



# **The Future of Intelligent Buildings: Emerging ASHRAE Standards for AI and Interoperability**

Jayson Bursill, Ph.D., P.Eng.

[jbursill@deltaww.com](mailto:jbursill@deltaww.com)

# Standards Enabling AI in Building Controls

## Sequence

- ASHRAE Guideline 36: High Performance Sequences of Operation for HVAC Systems
- Other sequences from application engineers
- Other sequences

## System

- ASHRAE Standard 135: BACnet
- Application Programming Interfaces (API)
- Other protocols

## Syntactics

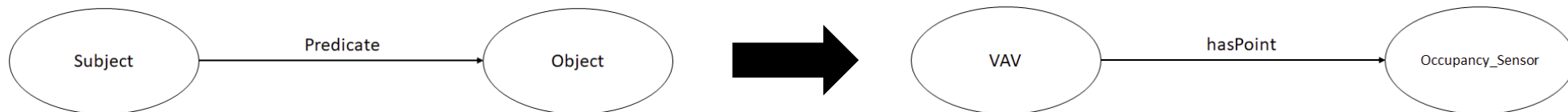
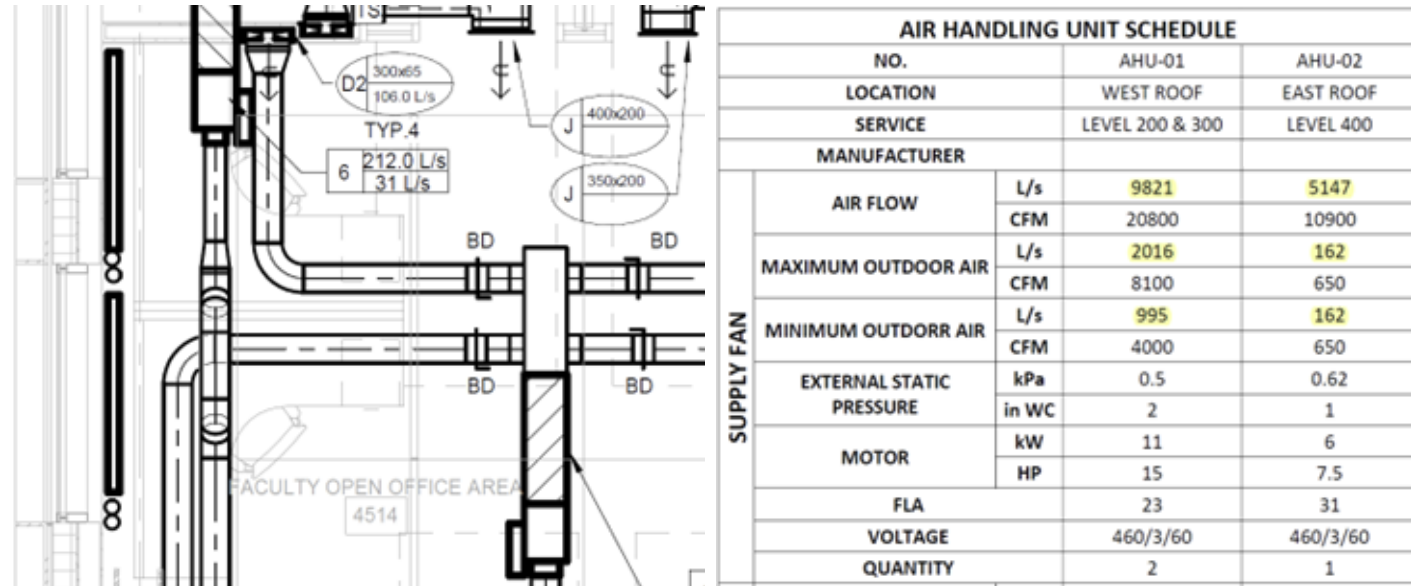
- ASHRAE Standard 223: Semantic Data Model for Buildings
- Brick
- Haystack
- Other ontologies

## Structure

- ASHRAE Standard 231: Control Description Language
- Other schemas

# Data Sources

- Building data:
  - BIM architecture and equipment schedules
  - BAS specs
  - Physical I/O
  - Parameters (AV, BV, MV)
  - Algorithms (e.g., guidelines or templates)
- Public metadata libraries/ontologies:
  - Brick/ RealEstateCore (based on Semantic Web)
  - Haystack (based on markers)

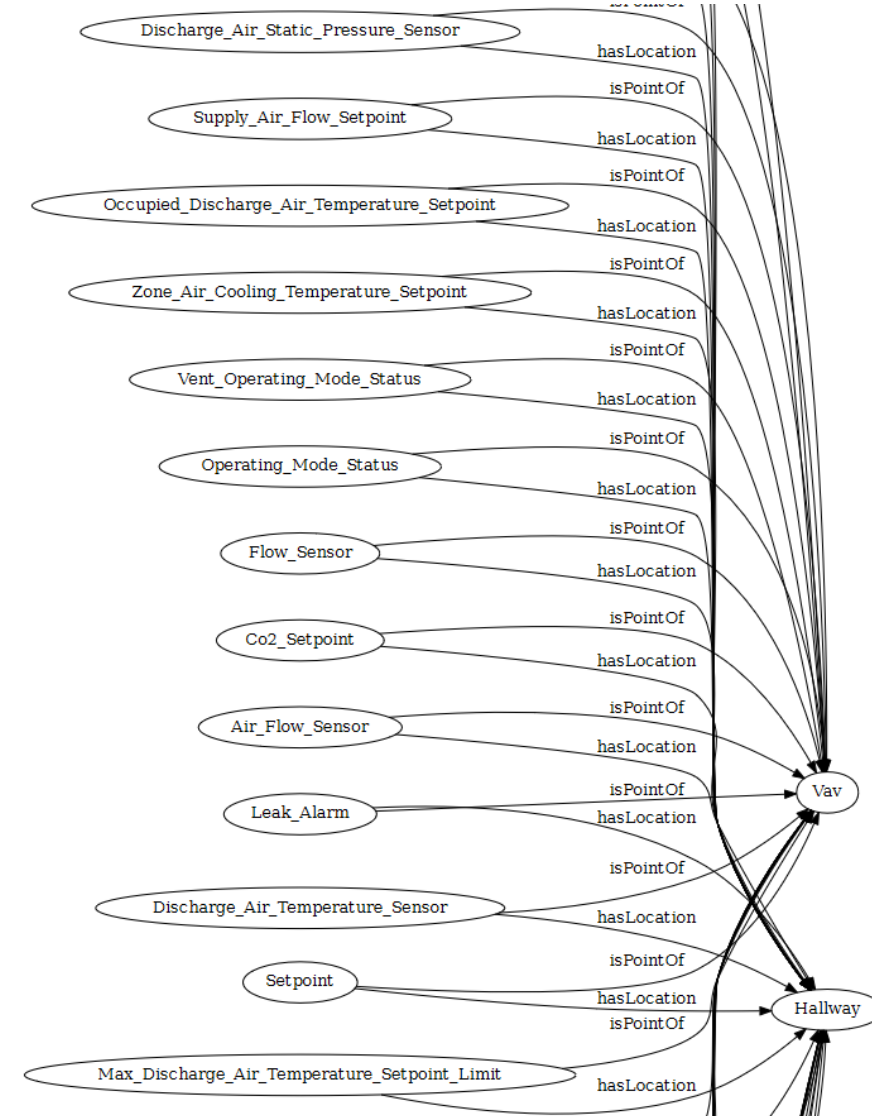


# Metadata Approaches and the Power of Ontology

Select SiteName

Search filter:    AND()

#	Point ID	Point Name	<input type="text" value="Point Brick (v1.2)"/>	<input type="text" value="Equipment Brick (v1.2)"/>	<input type="text" value="Location Brick (v1.2)"/>	User-Defined Tag
	test.1100.analog-input.3	DAT	<input type="text" value="discharge_air_temperatu"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>
	test.1100.analog-input.7	RMT	<input type="text" value="zone_air_temperature_s"/>	<input type="text" value="thermostat"/>	<input type="text" value="private_office"/>	<input type="text" value="RM_101"/>
	test.1100.analog-value.1	AHU SAT	<input type="text" value="air_temperature_setpoir"/>	<input type="text" value="ahu"/>	<input type="text" value="room"/>	<input type="text" value="A1"/>
	test.1100.analog-value.9	DAT - RMT Heat Active Setpoint Differential Max Setpoint	<input type="text" value="discharge_air_temperatu"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>
	test.1100.analog-value.10	DAT Active Setpoint	<input type="text" value="occupied_discharge_air_"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>
	test.1100.analog-value.11	DAT Low Limit Setpoint	<input type="text" value="min_discharge_air_temp"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>
	test.1100.analog-value.12	DAT Max Setpoint	<input type="text" value="max_discharge_air_tem"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>
	test.1100.analog-value.43	Outside Air Temperature	<input type="text" value="outside_air_temperature"/>	<input type="text" value="ahu"/>	<input type="text" value="mechanical_room"/>	<input type="text" value="A1"/>
	test.1100.analog-value.56	RMT Cool Active Setpoint	<input type="text" value="zone_air_cooling_tempe"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>
	test.1100.analog-value.57	RMT Cool Max	<input type="text" value="zone_air_cooling_tempe"/>	<input type="text" value="vav"/>	<input type="text" value="hallway"/>	<input type="text" value="ZN_A"/>

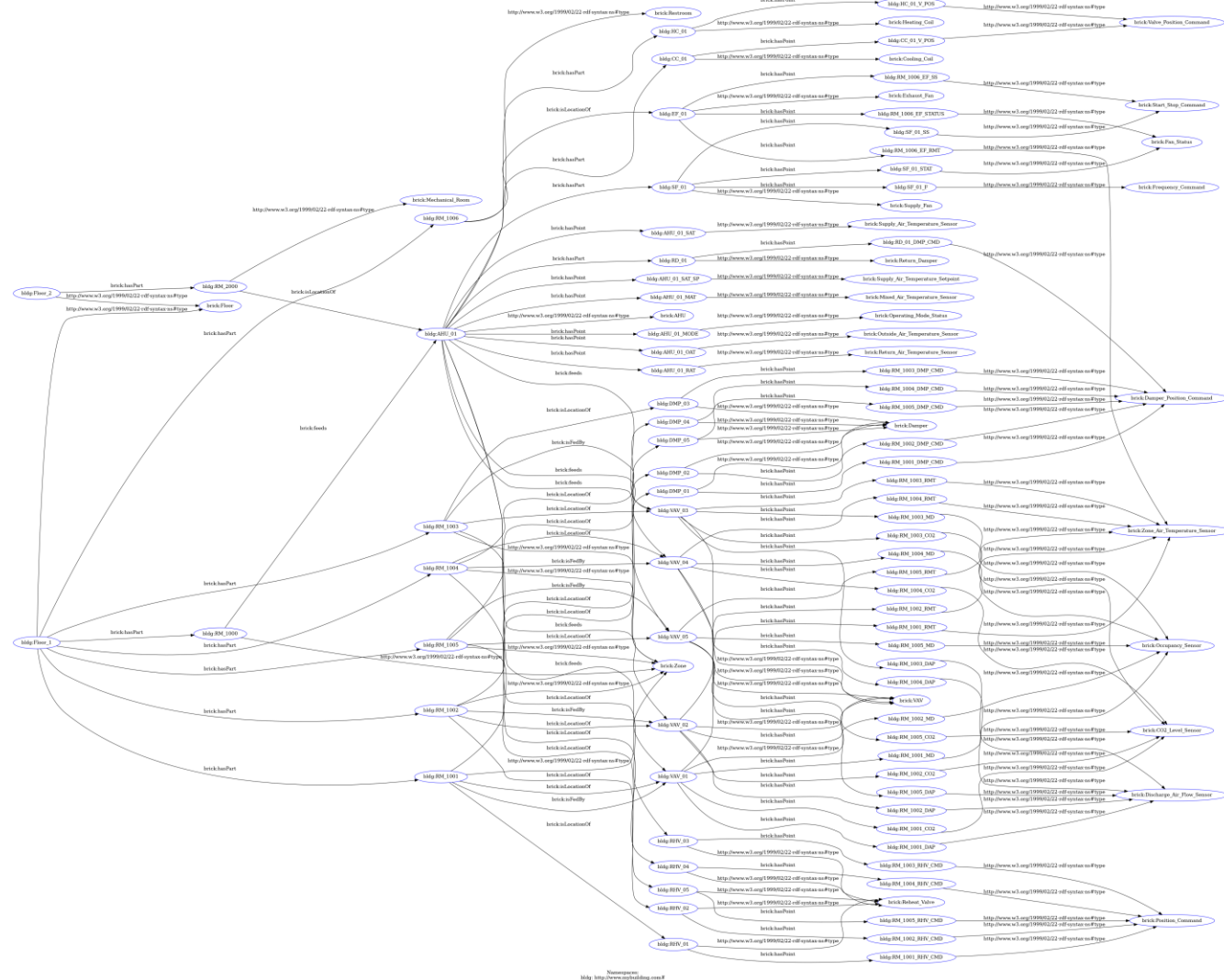


# Semantic Data Modeling with RDF & ASHRAE 223P

## A Simple Building in Brick and RDF

**NOTE: Brick is higher level and requires less entities and classes than 223P**

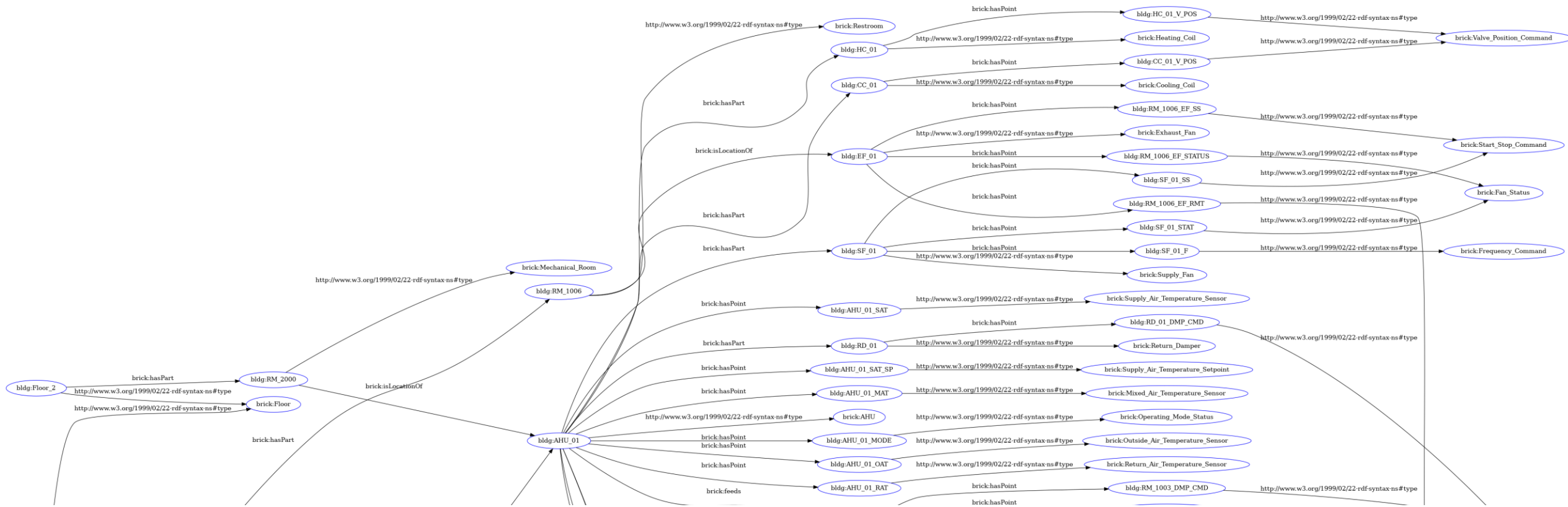
```
190 bldg:SF_01_SS a brick:Start_Stop_Command .
191
192 bldg:SF_01_STAT a brick:Fan_Status .
193
194 bldg:AHU_01 a brick:AHU ;
195   brick:feeds bldg:VAV_01,
196     bldg:VAV_02,
197     bldg:VAV_03,
198     bldg:VAV_04,
199     bldg:VAV_05 ;
200 brick:hasPart bldg:CC_01,
201   bldg:HC_01,
202   bldg:RD_01,
203   bldg:SF_01 ;
204 brick:hasPoint bldg:AHU_01_MAT,
205   bldg:AHU_01_MODE,
206   bldg:AHU_01_OAT,
207   bldg:AHU_01_RAT,
208   bldg:AHU_01_SAT,
209   bldg:AHU_01_SAT_SP .
210
211 bldg:VAV_01 a brick:VAV ;
212   brick:hasPoint bldg:RM_1001_CO2,
213     bldg:RM_1001_DAP,
214     bldg:RM_1001_MD,
215     bldg:RM_1001_RMT .
216
217 bldg:VAV_02 a brick:VAV ;
218   brick:hasPoint bldg:RM_1002_CO2,
219     bldg:RM_1002_DAP,
220     bldg:RM_1002_MD,
221     bldg:RM_1002_RMT .
```



# Semantic Data Modeling with RDF & ASHRAE 223P

## A Simple Building in Brick and RDF

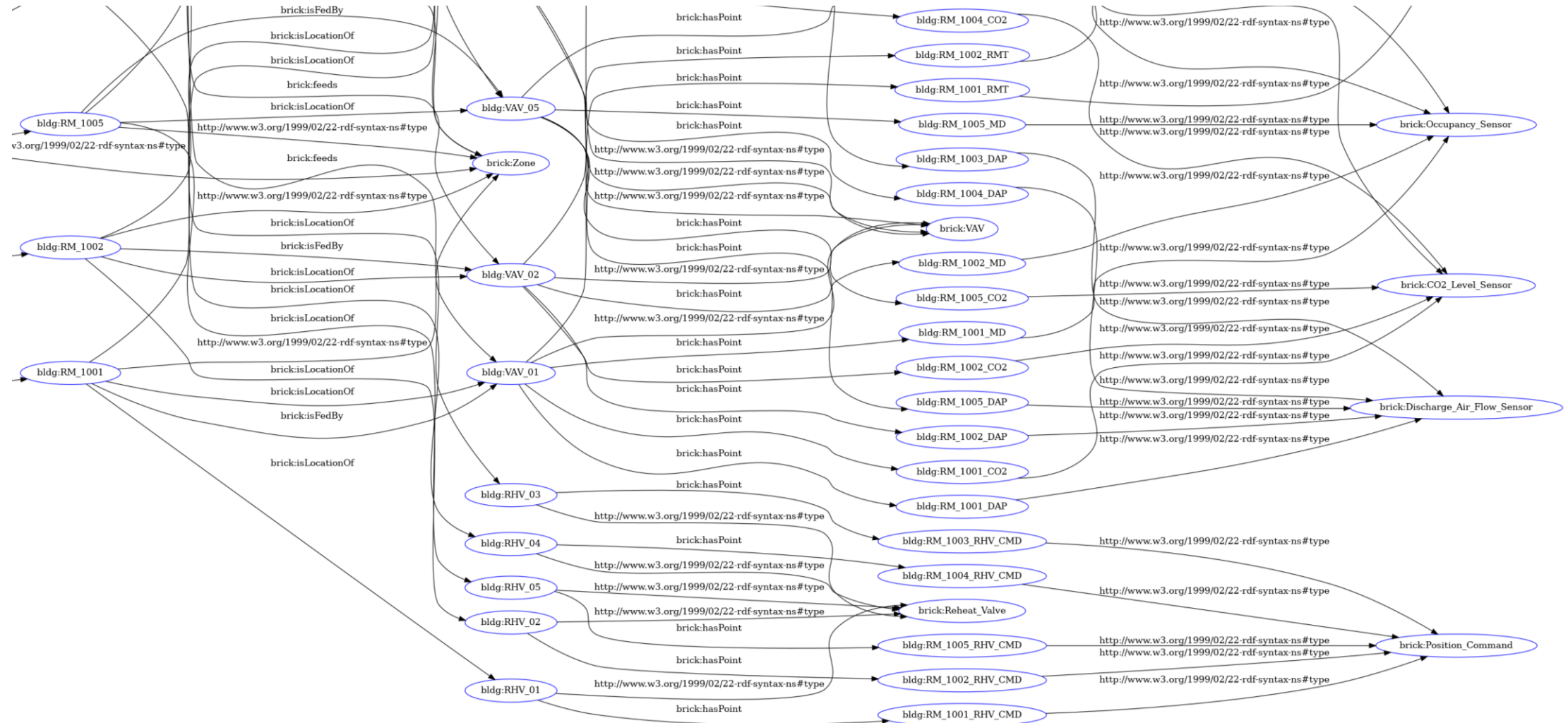
*NOTE: Brick is higher level and requires less entities and classes than 223P*



# Semantic Data Modeling with RDF & ASHRAE 223P

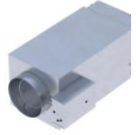
## A Simple Building in Brick and RDF

*NOTE: Brick is higher level and requires less entities and classes than 223P*

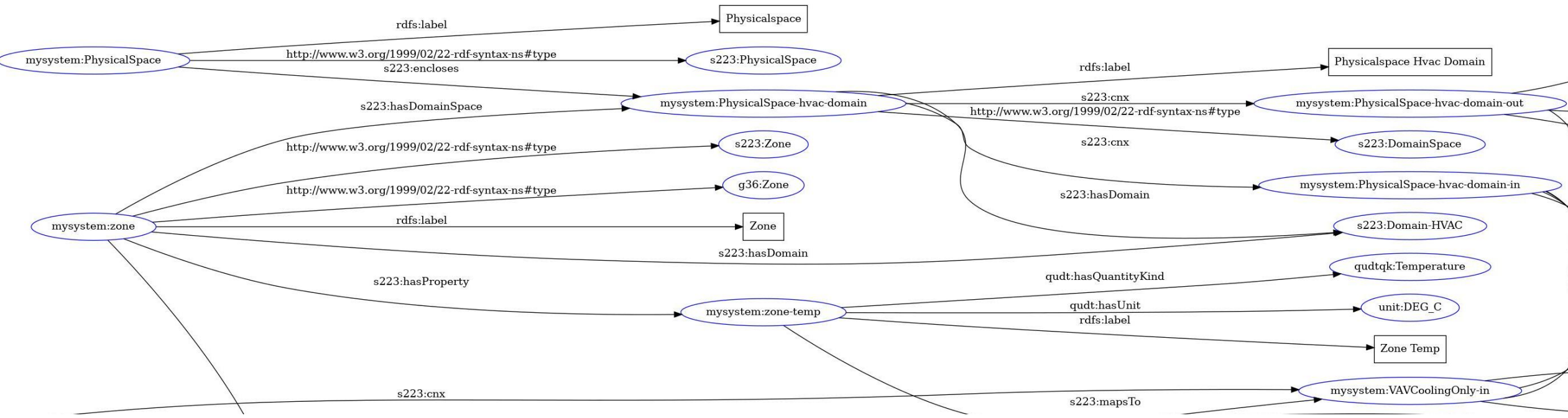




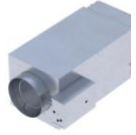
# Semantic Data Modeling with RDF & ASHRAE 223P



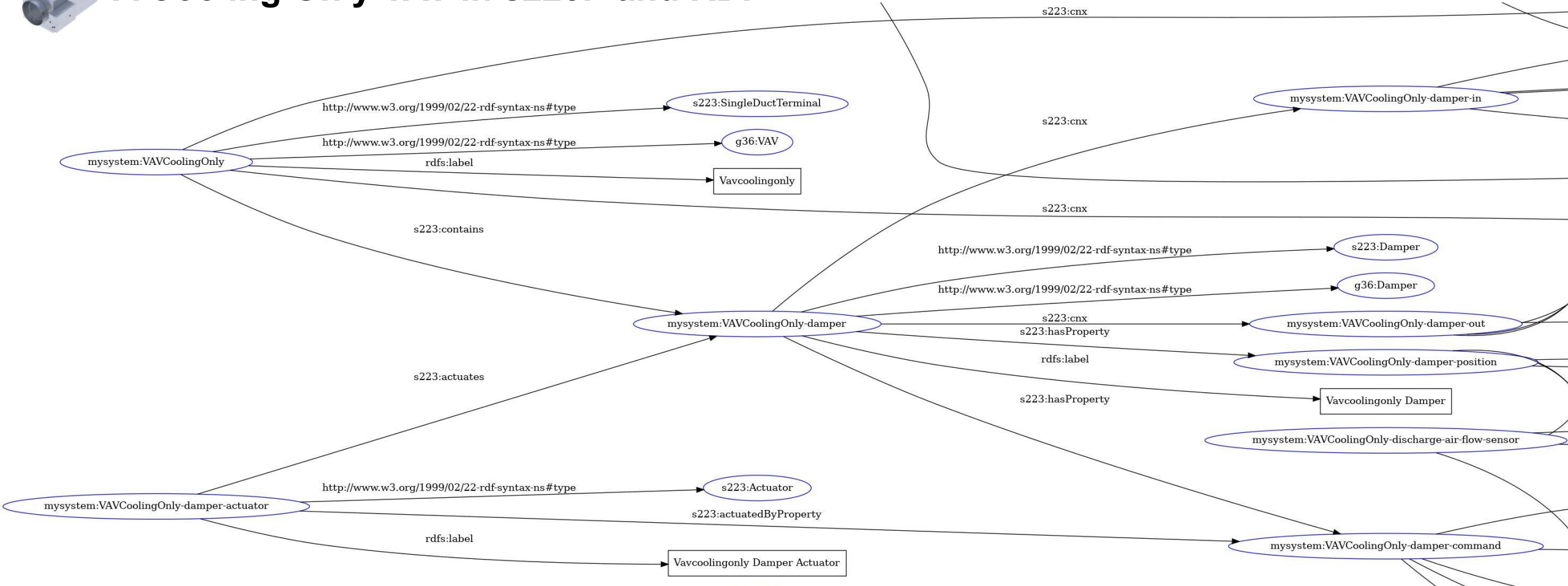
## A Cooling Only VAV in s223P and RDF



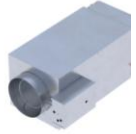
# Semantic Data Modeling with RDF & ASHRAE 223P



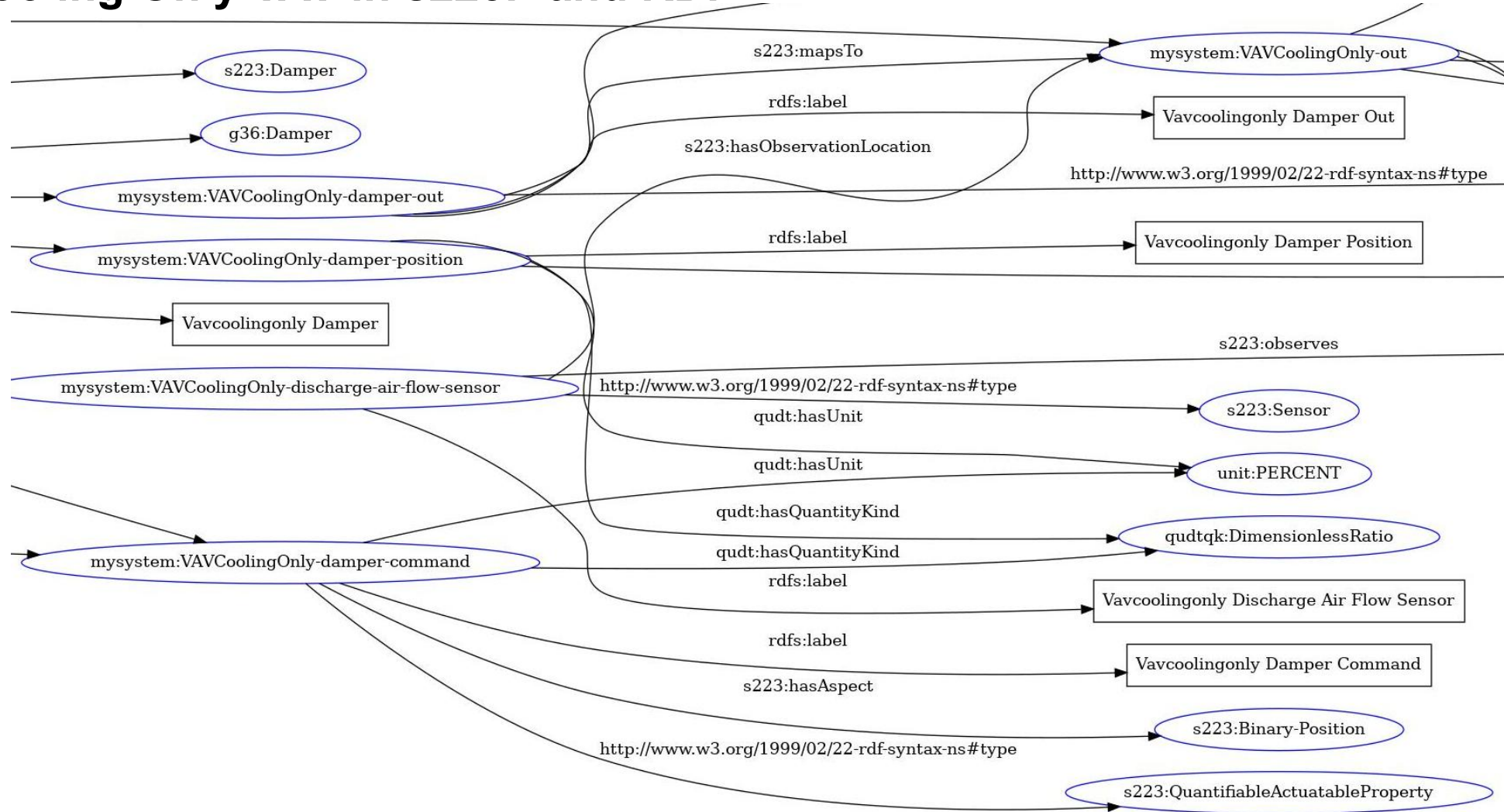
## A Cooling Only VAV in s223P and RDF



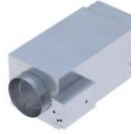
# Semantic Data Modeling with RDF & ASHRAE 223P



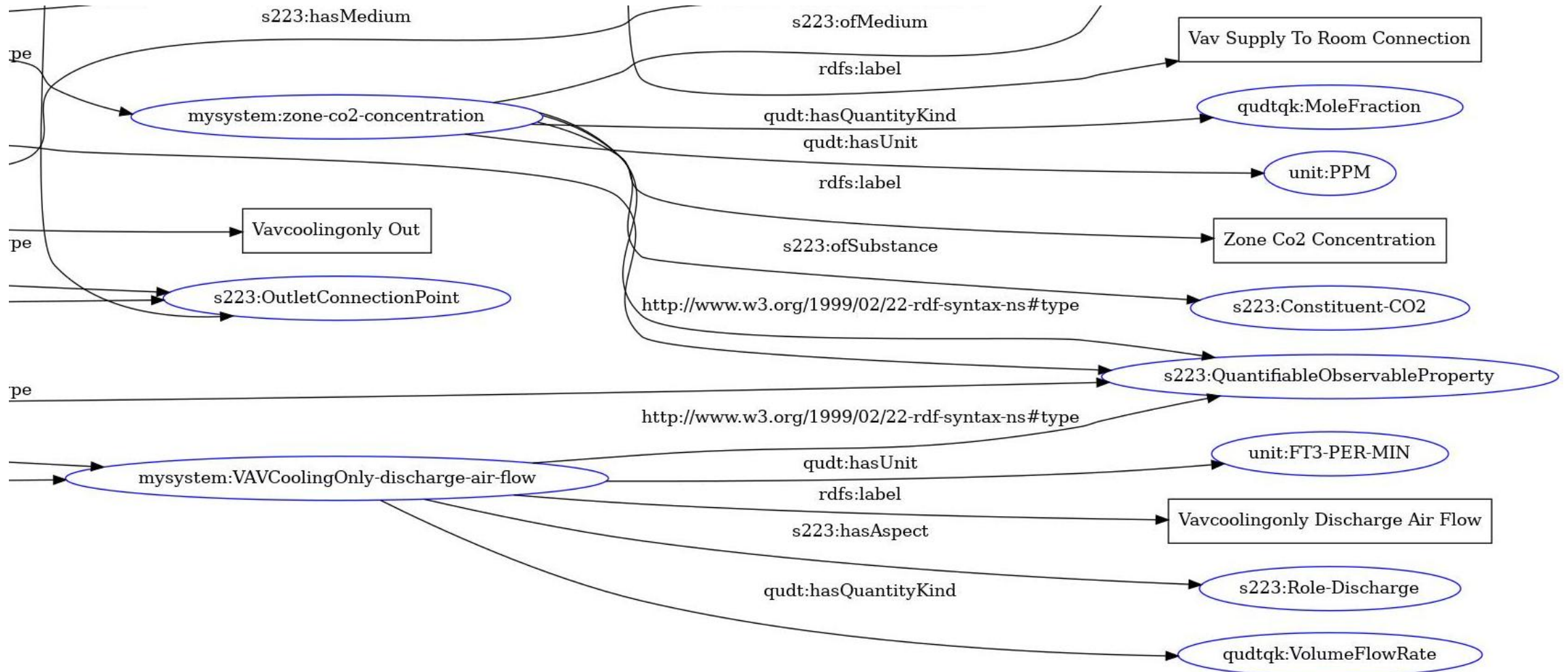
## A Cooling Only VAV in s223P and RDF



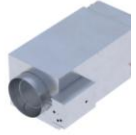
# Semantic Data Modeling with RDF & ASHRAE 223P



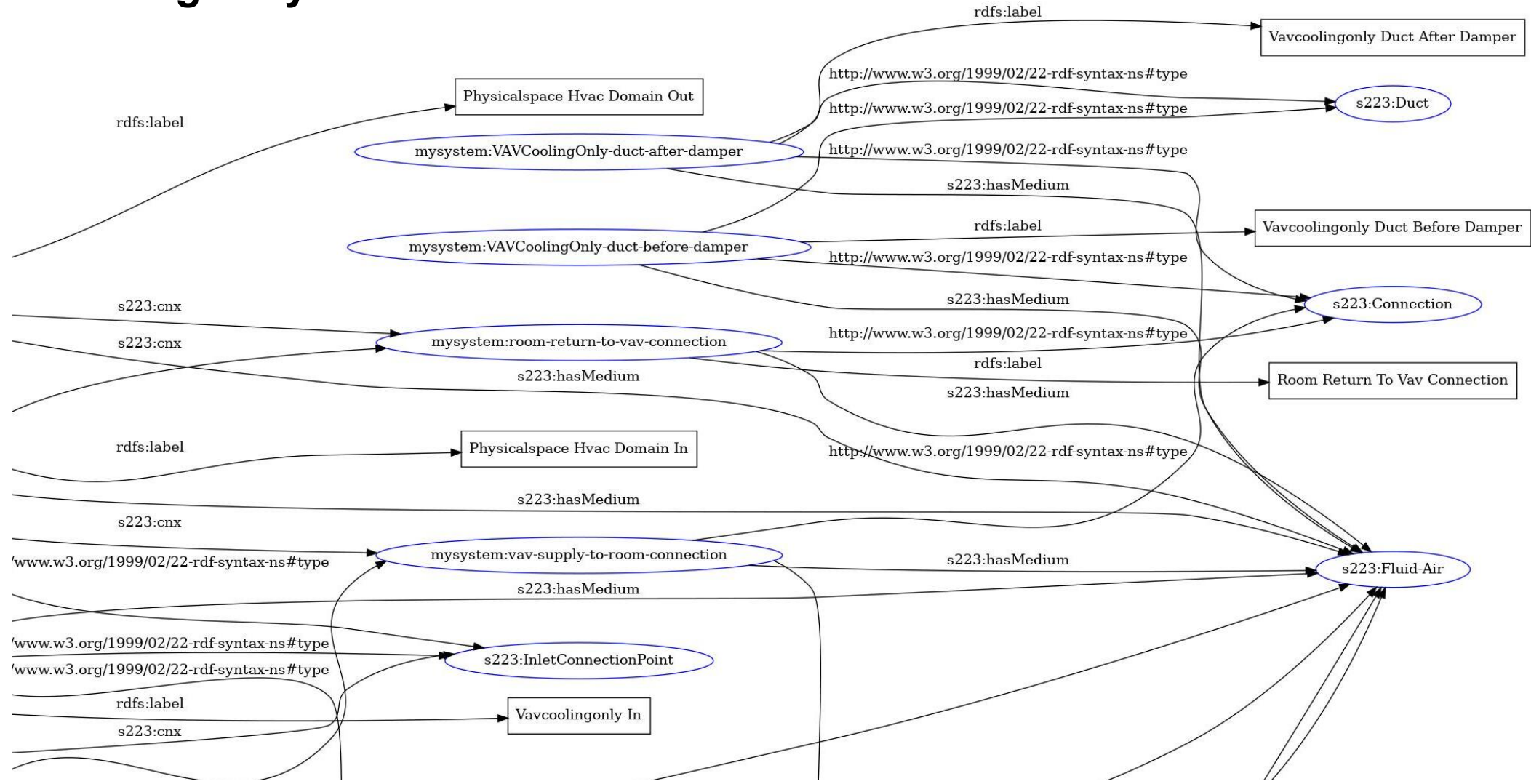
## A Cooling Only VAV in s223P and RDF



# Semantic Data Modeling with RDF & ASHRAE 223P



## A Cooling Only VAV in s223P and RDF



# BACnet RDF

- Provides a path for combining BIM and BACnet (and everything between)
- Demonstrates the importance of linking metadata to dynamic assets

## 135-2024<sup>ct-1</sup> BACnet Resource Description Framework

### Rationale

While the SI-WG (ASHRAE 223p) is developing an RDF data model that can be used to build a graph of building equipment with interconnected components, these views are created for human interpretation and not necessarily machine readable.

This addendum describes the serialization of primitive data elements and constructed data using RDF.

[**Change** Clause 3.3, pg. 21]

...

**RBAC**      role-based access control

**RDF**        *resource description framework*

**REQ**        request primitive

...

# BACnet RDF

## ZZ.1 Example Object

The following example illustrates an Analog Input Object using the `bacnet:object-type` property to reference the `ObjectType` enumeration.

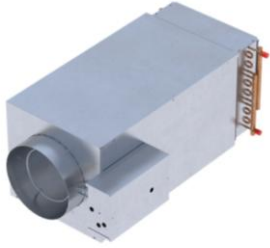
```
<ex:aio-1> bacnet:object-type bacnet:ObjectType.analog-input ;  
  bacnet:object-identifier "analog-input,1" ;  
  bacnet:object-name "OAT" ;  
  bacnet:description "Outside air temperature" .
```

## ZZ.2 Example Binary Value Object

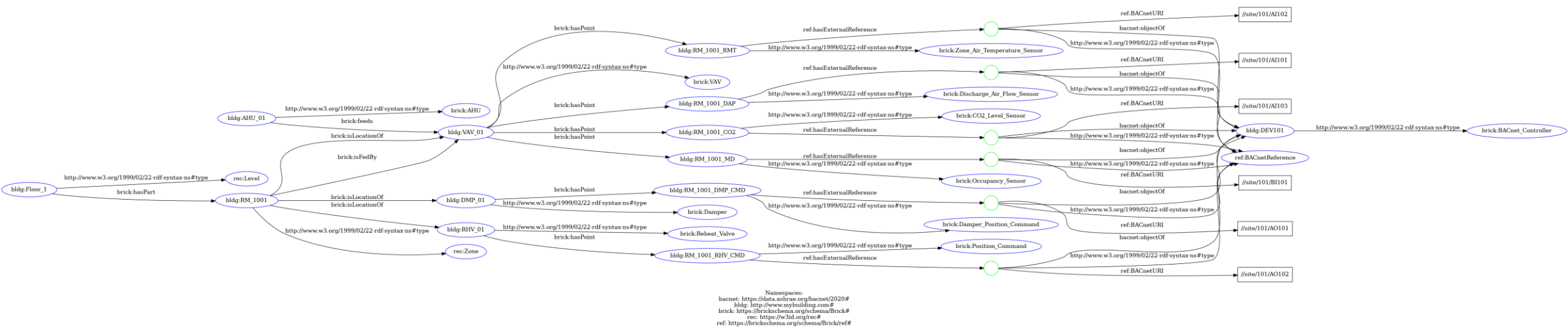
The following example illustrates a Binary Value Object using `rdf:type` to describe the type of RDF node. The `bacnet:object-type` property value can be inferred.

```
<ex:bv-2> rdf:type bacnet:BinaryValueObject ;  
  bacnet:object-identifier "binary-value,2" ;  
  bacnet:object-name "OCCENAB" ;  
  bacnet:description "Occupancy control enabled" ;  
  bacnet:present-value bacnet:BinaryPV.active ;  
  bacnet:out-of-service false ;  
  bacnet:event-state bacnet:EventState.normal .
```

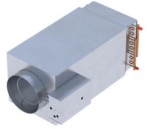
# A Simple Application of BACnet RDF with Brick



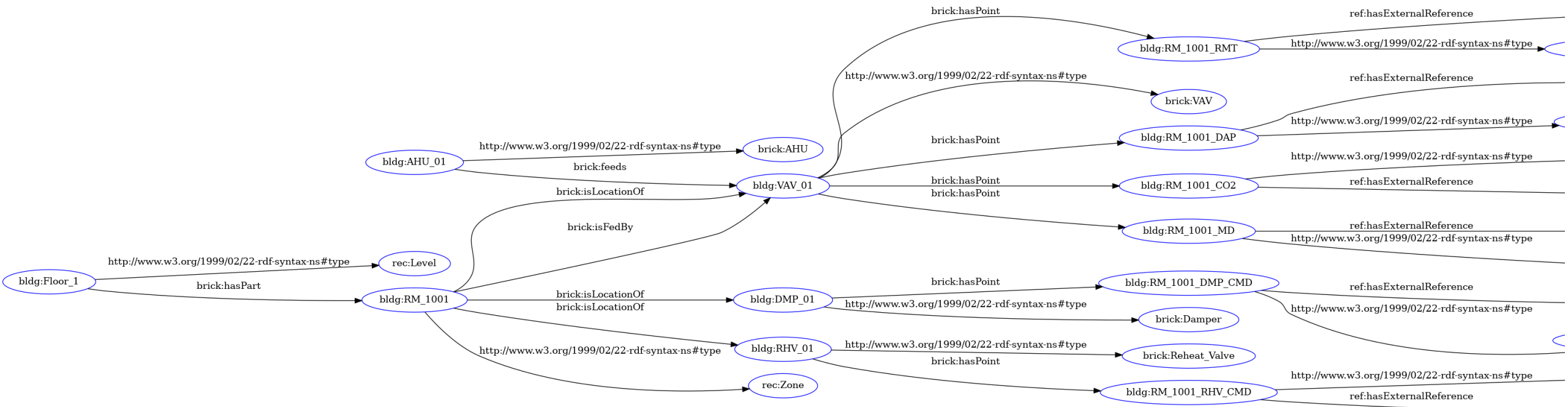
Example:  
VAV + Reheat



# A Simple Application of BACnet RDF with Brick



## VAV + Reheat



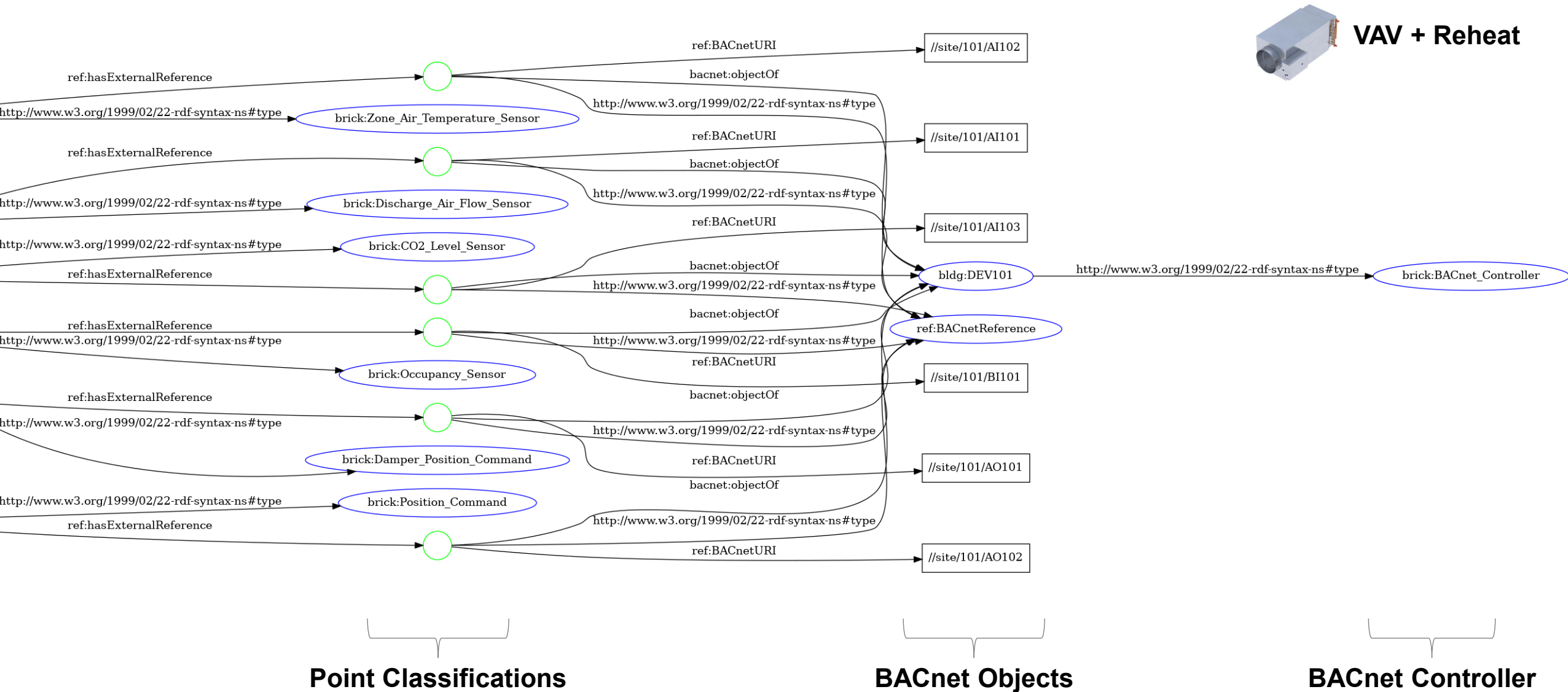
**Building &  
External Relationships**

**Equipment  
& Components**

**Control Points  
& Classifications**

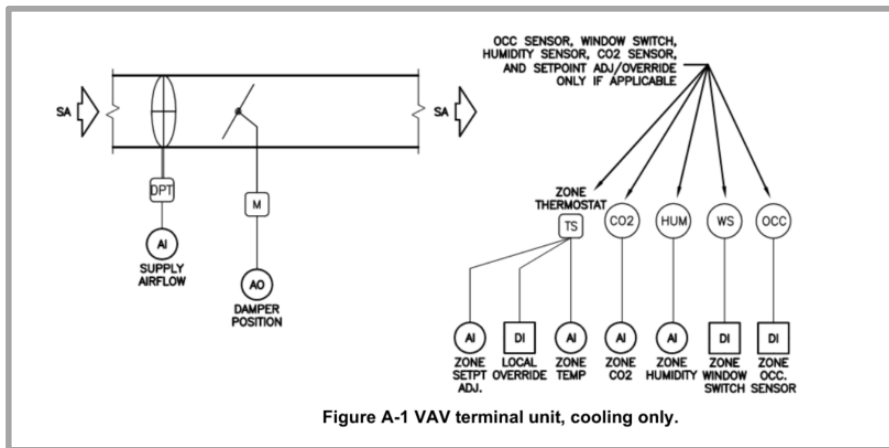


# A Simple Application of BACnet RDF with Brick



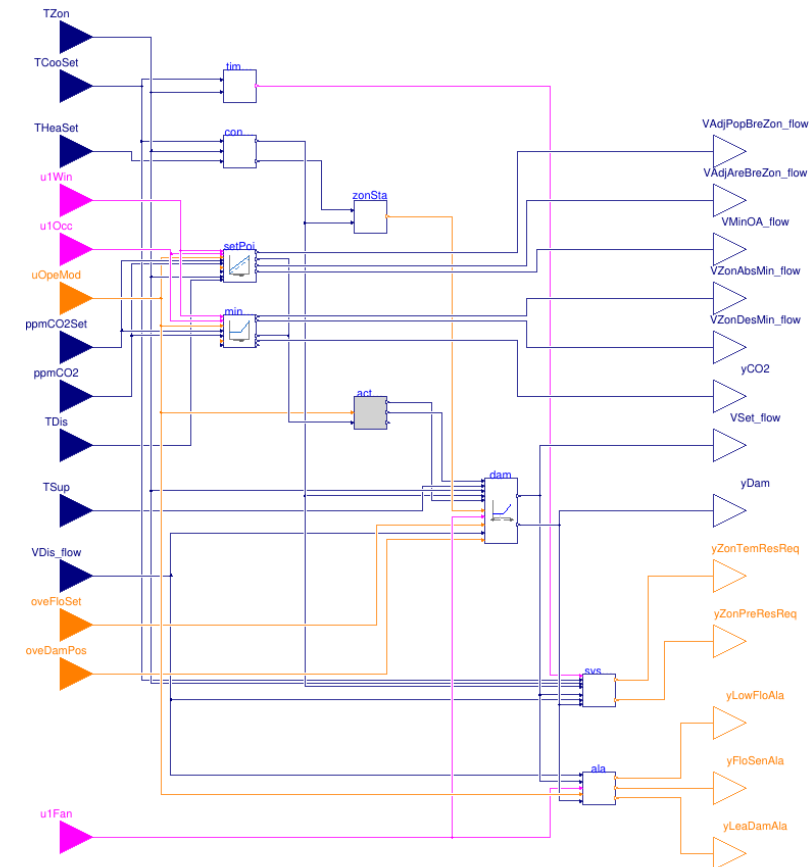
# ASHRAE Guideline 36 with Standard 231

## Guideline 36 Sequence of Operations



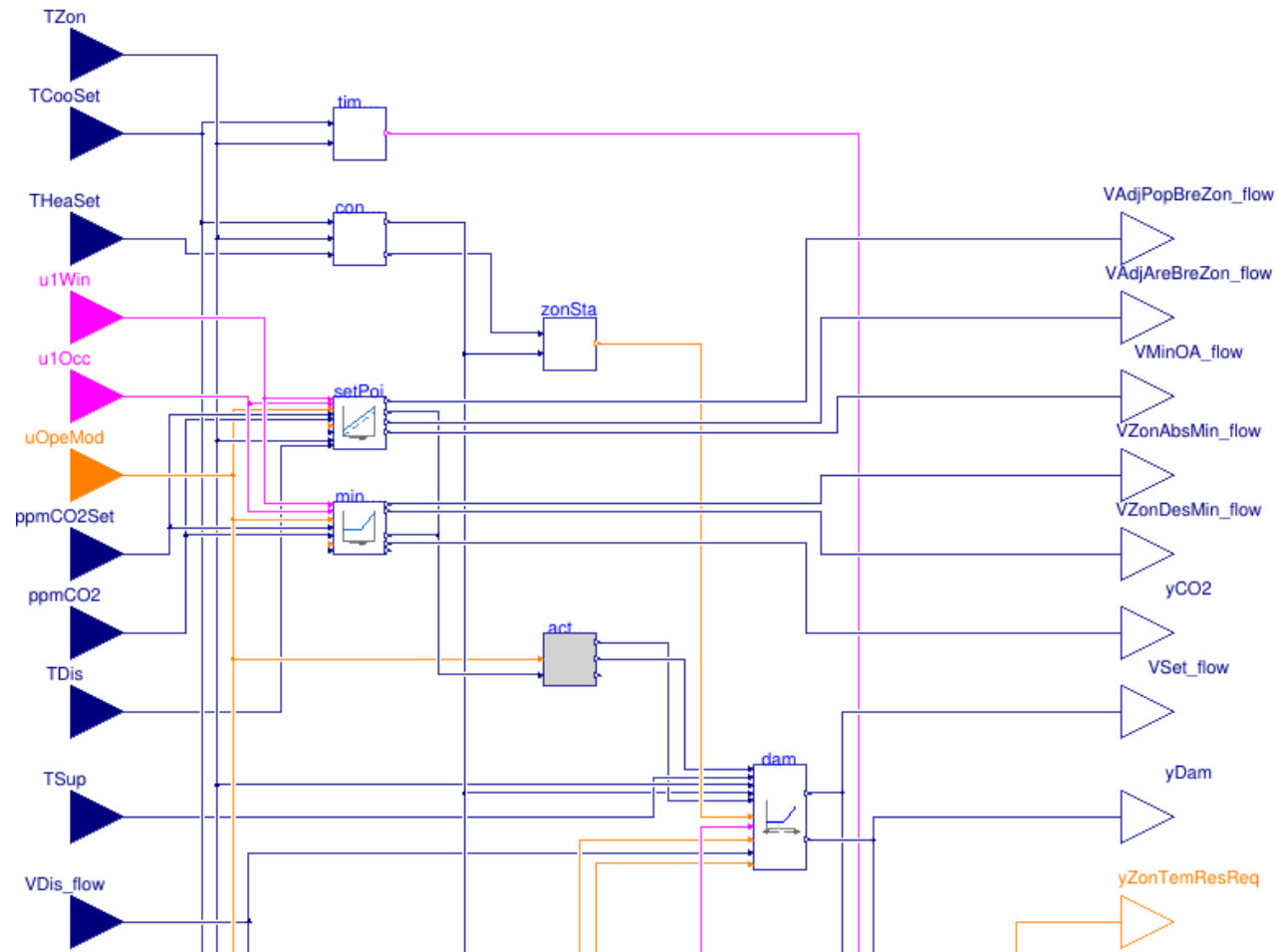
- 5.5.5.1. When the Zone State is cooling, the cooling-loop output shall be mapped to the active airflow setpoint from the minimum endpoint to the cooling maximum endpoint.
  - a. If supply air temperature from the air handler is greater than room temperature, the active airflow setpoint shall be no higher than the minimum endpoint.
- 5.5.5.2. When the Zone State is deadband, the active airflow setpoint shall be the minimum endpoint.
- 5.5.5.3. When the Zone State is heating, the Heating Loop output shall be mapped to the active airflow setpoint from the minimum endpoint to the heating maximum endpoint.
  - a. If supply air temperature from the air handler is less than 3°C (5°F) above the room temperature, the active airflow setpoint shall be no higher than the minimum endpoint.
- 5.5.5.4. The VAV damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint.
- 5.5.6. Alarms
  - 5.5.6.1. Low Airflow
    - a. If the measured airflow is less than 70% of setpoint for 10 minutes while setpoint is greater than zero, generate a Level 4 alarm.
    - b. If the measured airflow is less than 50% of setpoint for 10 minutes while setpoint is greater than zero, generate a Level 3 alarm.
    - c. If a zone has an Importance-Multiplier of 0 (see Section 5.1.16) for its static pressure reset T&R control loop, low airflow alarms shall be suppressed for that zone.

## Standard 231 Control Description Language



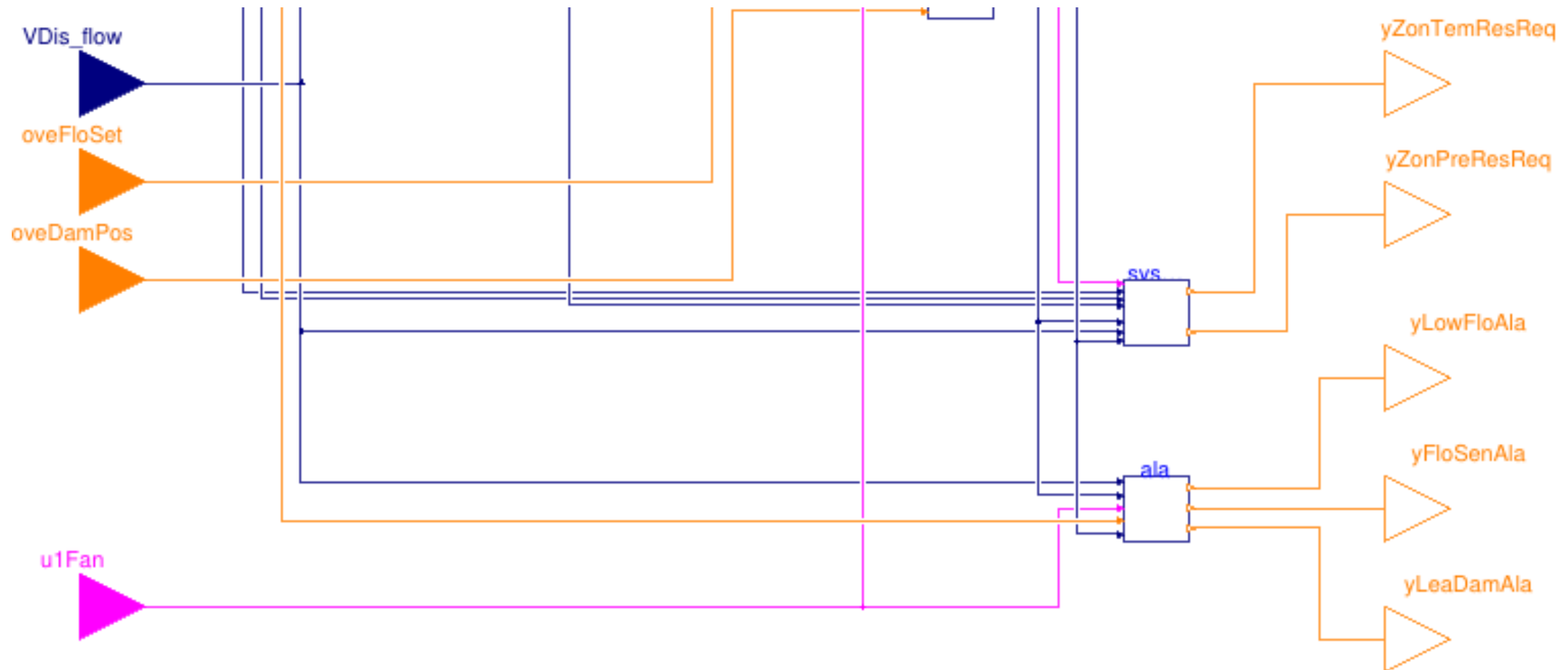
# ASHRAE Guideline 36 with Standard 231

## Cooling Only VAV in S231 (Control Description Language)



# ASHRAE Guideline 36 with Standard 231

## Cooling Only VAV in S231 (Control Description Language)



# What Can We Do When Semantic Data Models are Embedded in Typical Workflows?

- Rapidly configure control graphics and graphical user interfaces (GUI)
- Rapidly configure analytics from public (or semi-public) libraries
- Improve single-pane-of-glass data aggregation from multiple protocols and application programming interfaces (API)
- Provide normalized context with ontological definitions of the assets in a system to LLM-powered AI systems



# Links for Context

- ASHRAE Standard 223P Examples: <https://models.open223.info/>
  - Can be rapidly viewed here: <https://www.ldf.fi/service/rdf-grapher>
- ASHRAE Standard 231 Examples of ASHRAE Guideline 36:  
[https://simulationresearch.lbl.gov/modelica/releases/latest/help/Buildings\\_Controls\\_OBC\\_ASHRAE\\_G36.html#Buildings.Controls.OBC.ASHRAE.G36](https://simulationresearch.lbl.gov/modelica/releases/latest/help/Buildings_Controls_OBC_ASHRAE_G36.html#Buildings.Controls.OBC.ASHRAE.G36)

# Questions

Jayson Bursill

[jbursill@deltaww.com](mailto:jbursill@deltaww.com)