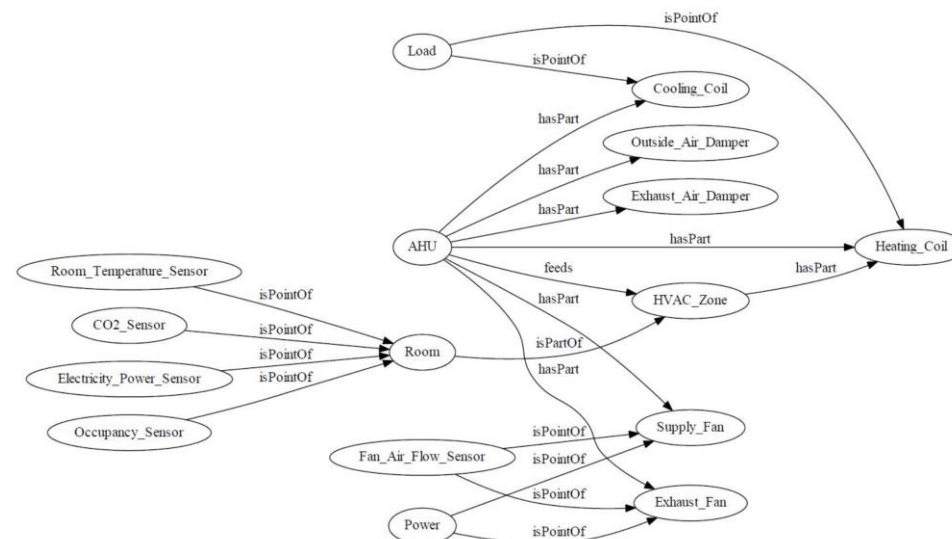
Points List

Level	ID	Variable
HVAC Component	SF000330	airflow
		power
HVAC Component	EF001301	airflow
		power
HVAC Component	HC002832	sensibleLoad
HVAC Component	CC000780	totalLoad
Space	RM000000	numberOfPeople roomCO2Concentration airTemperature lightingGain

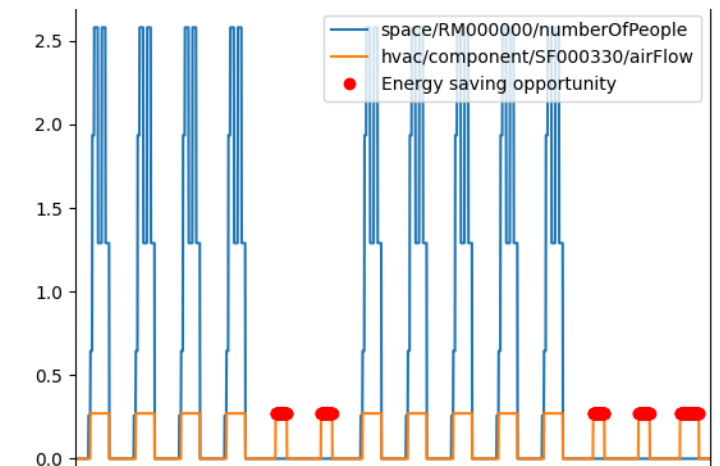
Sample Query

```
select ?occupancy_uuid ?airflow_uuid where {
  ?airflow_sensor rdf:type brick:Fan_Air_Flow_Sensor ;
    brick:hasUuid ?airflow_uuid .
  ?fan rdf:type brick:Supply_Fan ;
    bf:hasPoint ?airflow_sensor .
  ?ahu rdf:type brick:AHU ;
    bf:hasPart ?fan .
  ?zone rdf:type brick:HVAC_Zone ;
    bf:isFedBy ?ahu .
  ?room rdf:type brick:Room ;
    bf:isPartOf ?zone .
  ?occupancy_sensor rdf:type brick:Occupancy_Sensor ;
    bf:isPointOf ?room ;
    brick:hasUuid ?occupancy_uuid .
}
```

BRICK model



Sample plot

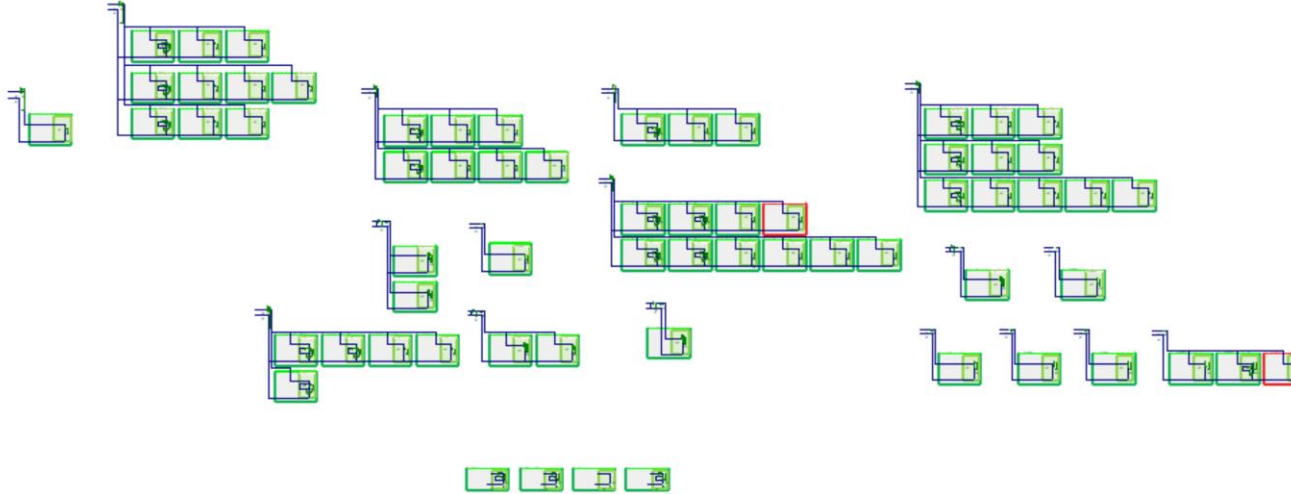




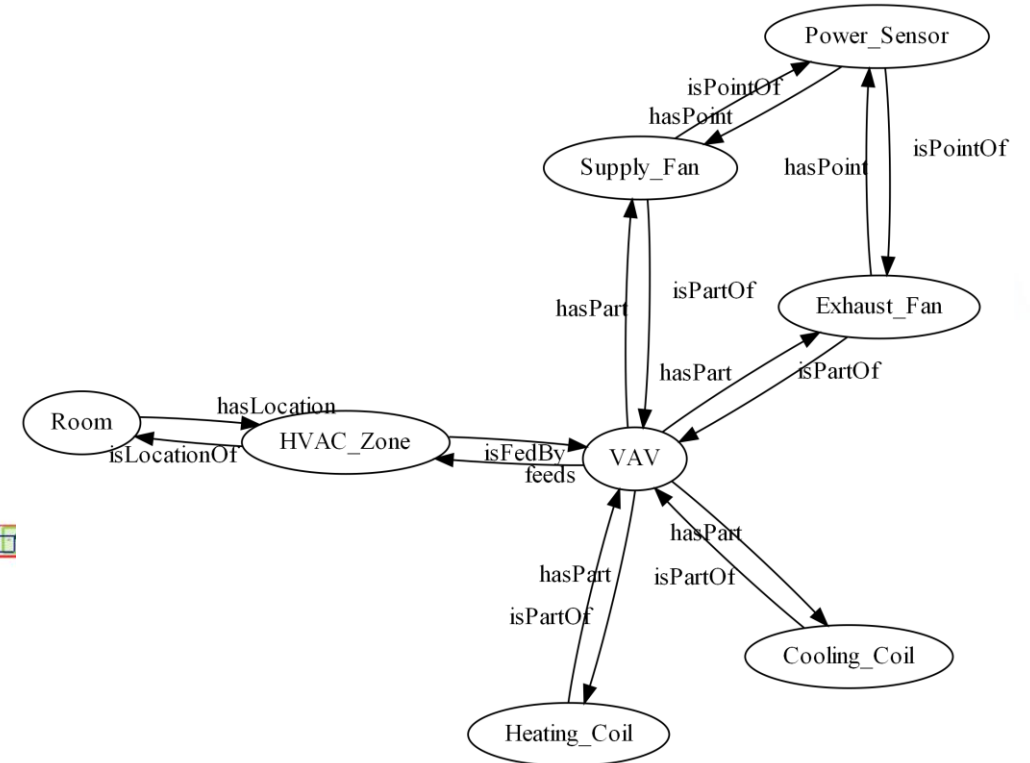
Case 2: Complex Office Building Model

Model with 1120 rooms and 1974 HVAC components across 45 systems. 302 points. Export time < 5 seconds.

Calibrated Apache HVAC model (building simulation team)



BRICK model (data engineering team)





Conclusions

- Integration platforms enable multiple applications for operational stages
- Applications can take advantage of a model with the same building naming convention
- A calibrated building energy model provides relationships between BMS points and creates an initial BRICK model for enabling a digital twin platform
- Apache to BRICK work enables coordinated updates





References

1. G. Fierro et al., “Interactive Metadata Integration with Brick,” in Proceedings of the 7th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation, Virtual Event Japan, Nov. 2020, pp. 344–345. doi: 10.1145/3408308.3431125
2. “brickschema package — brickschema documentation.”
<https://brickschema.readthedocs.io/en/latest/source/brickschema.html> (accessed Jul. 01, 2021).

Acknowledgments

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Thank you

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