Smart building controls

Smart building control platform

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Learning Objectives

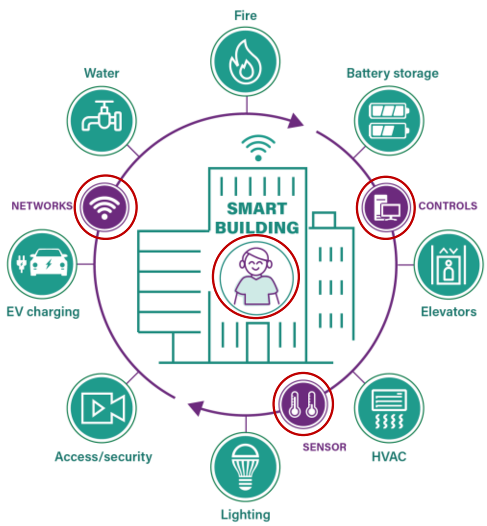
- Explain the generic smart building control platform architecture
- Describe the major components in the system, integration, and application layers and their functionalities
- Describe how smart buildings communicate with external applications
- Compare open source and proprietary platforms

Outline

- Smart Building Elements
- Control Platform Architecture
- System Layer
  - Building automation system
  - Networked lighting
  - BESS control
  - Managed EV charging
  - IoT sensors and devices
  - Communication protocols
- Integration Layer
  - Approach 1
  - Approach 2
  - Data modeling
- Application Layer
- Smart Building Communication
- Open source vs. proprietary platforms

Smart Building Elements

Smart Building Elements



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1) Building systems
   1) Envelope
   2) HVAC
   3) Lighting
   4) Water
   5) Solar PV + battery energy storage
   6) EV charging
   7) Other (elevator, fire, access/security)
2) Sensors
3) Controls
   1) Platform
   2) Control methods
4) Networks
5) Occupants!

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Smart Building Control Platform Architecture

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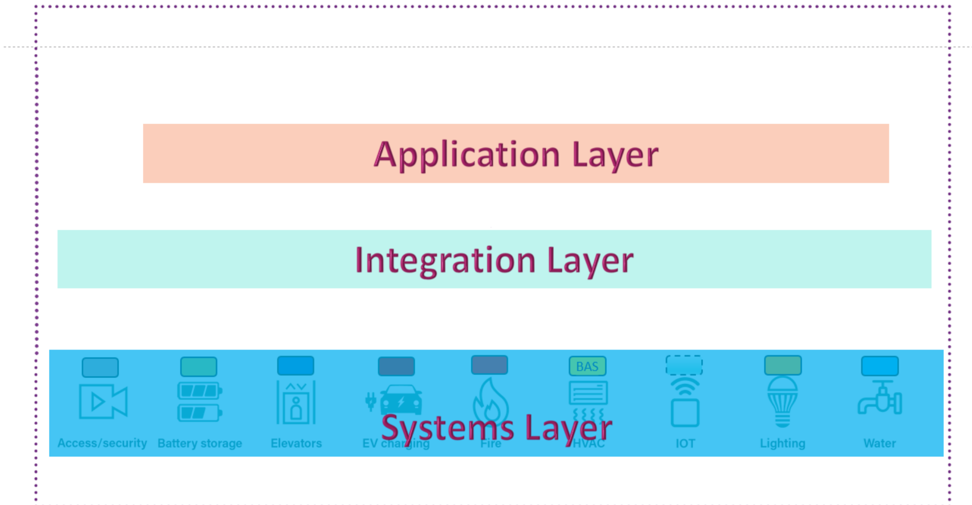
A Generalized Smart Building Control Platform Architecture



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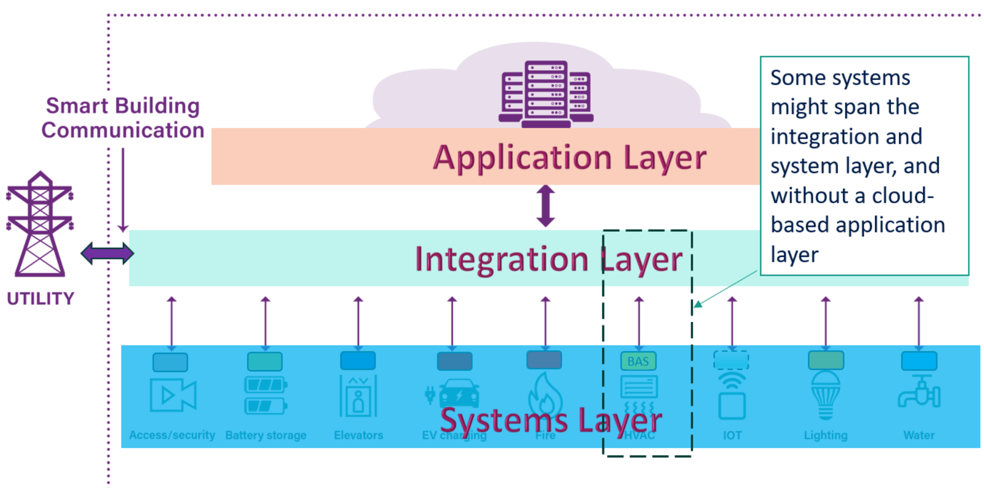
A Generalized Smart Building Control Platform Architecture



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Smart Building Control Platform Layers

Systems Layer

- Individual building system controls
- May use different protocols and data formats

Integration Layer

- Establish building-level communications among different building systems
- Unify data structures

Application Layer

- Building-level global optimization and control

External Communication

- Establish external two-way communications

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System Layer

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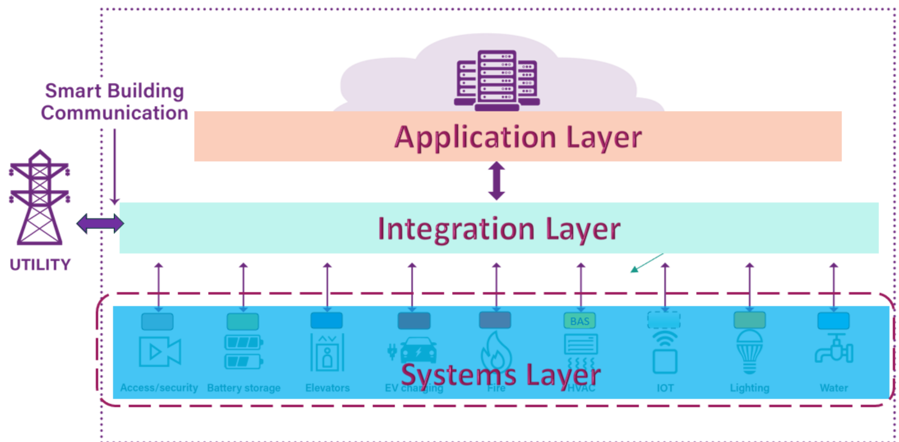
System Layer



Building Automation System

Application

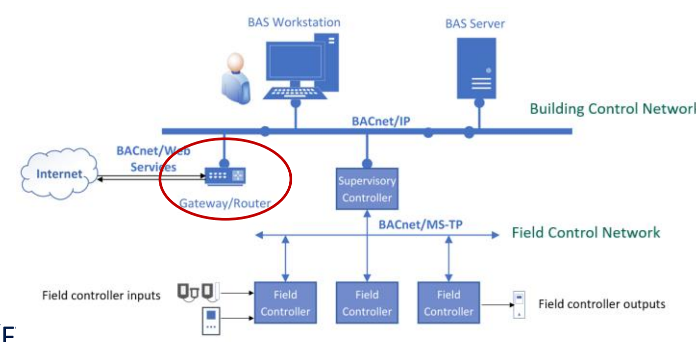
- Medium and large commercial buildings

Networking

- Building control network
- Field control network

Protocols

- BACnet/IP
- BACnet/SC
- LonWorks/IP
- BACnet MS/TP
- LonWorks TP/F
- Modbus
- KNX



Refer to Session #3 for more information on building automation systems

Networked Lighting Controls

Application

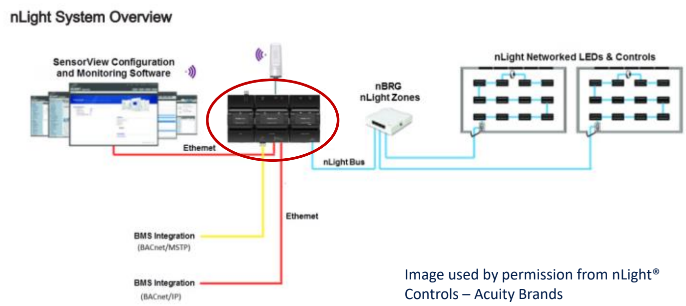
- Most commercial buildings with networked lighting systems installed

Networking

- Ethernet
- Wired or wireless lighting control network

Protocols

- DALI, DMX, BACnet, ZigBee, Bluetooth



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Refer to Session #4 for more information on Networked Lighting Controls (NLC)

Battery Storage Controls

Application

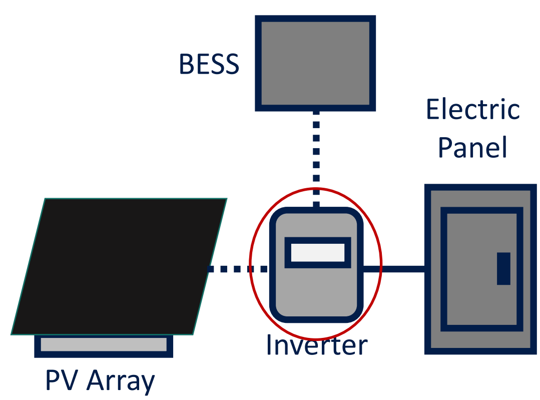
- Behind-the-meter battery energy storage
- Resilience, cost savings, and/or clean energy

Networking

- Ethernet, RS-232, RS-485

Protocols

- Sunspec Modbus, DNP3, IEEE 2030.5, OpenADR



Refer to Session #5 for more information on Battery storage controls

Managed EV Charging

Application

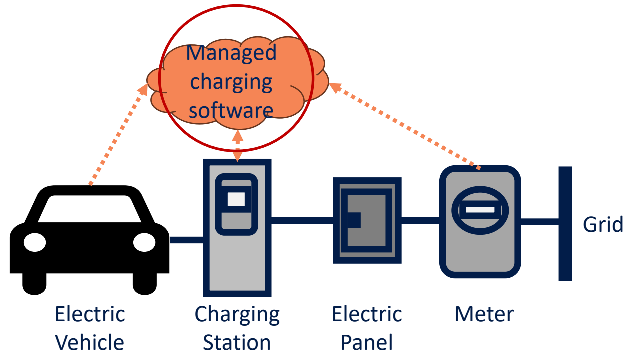
- Commercial buildings with EV charging stations

Networking

- Ethernet
- EV control network

Protocols

- OCPP (Open Charge Point Protocol)
- Sunspec Modbus
- OpenADR
- IEEE 2030.5



Refer to Session #5 for more information on Managed EV charging

IoT Sensors and IoT Devices

Application

- Individual device sensing and control
- Can be shared with multiple systems

Networking

- Ethernet

Protocols

- Http/Https
- Wifi
- Bluetooth
- Bluetooth Low Energy
- (BLE)
- Zigbee
- MQTT
- LoRaWAN

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Refer to Session #7-#8 for more information on sensors and IoT devices

Common Communication Protocols

Common Communication Protocols

- BACnet: a public, open standard for building controls
- LonWorks: a proprietary, open standard for building controls
- Modbus: widely used in industrial automation and controls, sensor, instruments, and meters
- SunSpec Modbus: used in solar PVs and renewable energy industry
- KNX: an open protocol for building and home automation
- MQTT: a lightweight, publish-subscribe messaging protocol
- DALI: commonly used in digital lighting controls

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Integration Layer

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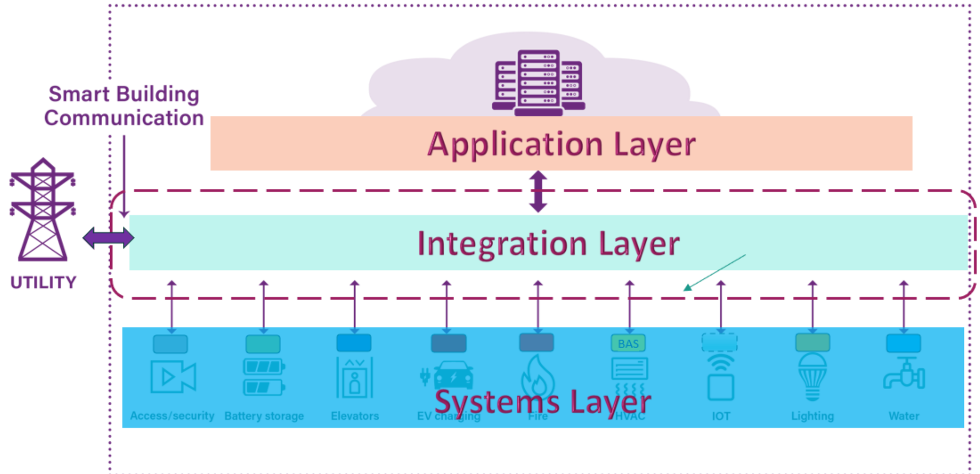
Integration Layer



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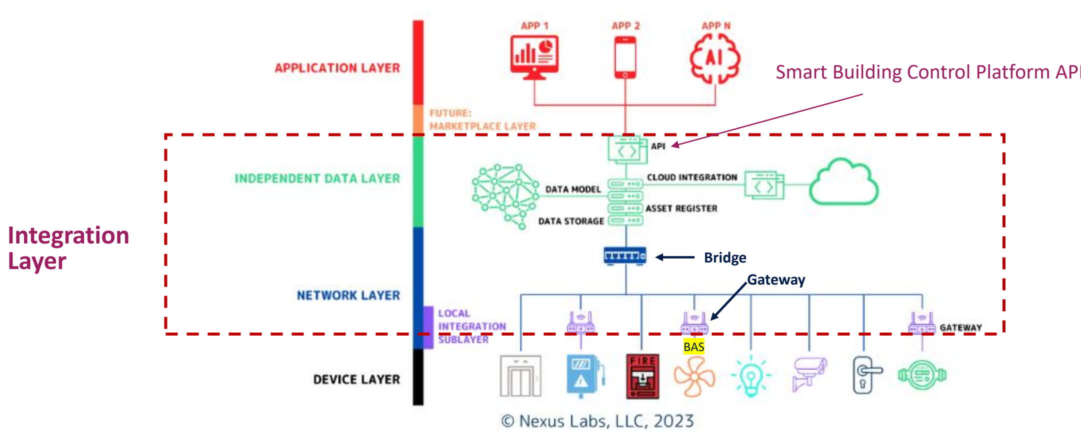
Integrate Layer – Approach 1



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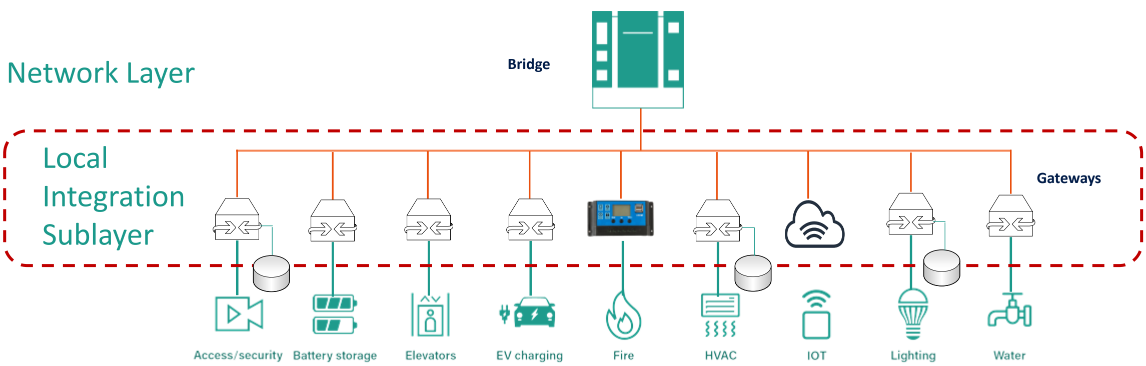
Integrate Layer – Approach 1



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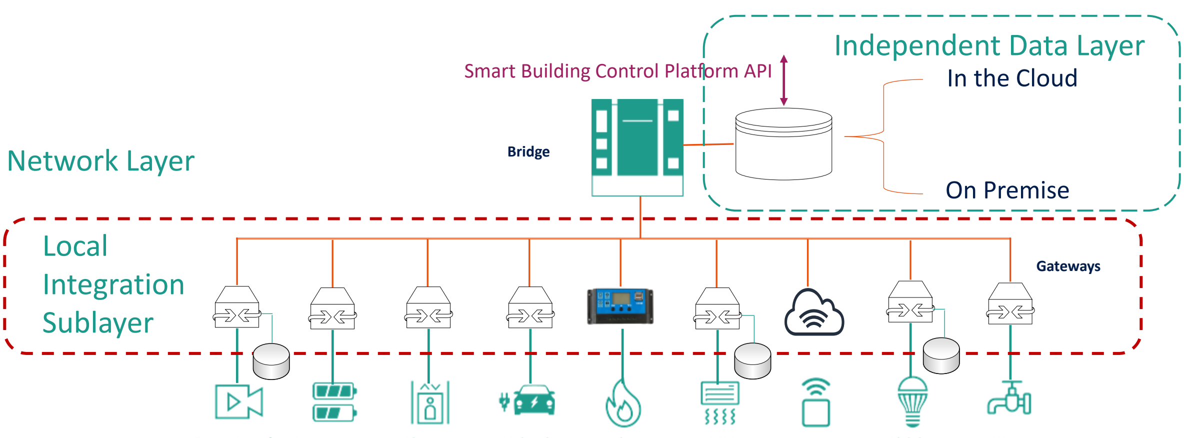
Integrate Layer – Approach 1



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Integrate Layer – Approach 1

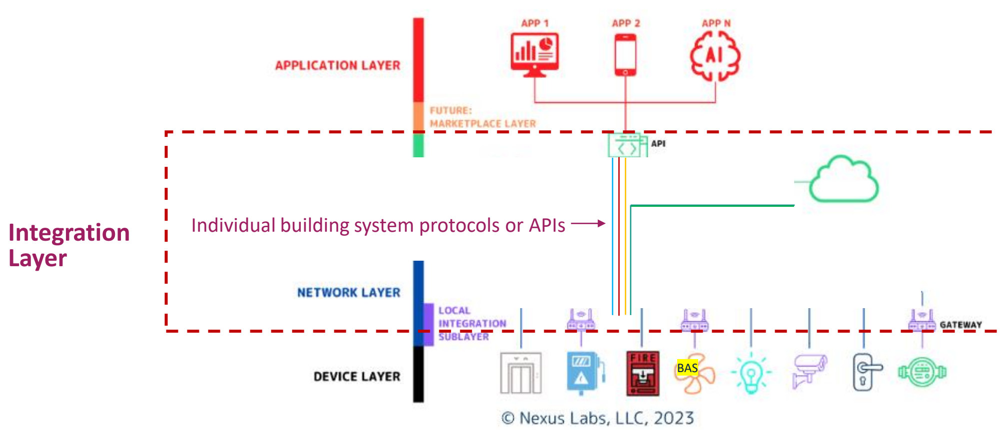
Benefits of IDL

- Unify data format across all building systems for smart building applications
- Enable modeling the data in an open and interchangeable way. Promote interoperability.
- Applications are easily added on top of the unified data model in the future

Challenges of IDL

- Potentially mass amount of data in the database/dataset
- Maybe difficult to implement if some building systems are not “open”
- Increased initial system complexity

Integrate Layer – Approach 2



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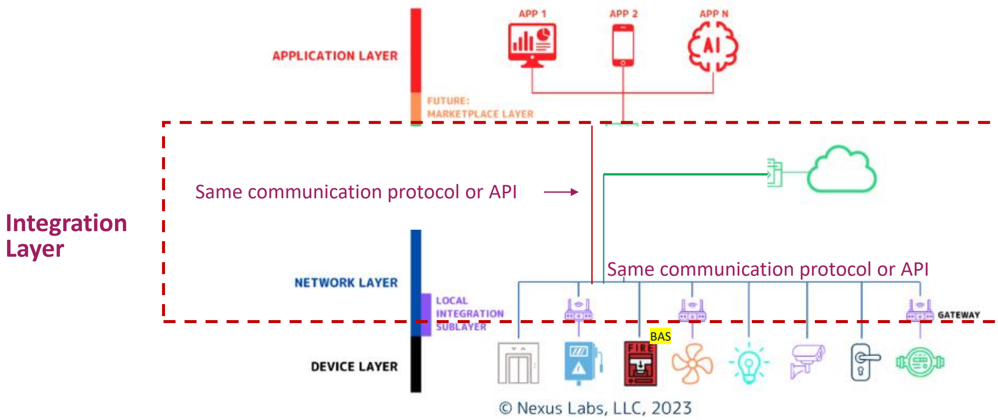
Integrate Layer – Approach 2



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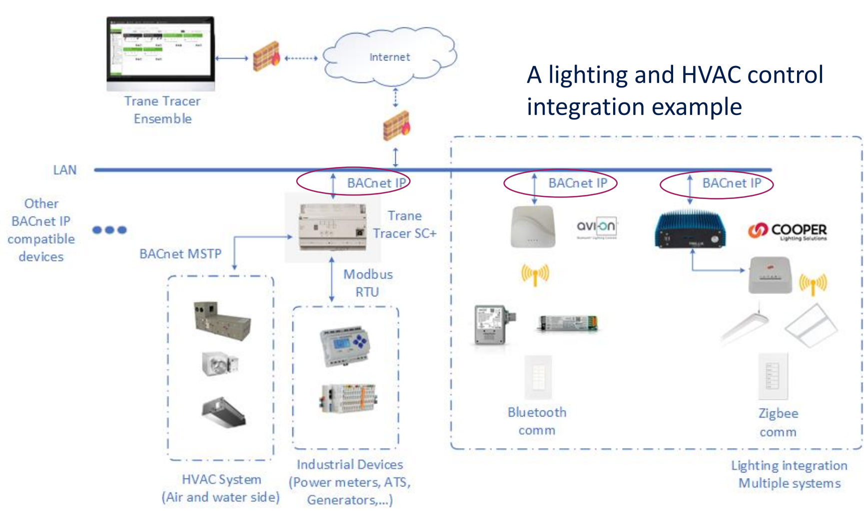
Integrate Layer – Approach 2

All building systems have t use the same communication protocol.



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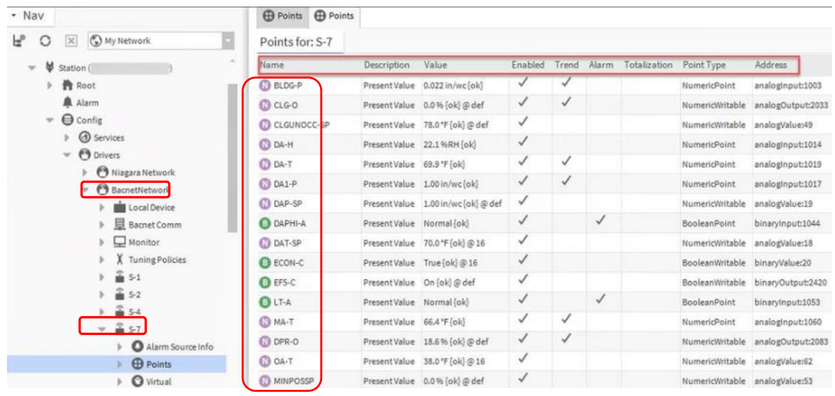
Building System Data

A BAS Data Example

- **Name**
- **Description**
- **Value – including unit**
- Trend
- Alarm
- Address

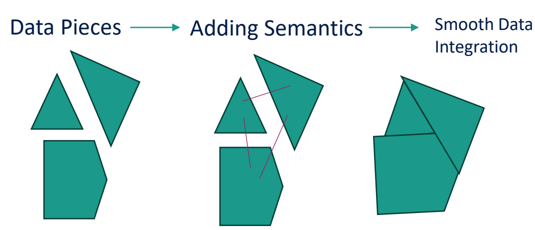


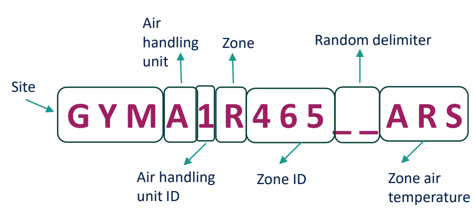
Name	Description	Value	Enabled	Trend	Alarm	Totalization	Point Type	Address
BLDG-P	Present Value	0.022 in/wc {ok}	✓	✓			NumericPoint	analogInput:1003
CLG-O	Present Value	0.0 % {ok} @ def	✓	✓			NumericWritable	analogOutput:2033
CLGUNOCC-SP	Present Value	78.0 °F {ok} @ def	✓				NumericWritable	analogValue:49
DA-H	Present Value	22.1 %RH {ok}	✓				NumericPoint	analogInput:1014
DA-T	Present Value	69.9 °F {ok}	✓	✓			NumericPoint	analogInput:1019
DA1-P	Present Value	1.00 in/wc {ok}	✓	✓			NumericPoint	analogInput:1017
DAP-SP	Present Value	1.00 in/wc {ok} @ def	✓				NumericWritable	analogValue:19
DAPHI-A	Present Value	Normal {ok}	✓		✓		BooleanPoint	binaryInput:1044
DAT-SP	Present Value	70.0 °F {ok} @ 16	✓				NumericWritable	analogValue:18
ECON-C	Present Value	True {ok} @ 16	✓				BooleanWritable	binaryValue:20
EFS-C	Present Value	On {ok} @ def	✓				BooleanWritable	binaryOutput:2420
LT-A	Present Value	Normal {ok}	✓		✓		BooleanPoint	binaryInput:1053
MA-T	Present Value	66.4 °F {ok}	✓	✓			NumericPoint	analogInput:1060
DPR-O	Present Value	18.6 % {ok} @ def	✓	✓			NumericWritable	analogOutput:2083
OA-T	Present Value	38.0 °F {ok} @ 16	✓				NumericWritable	analogValue:62
MINPOSSP	Present Value	0.0 % {ok} @ def	✓				NumericWritable	analogValue:53

Data Modeling

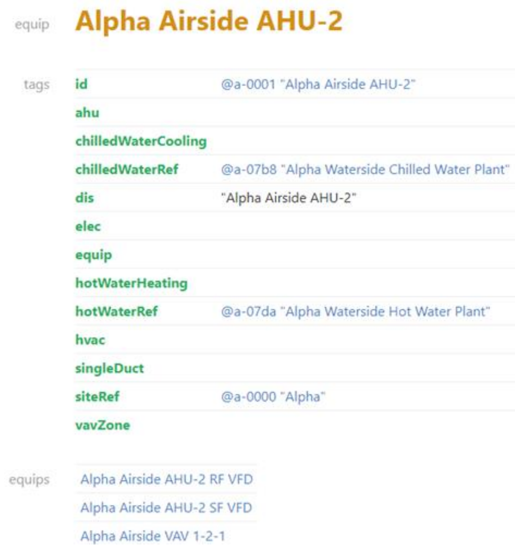
What is a Data Model

- Conceptual representation or abstraction of how data is structured and organized
- Can include standardizing on an ontology, a common understanding that provides specific meaning to terms used to describe the data





Data Modeling



Haystack

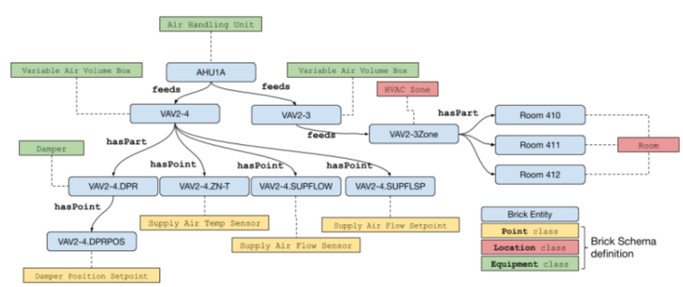
- Provides a framework to tag and describe data points, equipment, and systems in commercial buildings.
- Built for flexibility and ease of deployment
- Enables easy end-user data querying and manipulation

Project Haystack
https://project-haystack.org/

Data Modeling

Brick Schema

- A tagging and data modeling methodology that allows building data to be categorized and organized in a consistent way
- Pre-defined modeling components for the vast majority of equipment
- Focus on machine-readable interchange that allows compatibility with other modeling frameworks and ontologies and enables scalable software development and smart building project implementations.



Brick Schema
https://brickschema.org

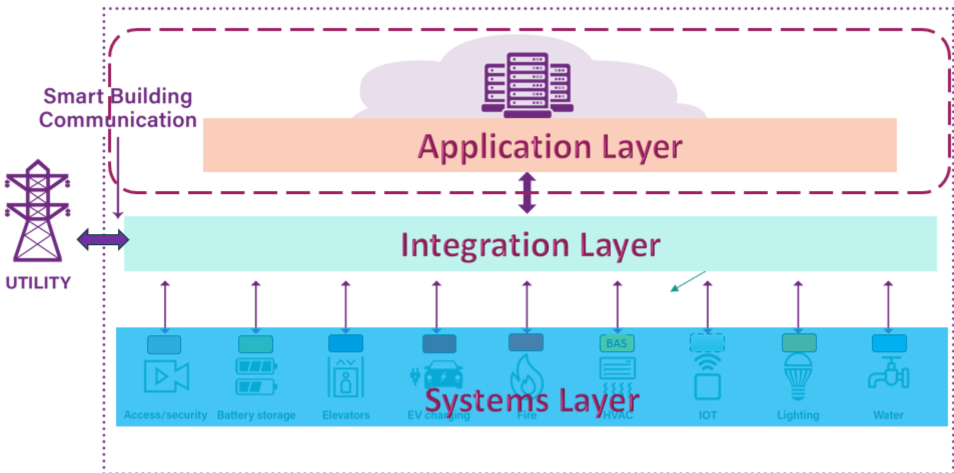
Data Modeling

ASHRAE Standard 223P

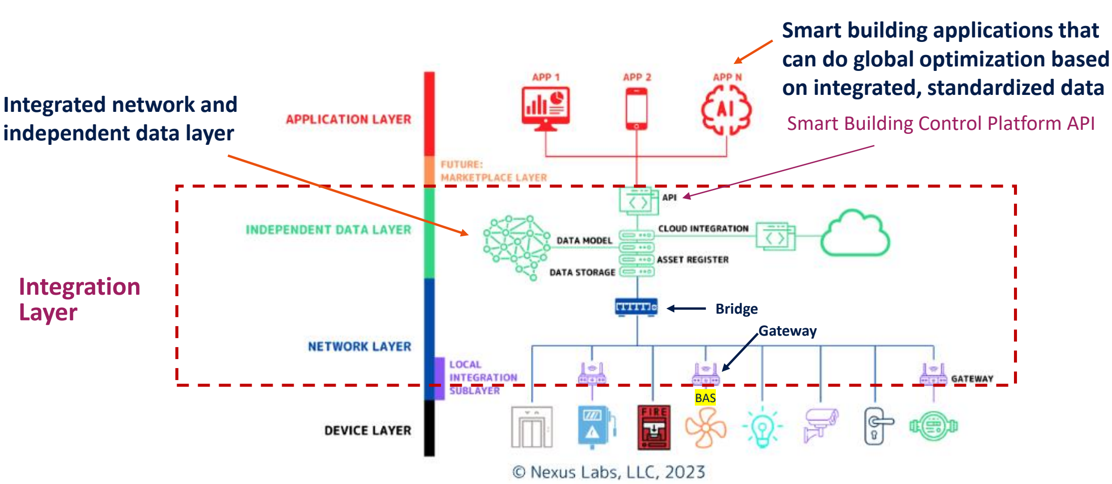
- "Semantic Data Model for Analytics and Automation Applications in Buildings"
- Integrate Haystack tagging and Brick Schema data modeling concepts
- Being developed by ASHRAE Standing Standard Project Committee(SSPC) 135 (BACnet)
- Provide a unified, structured framework that different players can use to communicate and interpret building data consistently.
- Intended for buildings and applications that benefit from accurate modeling of building HVAC equipment and energy flow
- Enables automated verification of semantic models, and configuration of smart building applications

Application Layer

Application Layer



Application Layer – Approach 1



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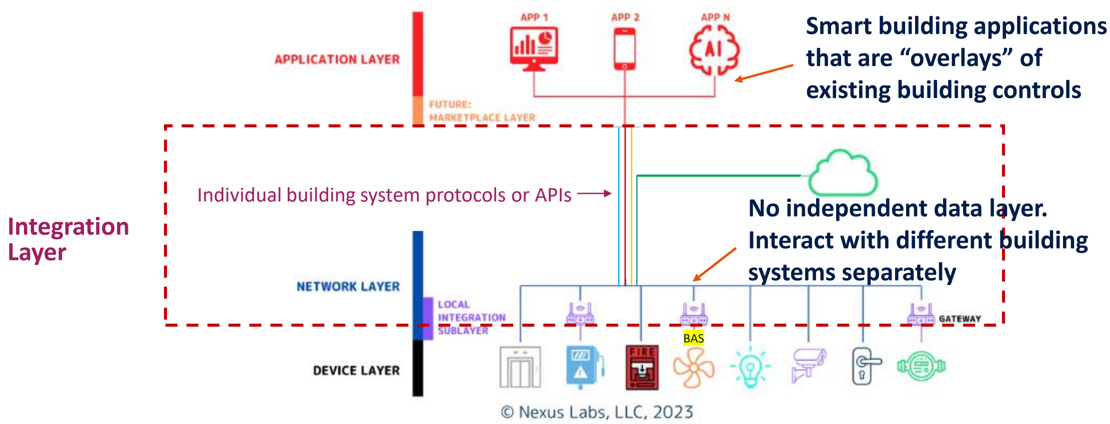
Application Layer – Approach 2



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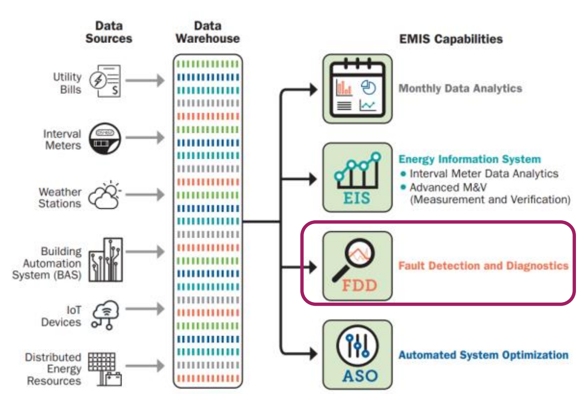
Common Smart Building Applications

EMIS - AFDD

- Automated HVAC Fault Detection and Diagnostics
- Fault diagnostics (limited)
- O&M optimization - prioritize faults based on economic impact ($)
- Workflow integration to enable automatic dispatch of facilities staff to issues
- Assist in M&V and commissioning



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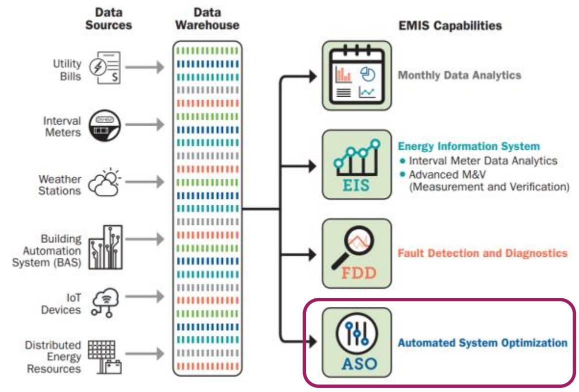
Common Smart Building Applications

EMIS - ASO

- Automated System Optimization
- Utilizes various data sources to continuously analyze and adjust HVAC system setpoints or other control parameters
- Attempts to optimize for efficient operations, performance, cost, demand reduction, and/or occupant comfort
- Can be rule-based, data-driven, machine learning, etc.
- Can run in the cloud or on-premise



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Common Smart Building Applications

Smart Room Control

- Integrate HVAC, lights, and shades controls
- Aggregate systems reporting into a single dashboard
- Optimize operational costs
- Better space utilization with historical data and analytics

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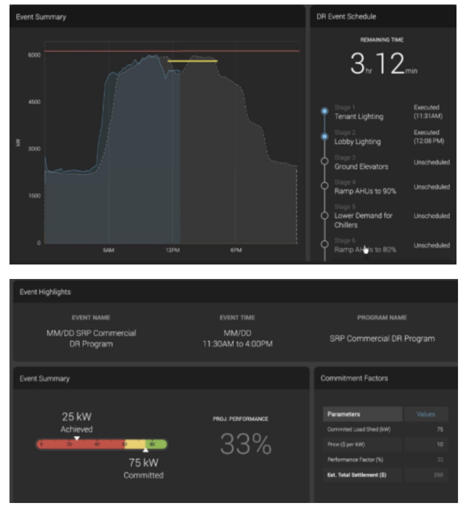
An Emerging Smart Building Application

GEB

- GEB – smart buildings using DERs (controls, solar PV, battery, EV charging, etc.) to provide grid services … in a continuous and integrated way.
- Integrate multiple DERs and apply more dynamic, adaptive strategies to maximize building load flexibility
- Allow buildings to play a significant role in the electric grid's operation and planning



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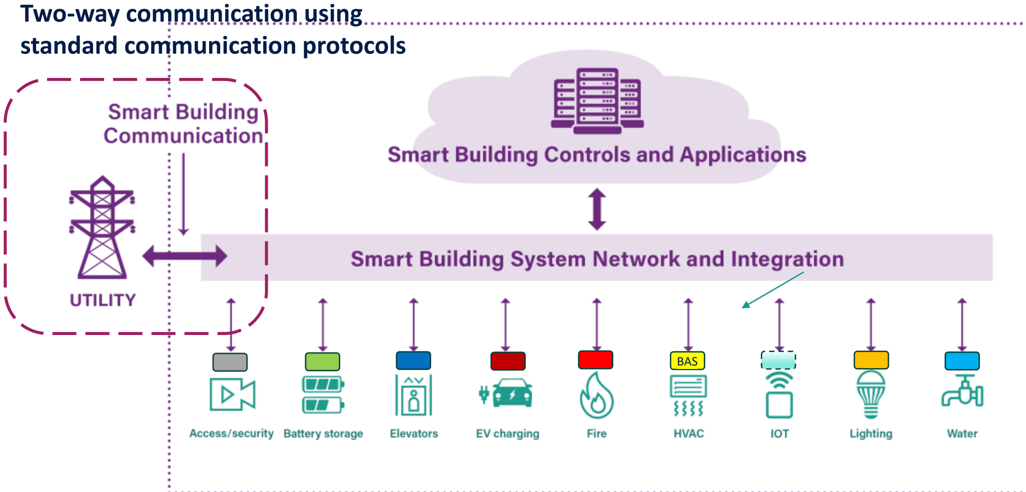
Smart Building Communication

Application Layer

Two-way communication using standard communication protocols

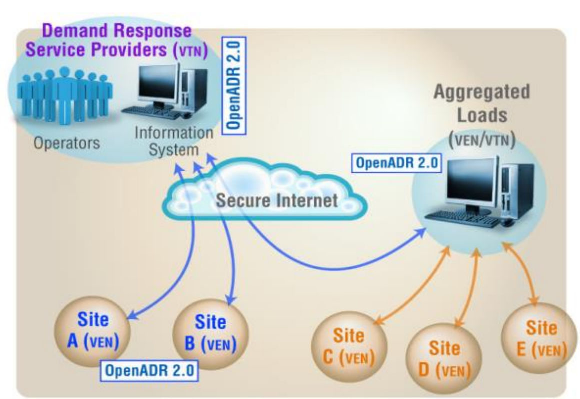


ADR: Automated Demand Response

Standard Communication Protocols

OpenADR

- A standard to receive ADR signals from the grid
- Can provide description of available load to grid for proper dispatch
- Timescale of minutes
- Profile specifications
    - OpenADR 2.0 a & b
    - OpenADR 3.0 (latest)



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Standard Communication Protocols

IEEE 2030.5 Standard for Smart Energy Profile Application Protocol

- Started as a data model for types of loads and sources participating in a grid
- Later versions added standardized interfaces that define communications protocols
- Timescale of milliseconds to seconds
- Enables more advanced use cases like frequency support, voltage support, voltage sag/swell management from distributed assets

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Open Source vs. Proprietary Platforms

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Open Source vs. Proprietary Platforms

Proprietary

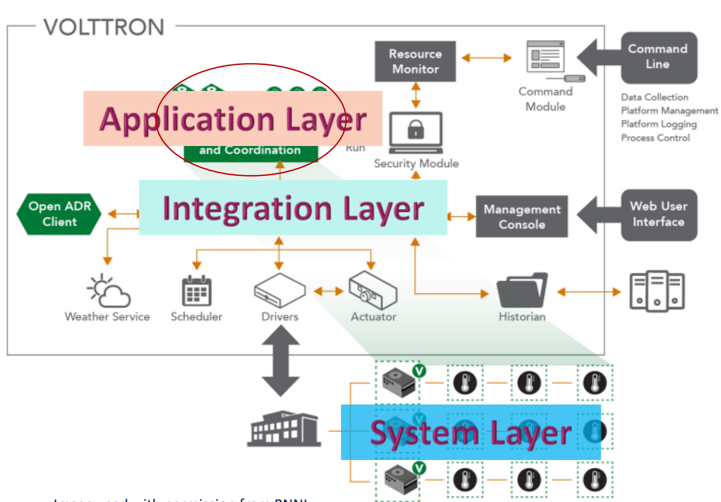
- Owned by a specific company. Could be Interoperable or Closed Ecosystem
- More expensive (potentially)
- May be able to offload implementation to vendor, requiring less technical expertise on the user side.
- Better technical support (potentially)

Open Source

- Promote interoperability. Codes are disclosed and can be modified. No future dependence on any one contractor or vendor. “Choice”
- Lower cost (potentially)
- Need more technical expertise
- Support by the community
- Product conformance testing to applicable standards is important

An Open-Source Platform Example - VOLTTRON

An **open** source, **distributed** sensing and control platform



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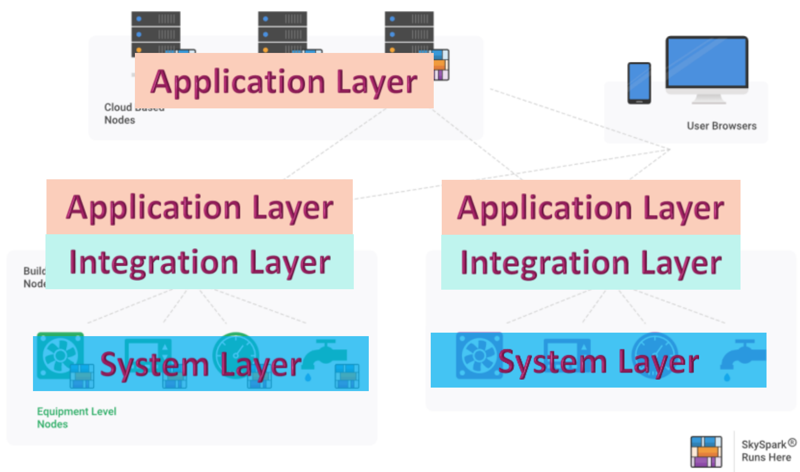
A Proprietary Platform Example - SkySpark® Everywhere™

SkySpark offers a variety of architectural choices: on prem, in the cloud or a hybrid.



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