Beyond BIM

Knowledge management for a smarter built environment

Shaun Howell and Yacine Rezgui

IHS Markit™

Beyond BIM

Knowledge management for a smarter built environment

Shaun Howell and Yacine Rezgui

IHS Markit™

Acknowledgements

This book includes findings and results drawn from over 10 research projects, including KnoholEM, RESILIENT, WISDOM, PERFORMER and MAS²TERING, completed over the last five years, supported by the European Commission. During this period, the authors are fortunate to have collaborated with leading organisations, research institutions and academics/researchers in their field. The book has been fuelled and inspired by the many discussions the authors have had with their colleagues in the context of project meetings, conferences or simply informal discussions; many of these discussions will be recognisable in the book to those involved. It has also been shaped by the authors' personal thoughts and reflections on these discussions and informed by the authors' own research. The authors are grateful for the input of all colleagues and their invaluable contribution is here acknowledged.

EP 106

Contents

Cont'd . . .

Contents

Preface

The built environment is increasingly embracing digital technologies, including control and automation systems, and as such is paving the way to smarter ways of managing our buildings and wider infrastructures. BIM has the opportunity to provide a key and distinct value proposition to this landscape, if it evolves to meet the requirements of modern systems which tend to be internet-based and embed a level of smartness through a learning capability. Specifically, the Artificial Intelligence (AI) and Internet of Things (IoT) fields are offering increasingly mature products and services in various application domains; the knowledge of built assets captured through BIM processes and models can offer invaluable context to these technologies to address current and future challenges, including the pressing climate change agenda. However, the legacy formats and lack of authoritative exemplary work in this space of 'future BIM' has hindered progress. Conversely, current ongoing BIM efforts in the UK, fuelled by a strong drive from Government, have raised a number of questions and uncertainties as to the future of BIM as reflected by the proposed UK BIM roadmap and its structuring into three debatable, and in academic terms, confusing levels.

This book discusses the future development of BIM from its current focus of improving knowledge creation and management in a project-based manner up to the operational stage, through to a mature whole life-cycle value proposition within assets and across their surrounding systems at the 'block of buildings', district and wider city scales. The book begins by introducing BIM and the broader evolving technological landscape, progressing to the evolution of the BIM paradigm and technologies, from a smart *construction* basis to a smart *built environment* basis. This pathway is evidenced by several collaborative research projects, and is concluded by a short discussion of recommendations for the future of this field.

SKH and YR
2018

1
Introduction

Information and Communications Technology (ICT) has fundamentally changed the way information is created, stored, exchanged and used across the built environment. Building Information Modelling (BIM) has been a key aspect of this, and has emerged within the Architecture, Engineering, Construction and Facilities Management (AECFM) industry as a transformative step towards digitisation. The past 30–40 years have seen increasing uptake of ICT in the sector, and this global effort has coagulated and evolved into a consensus-based approach led by governments, standards development organisations and software vendors. Most notably, the Industry Foundation Classes (IFC)[1] and BuildingSMART[2] have paved the way for a more integrated approach to knowledge creation and management through the design and construction phases of built environment assets, which is leading to significant improvements across the industry. However, digital technologies are advancing at an ever-increasing pace, and the future direction of BIM's momentum is unclear. Thought leadership and practical examples are required to demonstrate potential avenues for BIM's ongoing evolution, which this book aims to provide. These should be carefully framed within a paradigm that factors in people (blue-collar and white-collar workers), processes (with a focus on a performance-based and total life-cycle approach) and technology (which is continuously being re-invented and re-shaped).

The dilemma is that the BIM philosophy has evolved from an initial need to support building data exchange between commercial CAD tools (ISO 10303[3] informally known as STEP) to a wider and more challenging scope and value proposition, as elaborated in this book. Ever since the advent of the Internet and World Wide Web in the early 1990s, new ways of leveraging raw data and conceptualising information have rapidly emerged with a greater level of knowledge expressiveness than the current underpinning formalism of BIM, ie EXPRESS. Therefore, this book aims to:

- raise awareness among stakeholders of the remaining interoperability challenges in buildings and wider smart urban systems
- advise practitioners on how to approach pressing challenges, such as the energy efficiency agenda, through a higher-order interoperability approach that transcends current barriers, based on the latest research and case study experience
- advise leading-edge technologists and business developers on the emerging landscape surrounding interoperability.

Smart built environments (smart cities, buildings and industrial systems [eg power grids], water distribution networks and district heating networks) are facing increasing pressures to improve sustainability, resilience and service quality. Digital technologies, such as Internet of Things (IoT) and artificial intelligence (AI), have been heralded as the solution to these challenges as they offer the potential to sense and actuate the physical environment remotely, informed by wider environmental conditions, while using machine-processing power to assist with the feedback and decision-making process. Recent computing advances, such as in machine learning, along with big data technologies, and low cost hardware and communication solutions, have created a wealth of resources for better management of a smart city's system of systems.

This increase in ICT penetration within complex systems has led to interoperability chasms between data silos in terms of syntax, protocols, semantics, security and trust. Also, the nature of leveraging these resources for business and societal value is not clearly understood, resulting in the idiom 'drowning in data'. In particular, there are chasms between:

- a building's static data, created during its design and construction, and its dynamic data, collected by sensors about the building's behaviour from facilities management and asset management perspectives, and
- a building's information systems and that of the urban systems which it both relies on and plays an active role in.

While these chasms are partly due to business and cultural issues, they are largely technical in nature, and require progress in information modelling and communication standards and technologies in order to be solved.

1 A data model used to describe buildings and construction industry data.

2 For more information visit www.buildingsmart.org.

3 ISO 10303 Industrial automation systems and integration. Various parts and various dates. London, BSI.

River Clyde waterfront, Glasgow

Beyond BIM: Knowledge management for a smarter built environment

While the latest developments in BIM have reinvigorated the research and practitioner community, the current technologies underpinning BIM standards, models and tools have struggled to keep pace with the accelerating technological landscape. New directions are required to drive BIM forward, and integrate it with complementary technologies such as the Internet of Things and artificial intelligence.

This book describes these new directions by drawing on research from more than 40 collaborative research projects over the last 25 years. Recommendations and practical advice are offered regarding the design and implementation of information models, intelligent components and surrounding system architectures, to enable the delivery of more intelligent built environments. Examples are given of innovative systems that have been successfully demonstrated, from saving energy in public buildings to the optimisation of water networks.

Starting at the smart building level, the book describes a progression towards smart cities through the integration of data and intelligence across building and infrastructure systems. This leads to a roadmap for the evolution of urban knowledge management from the current focus on project-based knowledge creation, to a whole life-cycle, multi-disciplinary and value-driven approach.

About the authors

Dr Shaun Howell is a senior machine learning researcher at Vivacity Labs, researching AI for the smart city mobility industry. He completed a PhD at the BRE Trust Centre of Excellence in Sustainable Engineering at Cardiff University, by researching semantic modelling and AI in the built environment, focusing on energy and water systems. Dr Howell has led and assisted across national and international projects, producing more than 30 publications. Research topics include applied deep neural networks, multi-agent systems and semantic web technologies.

Professor Yacine Rezgui is a BRE (Building Research Establishment) Chair in Building Systems and Informatics and Director of the BRE Trust Centre of Excellence in Sustainable Engineering at Cardiff University. He has over the last 20 years completed, in the capacity of principal investigator and co-investigator, over 40 research and development projects at a national and European level. He has over 200 refereed publications which have appeared in international journals such as *IEEE Transactions on Systems, Man, and Cybernetics, Proceedings of the Royal Society A, Expert Systems with Applications, IEEE Transactions on Services Computing*, and *IEEE Transactions on Automation Science and Engineering.*

ISBN 978-1-84806-476-8

IHS Markit™

EP 106 9 781848 064768