Brick: Towards a Unified Metadata Schema For Buildings

http://brickschema.org/

A Vision for "Smart Buildings"

Anniertiens	Demand Response	Occupant Interaction	NILM
Applications	Occupancy Models	Predictive Control	Fault Detection
Management	APIs	Data Storage	Access Control
Services	Monitoring	Search	Privacy
Duildingo	Home	Office	Factory
Buildings	Home Research Lab	Office Hospital	Factory Shopping Mall
Buildings Infrastructure:	Home Research Lab Smoke Detector	Office Hospital Thermostat	Factory Shopping Mall Motion Sensor

Data From Buildings Faces Significant Challenges in Integration

Apps need to understand building metadata

- Location of sensors and equipment
- How equipment connect with each other
- Configuration parameters of control systems
 - Temperature sensor as an example
 - What? -> air, water
 - Where? -> room, exhaust, refrigerator
 - How is it used? -> control system, fault

But metadata not consistent or machine readable
 E.g. "Temperature" -> "Temp", "Temporary" -> "Temp"
 Metadata varies with building, vendor, type of system

Metadata For An Existing Building

Energy Loss Heating Occupied Supply Hi Alarm Enable Standby TUNING Min Sensor Position F1 Adarm Enable Standoy TUNING WITH Sensor POSITION 1 TO VV Point Overload Humidity AI Current Occupancy Damper open Deceleration System Adjust Valve Booster Liquid SP Unit DIFF Temp File Good Low Angle Output Short Suction Motor Pan Discharge Setpt HWP Stages OSA VFD DC Standy Shed Off By Server HX Ret Direction Pan Discharge Setpt Control of thigh Warm/Cool Standy Shed Off By Server HX Ret Direction Power Exhaust Chilled Last Electrical Reset ST Delay Occ PID L Exchanger EPO Reference HW DISCH Lobby ISO FLR Floor Activated Torque Are Sts Local Water Limit Change Bypass Feedba Maintenance Main OUT Pump Heat Bus stat Htg Detected Fan Locally Filter Compressor Gain AO LEAD Turned Commanded Acceleration Econ-O-Cycle Cmd DO Lock Remotely Acceleration Econ-O-Cycle Cmd DO Lock Remotely Glycool Domestic Battery Smoke Filters Max Control Present Status PID Load Feedback Max Average Temperature Reheat DEMAND Airflow Setpoint Humidification CHWP Differential Frequency ON=1/OFF Communicat Emergency Status Communications

Source: EBU3B building at UCSD, built in 2004. Word cloud limited to 200 most frequent words

We Need a Metadata Schema



BIM/IFC

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Construction

Coverage

Architecture, Mechanical, Electrical Design

Data Model

EXPRESS

Limitation

Lack of sensors, equipment

BIM/IFC

SAREF, SSN

Domain

Coverage

Data Model

Limitation

Construction

Architecture,

Mechanical,

Electrical Design

EXPRESS

Lack of sensors,

equipment

Smart Appliances, Sensor Networks

> Location, Appliance, Sensors

Semantic Ontology

Limited vocabulary

	BIM/IFC	SAREF, SSN	Haystack
Domain	Construction	Smart Appliances, Sensor Networks	Building Management
Coverage	Architecture, Mechanical, Electrical Design	Location, Appliance, Sensors	HVAC, Lighting Weather, Sensor Points
Data Model	EXPRESS	Semantic Ontology	Tags
Limitation	Lack of sensors, equipment	Limited vocabulary	Inadequate tooling, limited relationships

Coverage and Expressiveness in Existing Schema



Bhattacharya, Arka, Joern Ploennigs, and David Culler. "Short Paper: Analyzing Metadata Schemas for Buildings: The Good, the Bad, and the Ugly." *BuildSys*, 2015.

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Collaborative Solution to a Common Problem

Limitations of	In	formal Workshop		Open Source
existing schema	Feb '16	at Berkeley	Jun '16	Release & Demo
BuildSys'15	Collaboration initiation	May '16	BuildSys Deadline	BuildSys '16



Bharathan Balaji, UCLA



Joshua Gluck, CMU



Joern Ploennigs, IBM



Rajesh Gupta, UCSD



Arka Bhattacharya, UC Berkeley



Dezhi Hong, UVA



Yuvraj Agarwal, CMU



Mikkel Kjaergaard, SDU



Gabriel Fierro, UC Berkeley



Aslak Johansen, SDU



Mario Berges, CMU



Mani Srivastava, UCLA



Jingkun Gao, CMU



Jason Koh, UCSD



David Culler, UC Berkeley



Kamin Whitehouse, UVA

UC San Diego













Brick: Building Metadata Schema



Brick: Building Metadata Schema



Completeness: Capture all sensors/subsystems
 Expressiveness: Capture relationships to run applications
 Usability: Easy to understand, easy to map buildings

Outline

- Why do we need Brick?
- Brick
 - Basics
 - Development
 - Results
- Moving forward

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Brick is a Graph of Building Entities



What Does Brick Contain?



An Example "Model" Building



Brick is a Graph of Building Entities



We choose to model this graph using ontologies Alternatives: Verilog, IFC

Tagsets: Brick Entities



Tagsets and Tags

Tagsets: Building entities described in Brick

- "Zone Temperature Sensor"
- "Zone CO2 Sensor"
- "Room"
- "Air Handler Unit" (also called "AHU")
- Tags: Decomposition of tagsets
 - "Zone Temperature Sensor" -> "Zone" "Temperature" "Sensor"
- Tags facilitate annotation and keyword search
- Tagsets facilitate semantic modeling

Thermostat

Temperature

CO2 Sensor

Tagsets are Organized in a Hierarchy

Location

- Building
- Room
 - Conference Room
- HVAC Zone
- Lighting Zone

- Equipment
 - Fire Safety System
 - HVAC

- AHU
- Fan
 - Supply Fan
- Thermostat

- Point
 - Alarm
 - Command
 - Damper Command
 - Sensor
 - Temperature Sensor
 - Setpoint
 - Temperature Setpoint

Relationships Link Tagsets



Essential to capture linkages between entities

Relationships in Example Building



Designed to capture essential aspects in BMS
 Restrictions to avoid misuse: "hasLocation" limited to

11/16/16

Location tagsets

Relationships in Example Building



Function Blocks



Enables modularity, encapsulation, reusability
 Library of function blocks to ease development

Brick, BuildSys 2016

Machine Readable & Queryable

➤Triples as data format

- subject predicate object
- Every entity is a URL brick: <http://buildsys.org/ontologies/Brick#>
- example:Berg_Hall rdf:type brick:Room example:Light hasLocation example:Berg_Hall

SPARQL for querying

- Pattern matches across the graph
- SELECT ?temp WHERE {
 - ?temp rdf:type brick:Temperature_Sensor

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Empirical Methodology

Six Buildings

UCSDUC BerkeleySDUUVACMUIBM, Ireland

17700 points, 630000 sqft.

Eight Representative Applications



Iterative Development Process



Iterative Development Process



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Coverage Across Buildings

 Building
 UCSD
 CMU
 IBM
 UVA
 Berkeley
 SDU

 Coverage
 96%
 99%
 99%
 98.5%
 98.7%
 98.8%

App Query Matches for Buildings



Live Demo

sensor



Brick

- TS is a Temperature Sensor
- **TS hasLocation Room**
- TS isPointOf VAV

Brick

Haystack

Brick

Reference Implementation

6 buildings, 8 applications Haystack

None

Brick

Reference Implementation

Relationships

6 buildings, 8 applications

Captures relationships within and across subsystems Haystack

None

Can link entities, but does not classify relationships

	Brick	Haystack
Reference mplementation	6 buildings, 8 applications	None
Relationships	Captures relationships within and across subsystems	Can link entities, but does not classify relationships
Querying	SPARQL queries that traverse Brick graph	Restrictive query, canno

Reference Implementation

Relationships

Querying

Encapsulation

6 buildings, 8 applications

Brick

Captures relationships within and across subsystems

SPARQL queries that traverse Brick graph

Functional blocks encapsulate complex subsystems Haystack

None

Can link entities, but does not classify relationships

Restrictive query, cannot traverse relationships

No modularity

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Lessons Learned

Mapping buildings to Brick
 Semi-automated mapping: 5 papers in BuildSys 2015
 New types of building and equipment

- Update building tagsets
- An unknown sensor can be referred to as "Sensor"

Separation of application from building infrastructure
 Application specific terms should not be part of Brick

Moving Forward: Call to Action!

Open Sourced with BSD license http://brickschema.org/

Sustained improvements, extensions:
 Comments, issue tracking, pull requests on github

Integrate with building management systems

We have an initial integration with BuildingDepot

Compatibility with IFC

Exploit IFC "adapters" to convert CAD specs to Brick

Brick in Practice

Usability testing, performance evaluation, tool-chain support

Thank You!

Visit our Demo!



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Jason Koh

Yuvraj Agarwal

David Culler



Mikkel Kjaergaard



Mario Berges

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Kamin Whitehouse

Authors who are at BuildSys

http://brickschema.org/

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