The Innovation Hub

for Affordable Heating and Cooling

Knowledge Sharing Report #001
Building of Data Models for 2 buildings

Improving the accuracy of PV analytics and energy analytics in buildings using open asset standards and data platform integration

19 November 2021

VBIS, CSIRO, PrediQ

About i-Hub

The Innovation Hub for Affordable Heating and Cooling (i-Hub) is an initiative led by the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) in conjunction with CSIRO, Queensland University of Technology (QUT), the University of Melbourne and the University of Wollongong and supported by Australian Renewable Energy Agency (ARENA) to facilitate the heating, ventilation, air conditioning and refrigeration (HVAC&R) industry's transition to a low emissions future, stimulate jobs growth, and showcase HVAC&R innovation in buildings.

The objective of i-Hub is to support the broader HVAC&R industry with knowledge dissemination, skills-development and capacity-building. By facilitating a collaborative approach to innovation, i-Hub brings together leading universities, researchers, consultants, building owners and equipment manufacturers to create a connected research and development community in Australia.

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Primary Project Partner

Improving the accuracy of PV analytics and energy analytics in buildings using open asset standards and data platform integration

Large scale adoption of technology in buildings has resulted in availability of large volume of data on the performance of HVAC and renewable generation assets. This data can be used for predicting availability of onsite generation, effectively manage HVAC operations and support decarbonisation of buildings.

While operational data exists, application of data driven analytics for accurate predictions will still require customisation of methods/models to specific systems and assets.

This project proposes the utilisation of the VBIS asset classification open standard and link them with Data Clearing House based semantic models to demonstrate the benefits of integrated asset and building tagging systems to be used by PrediQ's analytics solutions.

Lead organisation

VBIS

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1. Executive Summary

As part of the DCH 7 i-Hub project there is a requirement to onboard and model five City of Melbourne buildings to allow applications to be trialled on the buildings. Onboarding consists of getting data flowing into DCH and creating the semantic model that represents and links the locations and equipment in a building, how they relate to each other and the data flowing in.

This report focusses on the creation of the first two semantic building models for the DCH7 project by the CSIRO. These buildings are the Lady Huntingfield Early Learning and Family Services Centre and the Boyd School / community hub building. The semantic model schema used in DCH is an extension of the BRICK schema. This project has a particular focus on incorporating the VBIS tagging information into these BRICK models to allow applications access to more detailed information of the assets in buildings. The following sections discusses the processes for constructing the models for these two sites.

2. Model Construction

2.1 Model scope

Semantic building models are conceptually unlimited in the level of detail they can represent. In practice it is desired and efficient if the model only contains the level of detail that is required to allow the users of the model (applications) to achieve their goals. With DCH7, there is a focus on energy usage and efficiency, so those aspects feature highly in the models created. I.e., power usage metering, power generation/solar systems, HVAC systems, Louver systems etc. Similarly, effort in modelling components that do not have data readily accessible or available for, can contain little value, so model construction can to some degree be driven by available point data.

2.2 Information Gathering

Construction of the Semantic models involved a significant information gathering exercise. Throughout the process 52 reference material files were sourced for the Lady Huntingfield site and (coincidentally) 52 reference files were sourced for the Boyd School site. These files covered aspects such as floor plans, images from BMS screens, solar system manuals, single line diagrams for solar systems, factory acceptance test documents, electrical schematics, as built mechanical systems schematics, commissioning sheets, Engineers reports, service manuals, electrical services operations, BMS point lists, BACnet scans, functional description documents, asset registers, VBIS tag information and as installed electrical diagrams.

Some of this information was provided by City of Melbourne on our initial request for information. Inevitably model constructors need further information to fully understand systems in buildings. This typically involves requests for further documents, request to access BMS systems, requests to access site. In the DCH7 project PrediQ were undertaking this information gathering with input from CSIRO as needed. PrediQ were also involved in getting the building data to flow into DCH.

Domain experts from CSIRO, familiar with the BRICK schema, collated this information into a series of standardised documents (spreadsheets) that form the basis of the semantic models. Creation of these documents is most of the work in creating the models. Three interrelated documents are created. One contains the names all the equipment and locations to be included in the model and describes BRICK relationships between them. These can be complex documents as they essentially represent a complicated network of relationships in tabular form. This required building domain expertise to understand the reference material as well as BRICK schema knowledge to categorise the appropriate BRICK relationships between those locations and equipment.

The second document is a more standard spreadsheet-type list. The primary column contains a copy of all the names of all the Locations and all the Equipment that are in the first spreadsheet. The BRICK type (Location or Equipment Class) for each of those named Locations or Equipment is also in this document. It also contains specific instance metadata for each of those named Locations or Equipment. This is where the VBIS tag information is captured.

From those two documents a placeholder BRICK model for the building can be made. At this stage it is not a complete model as the critical linkages to the data flowing from the building are yet to be incorporated.

A third spreadsheet is required to map point data that is flowing into DCH to entities in the model. Some buildings can have many thousands of points, that all need to be classified into a type (Point Class) and linked to some piece of Equipment or Location in the building model. Again, this needs domain knowledge and BRICK schema knowledge as well as detailed knowledge of the source of each of those data streams.

2.3 VBIS asset classification tags

As part of DCH7 we defined the standard for embedding VBIS tag information into BRICK models. The use of VBIS tags further enhances the model by providing asset type information within the model. This can be used for:

- Building equipment relationship reviews. E.g., if the asset type is a BRICK:Chiller with VBIS: ME-Chr-WC-Sc indicating it is a water cooled scroll chiller, any software vendor on-boarding the DCH model will automatically know to check for Cooling Towers and Condenser Pumps. Without the VBIS Tag, it will require additional effort to identify equipment or potential errors in the model.

- Asset tagging provides additional detail for analytics. An example of this is brick: Fan Coil Unit. VBIS asset tags help to indicate whether the fan coil unit is a refrigerated system (VBIS: ME-ACFCU-DX-HW for a High Wall Split System) or a water system (VBIS: ME-FCU-Du-CAH for a ducted cooling and heating system). This enables application providers to implement correct analytics for energy saving suggestions or performance assessments.

- By understanding equipment type, it is then possible to use VBIS tag information for efficiency calculations and improved forecasting. E.g., monocrystalline solar panels (VBIS: EP-SPS-Pa-MC) vs polycrystalline ones (VBIS: EP-SPS-Pa-PC). With sufficient sample size, it will also be possible to benchmark similar asset types.

Prior to this DCH7 project the BRICK and VBIS tag communities had completed initial work together (a BRICK Alignment). This Alignment is a mapping between BRICK classes to VBIS tags. The reason that VBIS tagging is complimentary to the BRICK schema is because the two schemas represent different concepts at different levels of detail. For this reason, a 1:1 mapping between the two concepts does not exist.

Whist some concepts do map one to one, more generally the mapping between the two modelling paradigms is many to many. The following examples are used to highlight these differences.

While some assets are at a higher level can have a 1 to 1 relationship between the two modelling paradigms, there are also 1 to many and many to 1 relationships that can exist (primarily due to VBIS classifying assets by type rather than function).

Examples:

1:1 mapping:

BRICK:Ceiling Fan = VBIS:ME-Fa-Ce (Mechanical - Fans – Ceiling Fan)

1:Many mapping:

BRICK:Supply Fan could be either of VBIS: ME-Fa-AAP (Mechanical - Fans - Axial Adjustable Pitch) or VBIS: ME-Fa-CF-SWSI (Mechanical - Fans – Centrifugal - Single Width Single Inlet).

Many:1 mapping:

BRICK:Supply Fan or BRICK: Discharge Fan or BRICK: Exhaust Fan, or BRICK:Fresh Air Fan, or even BRICK:Return Fan, BRICK:Standby Fan could all be VBIS: ME-Fa-AAP

Importantly one area the Alignment does not address is that it does not extend to how VBIS tag information should be represented in BRICK models.

To correctly represent VBIS tag information in BRICK models that information needs to be associated with entities in the model rather than classes. BRICK has the concept of EntityProperties for this purpose (e.g BRICK:tilt and BRICK:azimuth to represent solar panel orientation to facilitate analytics). The latest version of BRICK does not include a definition for a VBIS tag property. Two solutions were considered, one where we define a generic extension to BRICK that allowed key:value entity properties to be added to the model, or a more specific addition to the BRICK schema that defines a specific vbis-tag entity property. Use of key:value instance metadata is a requirement for platform that uses BRICK moving forward to allow flexibility, however as VBIS tagging may be a common component of BRICK models, we chose to extend BRICK and create a vbis-tag specific entity property.

When encoded into a TTL file VBIS-tag information looks like:

```
LH:OAF-G-02 a brick:Fresh_Air_Fan ;
   brick:feedsAir LH:LadyHuntingfield_LevelG_Kitchen ;
   brick:vbis-tag [ brick:value "ME-Fa-CF" ] .
```

3. Challenges

While all buildings are similar in their mechanical operation, no two are the same in design and construction. Therefore, the construction of each building model contains its own unique challenges. These challenges generally stem from both the quality and quantity of information available about a building. This includes limited drawings or design manuals, inconsistencies or errors in the information, un-recorded changes to a building over time and unusual data point names with no associated metadata. These issues often need to be addressed by making assumptions based on past domain experience or by creating the model in such a way to circumvent the issue. In some cases, it may simply not be possible to model a particular part of a building accurately.

For the construction of the City of Melbourne models, the information concerning the buildings initially provided was comprehensive enough to cover most of what was needed to construct the models. Even so, no single source contains all the information needed to construct a model. While some sources are relied upon more than others (such as floorplans, mechanical drawings and BMS manuals), it is quite common to need to cross-reference sources against each other to fill in unknowns or build the complete picture.

When drawings for systems in a building may not be complete or even available, accurate assumptions may not be possible with less common or bespoke designs. One such example was a City of Melbourne building that contained a unique condenser system with a ground bore heat rejection/recovery loop integrated with a heating hot water system that could operate to reject or supply heat depending on the building operation mode. The information provided was insufficient to accurately capture the design of the condenser system. In this case, permission was granted to access the BMS and fortunately the BMS was designed with visuals of the system which could be used to complete the condenser system in the model. Not every BMS has visual schematics of their corresponding building.

Another common challenge encountered in the City of Melbourne buildings were inconsistencies between room names/descriptions in floorplans and other information such as BMS manuals or area registers. Floorplans may not be updated with functional changes to rooms, room numbers can also quite often be labelled erroneously in drawings. In most cases these issues can be resolved by cross-referencing across all the building information, even utilising indirect information such as the zones AHUs feed air to and associated points.

Constructing building models without all the information at hand can also lead to the necessity of later model revision. The City of Melbourne models were initially constructed without a points list. The points list can be influential in the level of detail required on the equipment and system side of the model. As was the case for the City of Melbourne models, minor revision was made once the points list was obtained in order to provide more appropriate and descriptive links for the points. This was generally to include additional system or equipment detail that may not have been deemed necessary to model or may not have been evident in the building information.

4. Building Models

4.1 Lady Huntingfield Early Learning and Family Services Centre

A visualisation of the Lady Huntingfield model is below. The densely populated section at the top represents the solar panel and micro inverter systems, the isolated section to the bottom right is the onsite weather station.

Some details of the model are:

Unique triples	4085
Total number of parts	1158
Unique types of entities	83
VBIS tags	205
Total number of Points	610

Table 1: Lady Huntingfield Brick Model Details

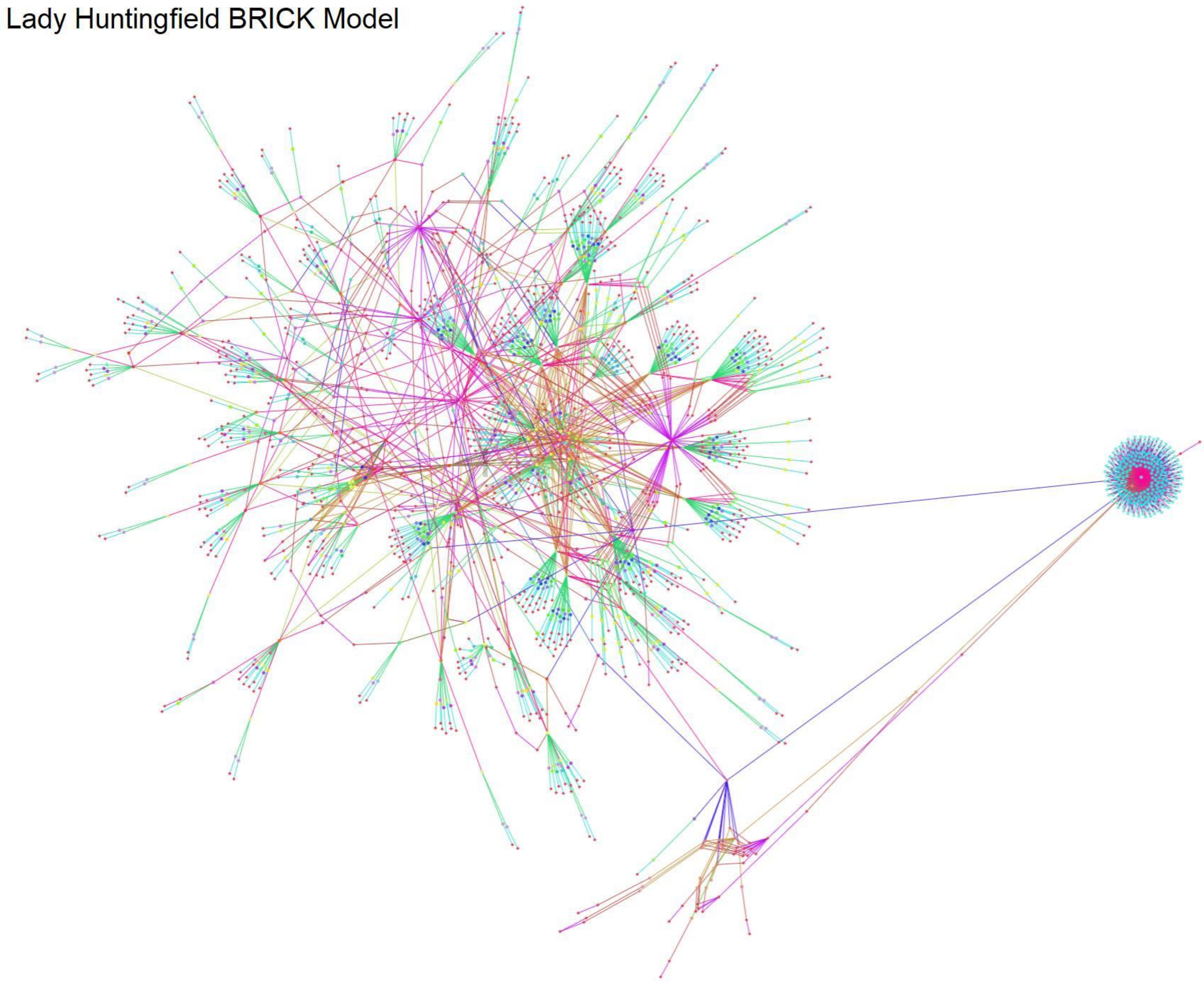

Figure 1: Lady Huntingfield Brick Model

4.2 Boyd School Community Hub

A visualisation of the Boyd School model is below. In this visualisation the circular sections on the lower right represent the solar systems. panel and micro inverter systems, the isolated section to the bottom right is the onsite weather station.

Some details of the model are:

Unique triples	2441
Total number of parts	759
Unique types of entities	91
Vbis tags	61
Total number of Points	550

Table 2: Boyd School Brick Model Details

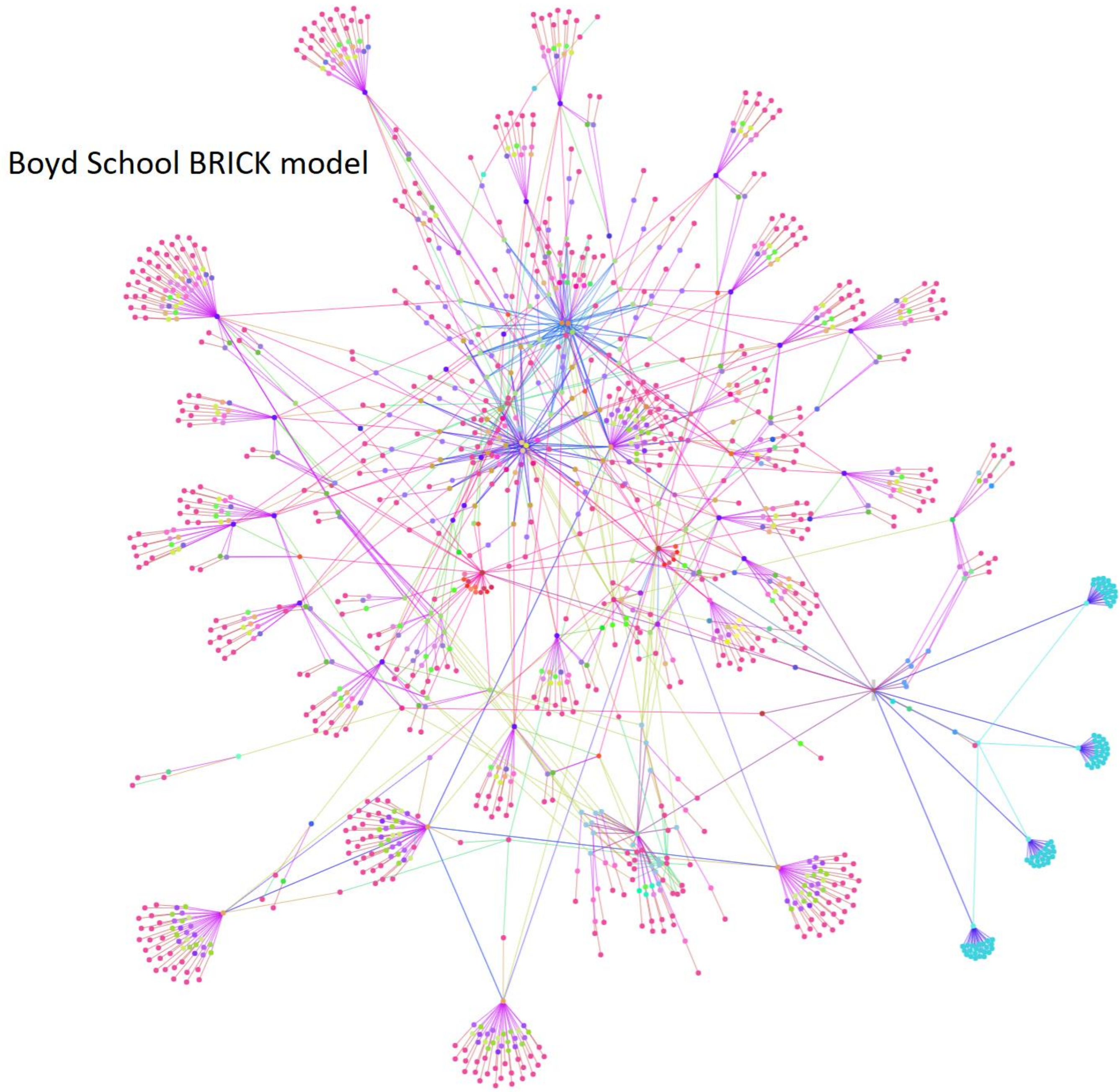

Figure 2: Boyd School Brick Model