Gathering21

Construction Innovations
for Future Generations

CitA

5th CitA BIM Gathering Virtual Conference

21 - 23 September 2021

Ongoing cloud-BIM research activities at UCD

Conor Shaw, PhD candidate
School of Mechanical and Materials Engineering and UCD Energy Institute
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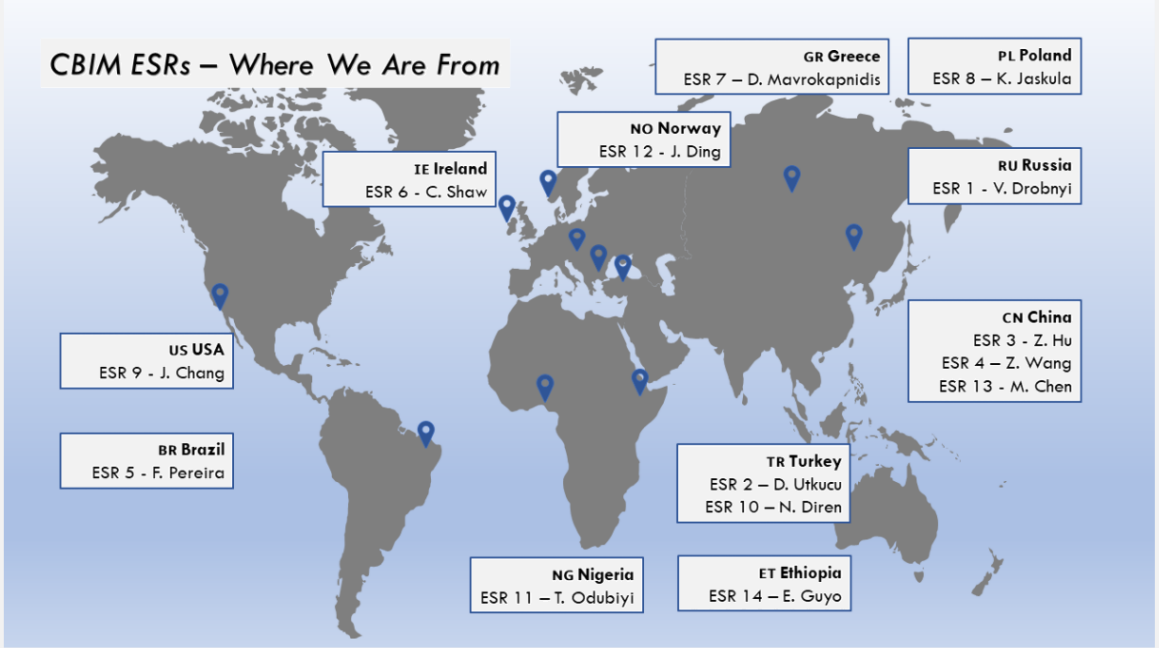
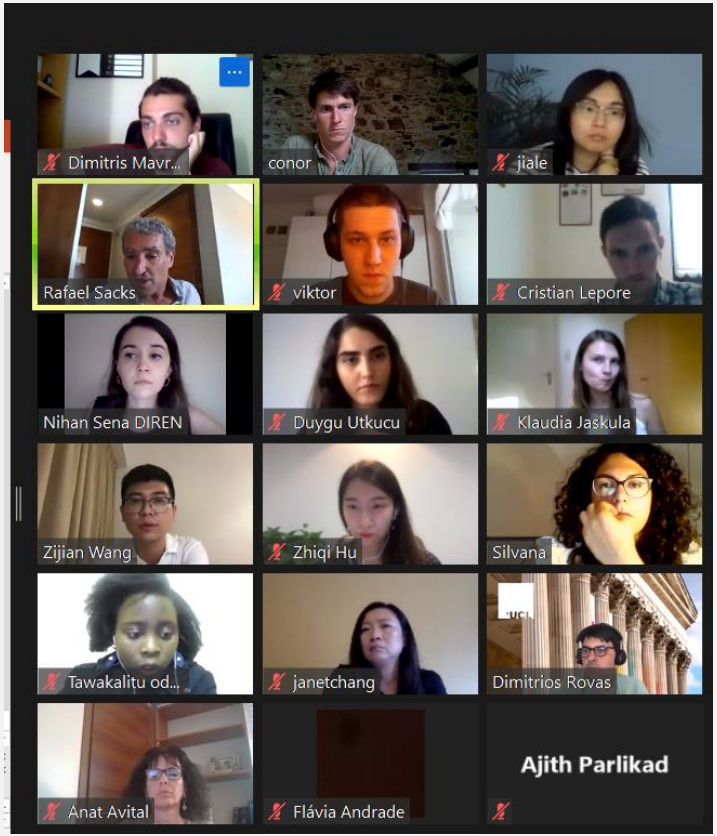
This work was supported by the CBIM-ETN funded by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 860555.

https://cbim2020.net.technion.ac.il/ Cloud-BIM European Training Network





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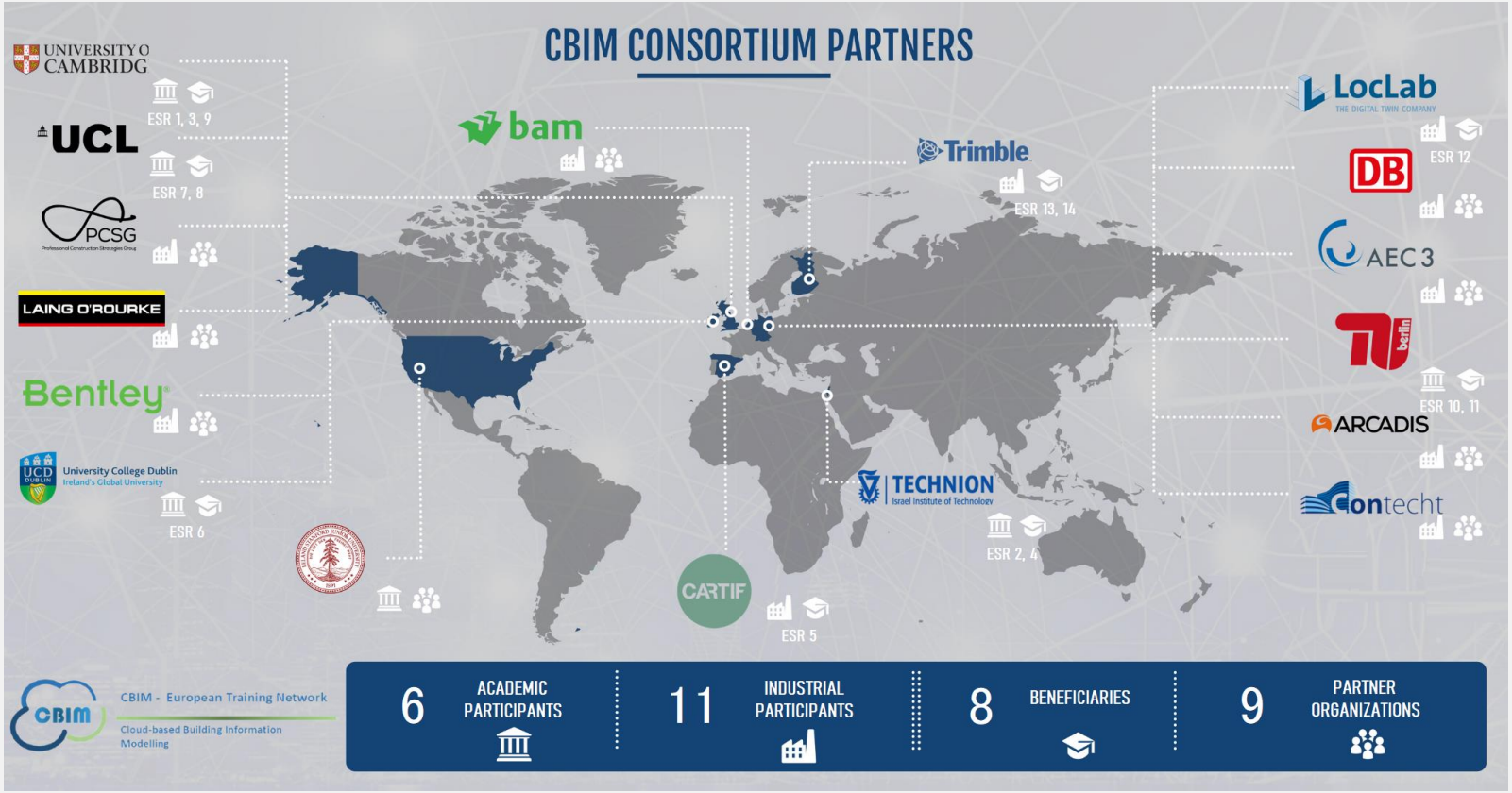

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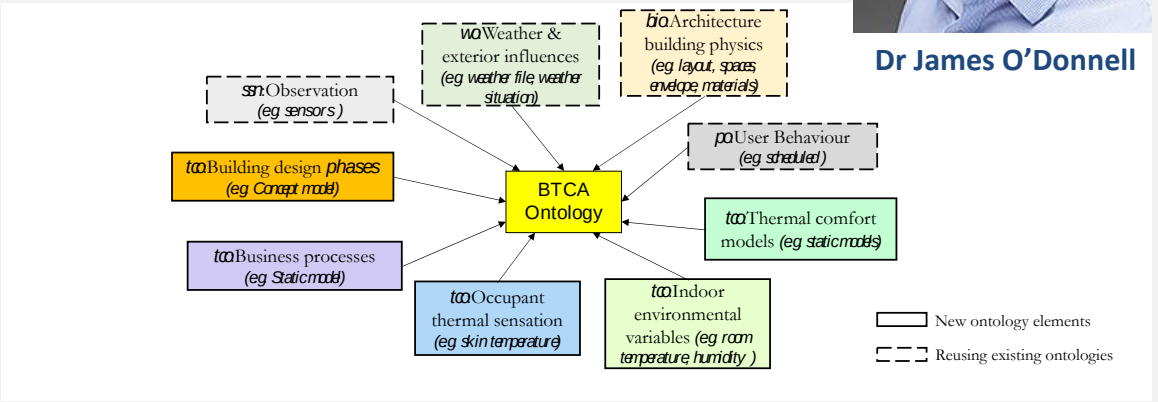
Interoperability / BIM-related UCD activities

- BIM for Advanced Energy Simulation (complete 2018)
- BIM for env. and energy performance mngmt. (complete 2020)
- BIM-based thermal comfort analysis (complete 2021)
- Semantic Web for data fusion (Ongoing)

Dr James O'Donnell



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Flavia de Andrade Pereira

BIM Enrichment for inclusion of Building Automation System information

Conor Shaw

Data fusion for operational optimization and facility management

European Commission

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Why focus on the operational phase?

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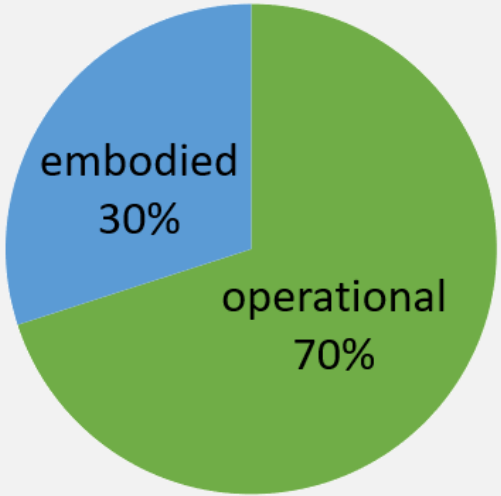
climate crisis → built environment significant contributor (~40%) →



(IPCC 2018)

(UN EIEA 2017)

Energy use of buildings over whole life
(Geekiyanage & Ramachandra 2018)

What is the Semantic Web?

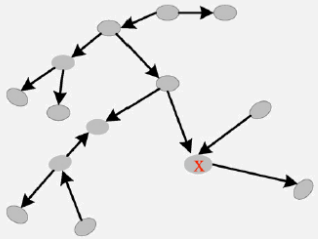
What is the Semantic Web?

"an enhancement of the current World Wide Web with machine-understandable information (as opposed to most of the current Web, which is mostly targeted at human consumption)"

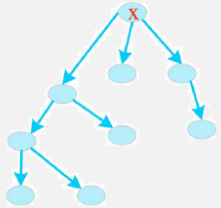
(CACM, 2021)

https://cacm.acm.org/magazines/2021/2/250085-a-review-of-the-semantic-web-field/fulltext

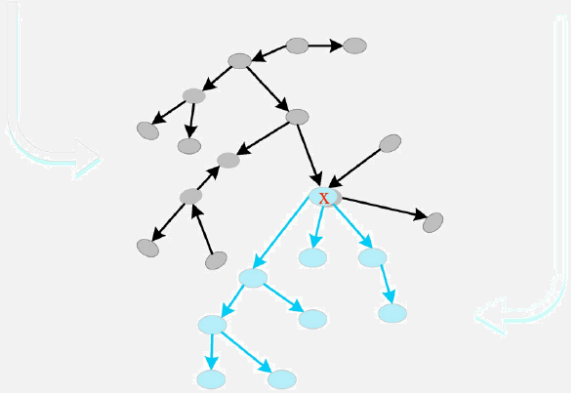
What is the Semantic Web?



Domain 1 RDF information

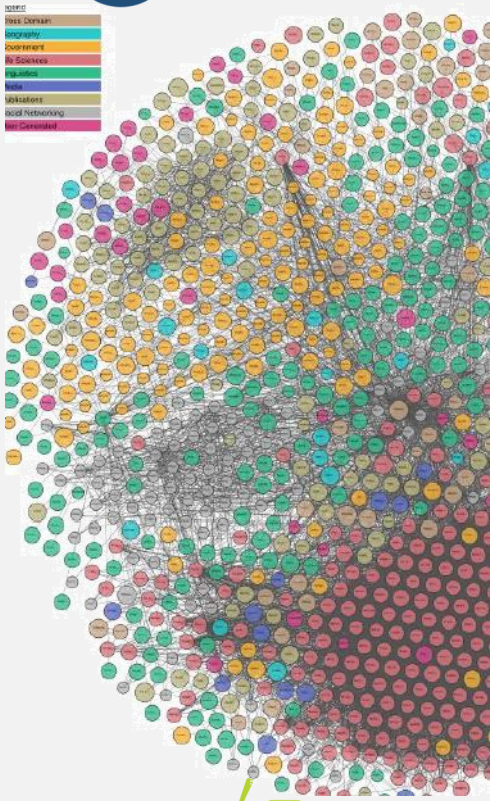


Domain 2 RDF information



Combined information from domains 1 and 2

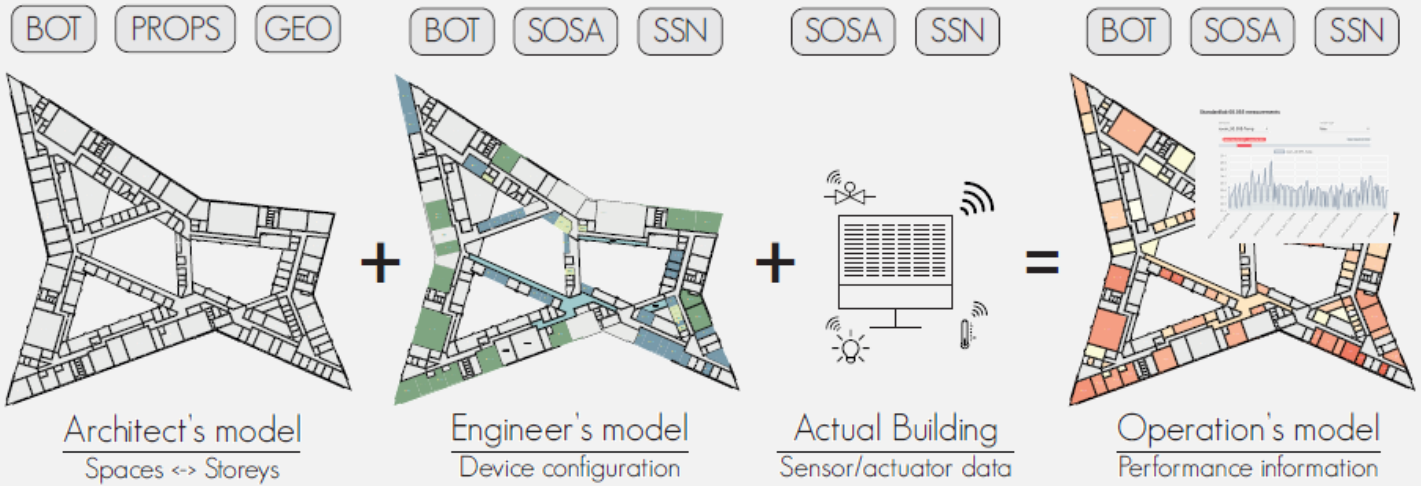
- Non-proprietary (open) format
- Data remains in source
- Reduces file exchanges
- Standardised query language
- Allows for granular selection



Cross domain understanding through linking ontology
(Niknam & Karshenas, 2017)

web of knowledge
(Sack & Alam, 2020)

How Semantic web technologies can facilitate data fusion



Demonstration of Semantic Web-enabled data fusion (Rasmussen 2019)

Interoperability / BIM-related UCD activities

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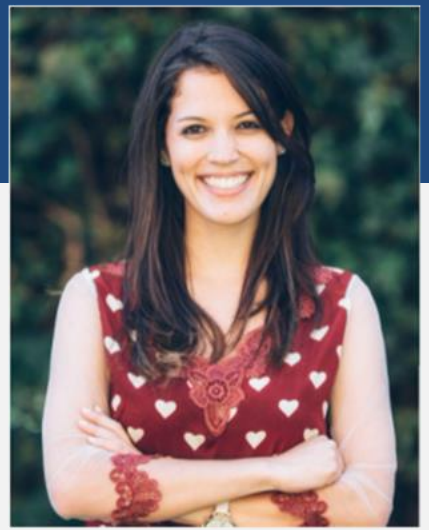
CBIM European Training Network

BIM and Building Automation System integration for Demand Side Management



Flávia de Andrade Pereira

Early Stage Research | ESR 5

University College Dublin
Ireland's Global University

CBIM - European Training Network
Cloud-based Building Information Modelling

CENTRO TECNOLÓGICO CARTIF

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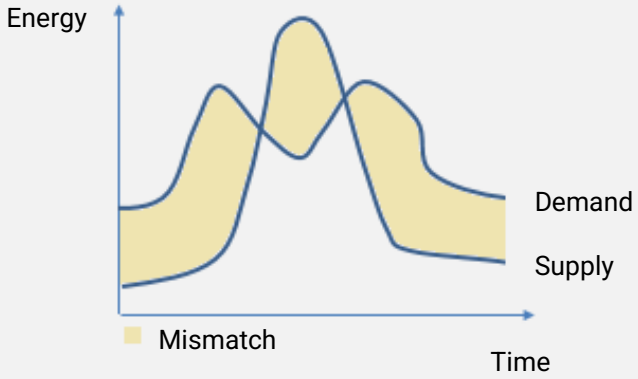
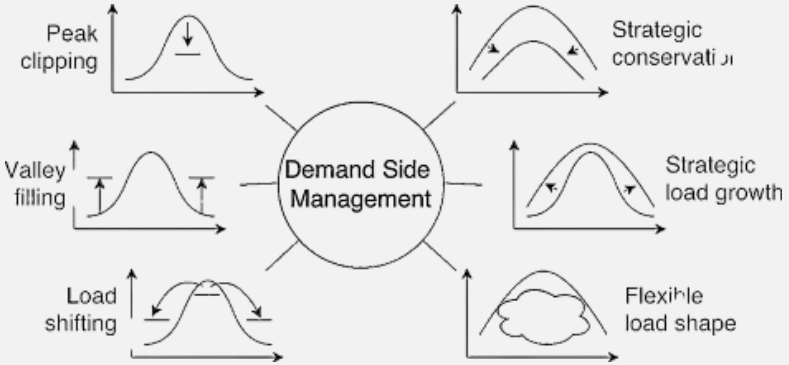
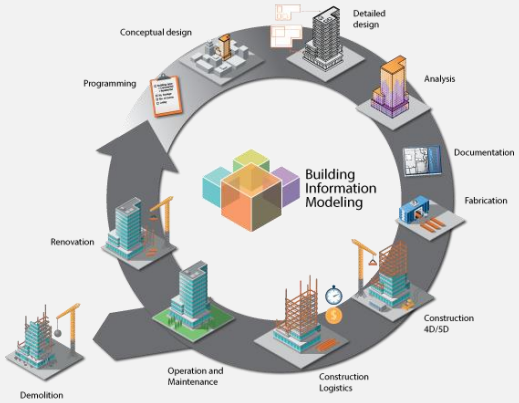
Motivation towards Demand Side Management (DSM)

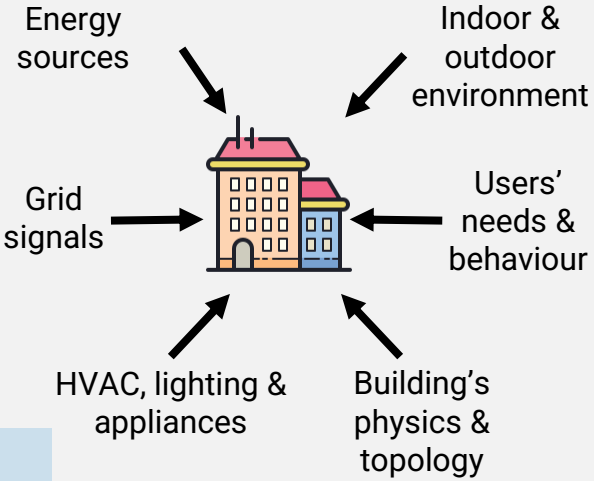




DSM strategies
(Gelazanskas & Gamage 2014)

BIM & BAS integration





Context-aware DSM	BIM	BAS
Spatial context	●	◑
Building energy systems specifications	◑	●
Communication and control technologies	○	●
Grid-interactivity	○	●

Legend

- ● Supported
- ○ Unsupported
- ◑ Partially supported

CBIM European Training Network

Data fusion with Semantic Web technologies for Facility Management

Conor Shaw

Early Stage Research | ESR 6

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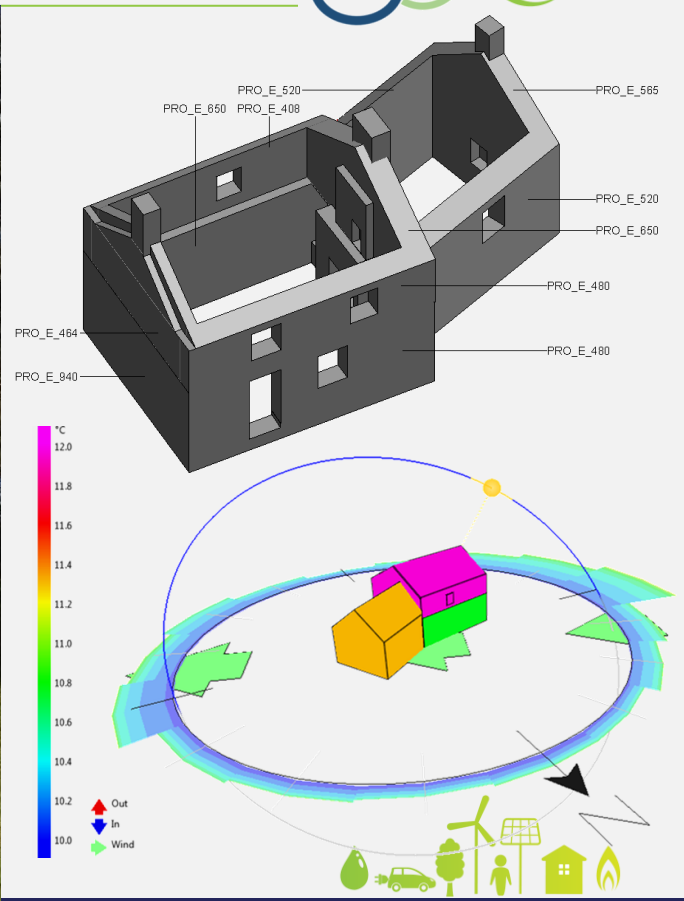
Current BIM paradigm = design/construction



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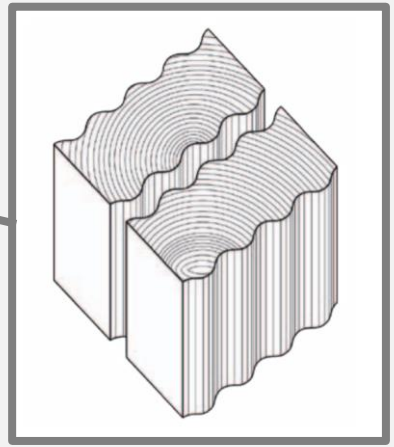
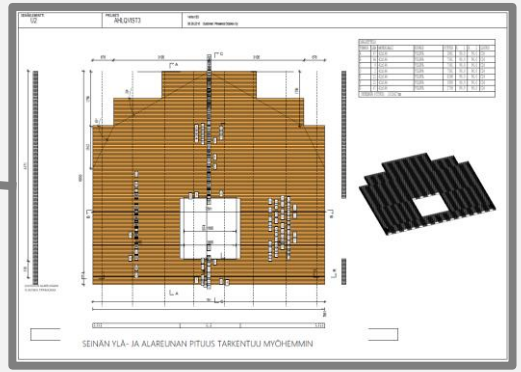
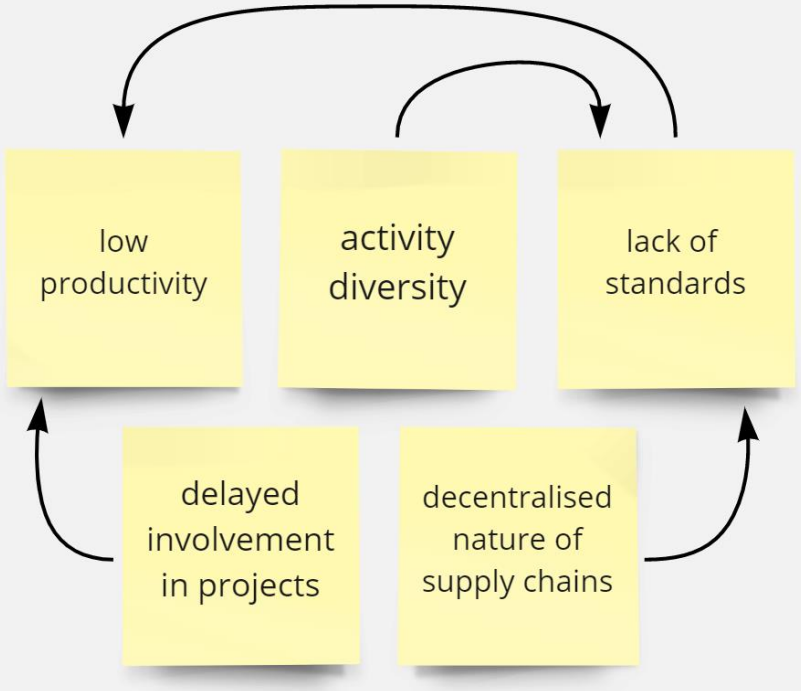




Challenges faced by facility managers – publication (EC3 2021)



2021 European Conference on Computing in Construction
Ixia, Rhodes, Greece
July 25-27, 2021

FACILITIES MANAGEMENT DOMAIN REVIEW: POTENTIAL CONTRIBUTIONS TOWARDS DIGITALISATION

Conor Shaw[1,3], Flávia de Andrade Pereira[1,4], Ciaran McNally[2] and James O'Donnell[1,3]
[1]School of Mechanical and Materials Engineering, University College Dublin, Ireland
[2]School of Civil Engineering, University College Dublin, Ireland
[3]UCD Energy Institute, University College Dublin, Ireland
[4]CARTIF Technology Centre, Energy Division, Valladolid, Spain

ABSTRACT

Digitalisation within the facilities management (FM) sector has great potential to positively impact the environmental performance of the architecture, engineering, construction and operations (AECO) industry. Currently, the domain suffers from poor data integration with other disciplines and earlier life-cycle phases. Though solutions which address the interoperability issue are replete in the literature, there remains no comprehensive alignment. This domain review paper synthesises the key literature around digitalisation within FM. In doing so, it outlines a broader working definition of FM, identifies key subtopics and gaps in knowledge and recommends a direction for future research contributions.

INTRODUCTION

According to the International Energy Agency's Global Status Report (2017), buildings and construction together account for around 40% of anthropogenic carbon dioxide (CO_2) emissions. These

mapped the stages of a construction project against the familiar graph of diminishing influence on cost over time (Figure 1) from project management theory.

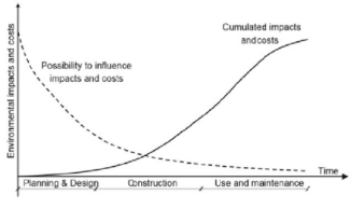


Figure 1: Phases of a building project and the diminishing influence on cost over time (Kohler & Moffatt 2003)

With the increasing complexity of systems within buildings and infrastructure, as well as a trend towards the outsourcing of [illegible] activities by organ[illegible] (FM),

SWT use within the FM domain – publication (CIB – LDAC 2021)

Digital Interoperability for the Facilities Management Domain: a Review of Semantic Web-based Approaches

Abstract

The use of Semantic Web-based Technologies (SWT) to support digital Facilities Management (FM) activities has been shown to address interoperability challenges between disciplinary stakeholders. By establishing shared understanding through ontologies, eliminating precarious file exchanges and democratising participation through non-proprietary technologies, SWTs are receiving growing interest from the research community. Despite this, no comprehensive review exists which analyses works with a specific focus on the FM domain. This paper reviews 42 academic works and provides a broad discussion around academic and industry initiatives in SWTs for the FM domain, identifying research gaps and future directions of interest. We find that SWTs are already being used by FM practitioners and that implementation is highly case-specific and thus, developments need to be flexible and user-oriented in their design. This work towards a comprehensive domain review provides a useful reference for others in the field as well as informing our own future research activities.

Keywords: facilities management, digitalisation, interoperability, semantic web technologies

1 Background

According to the International Energy Agency's *Global Status Report* UN Environment and International Energy Agency (2017), the built environment accounts for around 40% of anthropogenic CO_2 emissions. These *greenhouse gases* are having a warming effect and causing the Earth's climate to change to the detriment of society (IPCC 2018). Until recently the focus has been on reducing environmental and financial costs primarily during design and construction (Krstić & Marenjak 2012), however, given that around 70% of these costs are incurred during the operation and maintenance (O&M) phase of a buildings life-cycle (Geekiyanage & Ramachandra 2018), the focus is broadly shifting towards a whole life view, also knows as the *life-cycle cost* (Kale et al. 2016).

According to Barrett & Baldry (2003) FM is a strategic outsourcing of non core activities of an organisation. This broad domain scope has been described by Shaw et al. (2021) and is responsible, in part, for a lack of domain standardisation. FM practitioners are concerned with the operational phase of the building life cycle, however, they are typically not involved in building projects until the handover phase, and thus have little control over data specification (McAuley 2016). Furthermore, due to the inherently complex and fragmentary nature of construction projects, interoperability issues frequently occur during data exchange between stakeholders (Huahui & Deng 2018), hence it is considered the single greatest area of focus for technical development in academic FM research (Gao & Pishdad-Bozorgi 2019).

The International Organization for Standardization defines interoperability as the ability to unambiguously exchange data between applications (ISO/IEC 2382:2015) and though the literature is replete with partial solutions to exchange challenges, no satisfactory methodology has yet been broadly

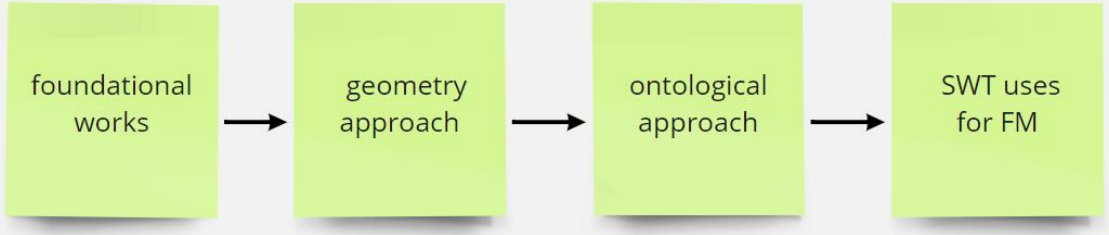
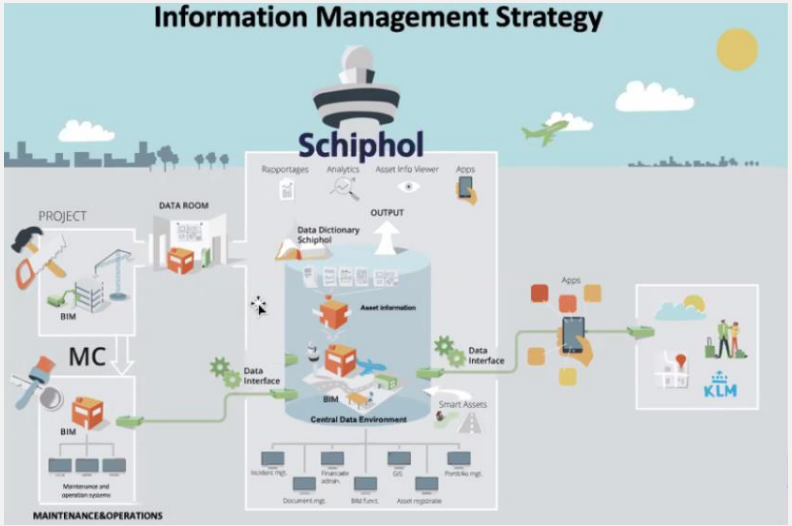


Table 1: classification of literature sources per the guiding conceptual model

relevant area	reviewed authors
foundational works	Noy & McGuinness (2001), Schevers et al. (2007), East (2007), Vanlande & Nicolle (2008), Ruikar et al. (2007), Törmä (2013), Beetz (2009), Redmond et al. (2012), Belsky et al. (2016), Pärn et al. (2017), Godager (2018), Patacas et al. (2020)
geometric approach	Pauwels & Roxin (2016), Rasmussen, Pauwels, Karlshøj & Hviid (2017), McArthur & Bortoluzzi (2018), Chen et al. (2018), Bonduel et al. (2018), Krämer & Besenyői (2018), Wagner et al. (2020), East et al. (2021), Jung (2021)
ontological approach	Rasmussen, Pauwels, Karlshøj & Hviid (2017), Niknam & Karshenas (2017), Bonino & De Russis (2018), Rasmussen et al. (2020), Luo et al. (2021)
SWT uses for FM	Kim et al. (2018), Chen et al. (2018), Yalcinkaya & Singh (2018), Hammar et al. (2019), Gouda Mohamed et al. (2020), Kumar & Teo (2021), Droog & Baayen (2021), Liu & Chou (2021)

SWT use within the FM domain - Findings

- A **need for abstraction away from programming languages** (to enable greater participation)
- A **need for flexible and intuitive middleware layers** (given changing nature of the domain and need for case specificity)



[Demonstration] of Semantic Web use in FM industry (Droog 2021)

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Niknam, M. & Karshenas, S. (2017), A shared ontology approach to semantic representation of BIM data, Automation in Construction

Gelazanskas L. & Gamage, K.A.A. (2014) Demand side management in smart grid: A review and proposals for future direction, Sustainable Cities and Society

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