Ontology-driven Comprehensive BIM Maturity Assessment Framework

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Abstract. As a collaborative project delivery process, BIM provides an efficient information management solution for all involved stakeholders throughout the lifecycle of built assets. With the continuous release of BIM standards, more and more enterprises are focusing on the assessment of BIM maturity. Although several BIM maturity assessment frameworks have been proposed, there are still limitations in the assessment methodology and comprehensiveness. Therefore, the authors propose a knowledge-informed framework for comprehensive BIM maturity assessment, which comprises criteria extracted from various BIM standards. With the help of the proposed framework, knowledge from different standards is linked and a flexible BIM maturity assessment can be conducted against specific roles, standards or overall BIM maturity. The proposed framework can help enterprises accurately identify their shortcomings in the BIM application and guide them in optimising their workflows to improve productivity.

1. Introduction

BIM maturity is a measure of how well an organisation is adopting BIM standards, which plays a significant role in quality insurance and workflow improvement. Due to differences in technology and productivity levels, variations exist in the BIM standards published in different countries and regions. Existing BIM maturity assessment methods only focus on a particular standard, which leads to a lack of uniformity and comprehensiveness in the BIM maturity assessment. With the spread of international cooperation for AEC projects, there is an urgent demand from enterprises for a standards- and role-specific BIM maturity assessment solution.

To fill the gap mentioned above, an ontology-driven comprehensive BIM maturity assessment framework is proposed, which utilises an ontology as the knowledge model to store domain knowledge extracted from various BIM standards and a AHP based weighted summation computing framework to quantify the result of maturity. To better leverage the framework, a web-based platform is developed to bridge users to the backend knowledge, which takes the demand of users and gets corresponding results from the knowledge model.

The proposed assessment framework innovatively utilises an ontological knowledge model to link domain knowledge different BIM standards, enabling both the comprehensive BIM maturity assessment and flexible customised assessments. Compared with existing approaches, this ontological representation makes it easier to manage and update the knowledge, and new knowledge can be continuously incorporated to form a larger knowledge model. Therefore, the proposed comprehensive BIM maturity assessment framework may profoundly impact the application of BIM in the AEC industry. It can constantly help various enterprises identify deficiencies in their workflow and optimise them accordingly to improve productivity.

2. Related Work

So far, there have been many frameworks produced on BIM maturity assessment by various authors. Bew (Bew and Richards 2008) proposed a broad maturity model named BIM Maturity Levels, which categorises the BIM maturity of a project into four levels based on the technologies and processes adopted during the project delivery. This model is considered the first maturity model and the specifications listed in the model serve as the measurement system for project maturity (Ammer et al. 2015). This model was then approved by the UK government and referenced in the UK's futuristic construction strategy (UK government 2011). In the same year, the Interactive Capability Maturity Model (I-CMM) (Mccuen 2018) was developed and published as a part of the USA National BIM Standard (NBIMS) (National Institute of Building Sciences buildingSMART alliance 2007). This I-CMM is an organisation-oriented self-assessment tool, which uses a spreadsheet-based method to help organisations evaluate their business practices along a continuum of the desired technical level of functionality. Compared with BIM Maturity Levels proposed by Bew (Bew and Richards 2008), I-CMM is of a higher granularity level. It used the 11 areas of interest defined in NBIMS as a basis for the framework establishing a BIM maturity assessment model. Each area of interest is assigned a weight, reflecting its relative importance. In 2011, Indiana University introduced the IU BIM Proficiency Index, a tool designed using an Excel spreadsheet framework. It encompasses 8 areas, includes 32 measures, and categorizes BIM maturity into 5 levels (CIC 2012). In contrast to the I-CMM, the IU BIM Proficiency Index assigns equal importance to each measure (Alaghbandrad et al. 2015). To further improve the reliability and consistency of the maturity assessment, Succar (Succar 2010) proposed a particular framework comprising 12 and 36 measures for assessing the maturity of BIM in organisations, which broadened the measuring scope to encompass non-technical aspects of BIM and offered detailed explanations for each measure to reduce inconsistencies (Giel and Issa 2013). In 2011, the BIM Quick Scan (Van Berlo et al. [no date]) was introduced by Berlo, featuring four primary areas and 44 measures structured as a multiple-choice questionnaire. This method adopts the weighted summation as a scoring approach and the Delphi method for the measure selection and framework formation. Another typical approach is the VDC Scorecard (Kam et al. 2013), which was developed by Stanford University in 2012. This tool comprises 4 primary areas, 10 subdivisions, and 74 measures and establishes confidence levels for maturity assessment to realise adaptive, holistic, and practical BIM maturity assessment (Kam et al. 2013). In addition to the above approaches, some other similar methods were developed during the same period, such as Owner's BIM CAT (Azzouz et al. 2015), BIMCS (Du et al. 2014), etc. These methods imitated the methodology of previous tools but with a wider assessment scope and higher granularity of measures. Apart from advances in assessment criteria, several studies have also made innovations regarding assessment methods. For instance, Yilmaz (Yilmaz et al. 2019) introduced a reference model-based method named BIM-CAREM to assess the BIM capability of organisations concerning their process of architecture, engineering, construction, and facilities management. Chen (Chen et al. 2023) involved probability distribution function aggregation and large-scale group decision-making (LSGDM) in the development of the BIM maturity model and proposed a refined assessment system that provides a more reliable assessment for project-based BIM performance.

Ontology is a knowledge structure comprising domain concepts and the semantic relationships between the concepts and is widely used to formally represent and share domain knowledge (Abanda et al. 2013). The ontology has now been applied to solve various problems in the AEC field. Many studies have leveraged the hierarchical structure of ontologies to represent the connections between domain concepts as a domain knowledge model, such as Building Topology Ontology (BOT) (*w3c-lbd-cg/bot: Building Topology Ontology* [no date]), Building Product Ontology (BPO) (Wagner et al. 2022), Brick Ontology (Balaji et al. 2018), etc. In addition, ontologies support reasoning about unknown properties of known entities by defining customised Semantic Web Rule Language (SWRL) rules. This feature led the ontology to be extensively utilised for complex tasks like cost estimation (Im et al. 2021), building condition monitoring (Ren et al. 2019), and energy consumption (Bonino and De Russis 2018).

Ontologies also support database-like information querying functions. Domain knowledge in the ontologies can be easily queried through SPARQL query language (Petrova et al. 2019). Another prominent advantage of the ontology is extensibility. Ontologies use Internationalized Resource Identifier (IRI) to tag all defined concepts, properties, and instances, which makes the representation of knowledge direct and explicit. Therefore, the reuse and extension of ontologies are common practices, and extending existing ontologies has become one of the fundamental approaches to ontology creation (Farghaly et al. 2023).

Through the review of the above most distinct and representative BIM maturity assessment methods, the characteristics of existing approaches can be summarised. First, most methods (Succar 2010; CIC 2012; Kam et al. 2013; Du et al. 2014; Alaghbandrad et al. 2015; Azzouz et al. 2015; Van Berlo et al. [no date]) adopt a hierarchical structure to evaluate maturity levels, which decompose the evaluation of maturity into multiple levels of indicators including areas, subdivisions, measures, etc. and calculates the maturity score via weighted summation. Additionally, these approaches have undergone validation through different methodologies, such as Delphi, complex statistical analysis, and face-to-face user interviews, to ensure the effectiveness and reliability of these indicators. Second, most of the existing tools are developed based on spreadsheets or databases and the score of maturity is calculated through the pre-embedded functions. This knowledge model represents relationships between indicators through embedded functions. Therefore, it is efficient in representing simple relationships. However, as the body of knowledge increases, defining an accurate relationship function becomes difficult. For this reason, despite progress on the scope and granularity of indicators, the knowledge volume of existing methods is insufficient and does not fulfil the demand of enterprises to assess the maturity of different criteria. In addition to this, the embedded relationship representation makes it difficult to modify, update and expand the knowledge model. Given the structural and functional characteristics of ontologies, using ontologies as the knowledge model to carry the domain knowledge for assessment shows a high potential to address the deficiencies of existing approaches in comprehensiveness, flexibility, and extendibility.

3. Ontology-driven maturity assessment framework

To verify the above hypothesis, an ontology-driven comprehensive BIM maturity assessment framework is developed in this research. Figure 1 illustrates the structure of the proposed framework, which comprises three components: an ontological knowledge model, a computing framework and an interactive platform. The ontological knowledge model is a domain ontology developed by Protégé. It constitutes indicators and relationships extracted from the BIM standard. The computing framework is composed of several algorithms designed to calculate the weights for each indicator and score of overall maturity score. The interactive platform is the core of this framework, which is developed based on Python and links the front-end users and backend knowledge model and computing framework together.

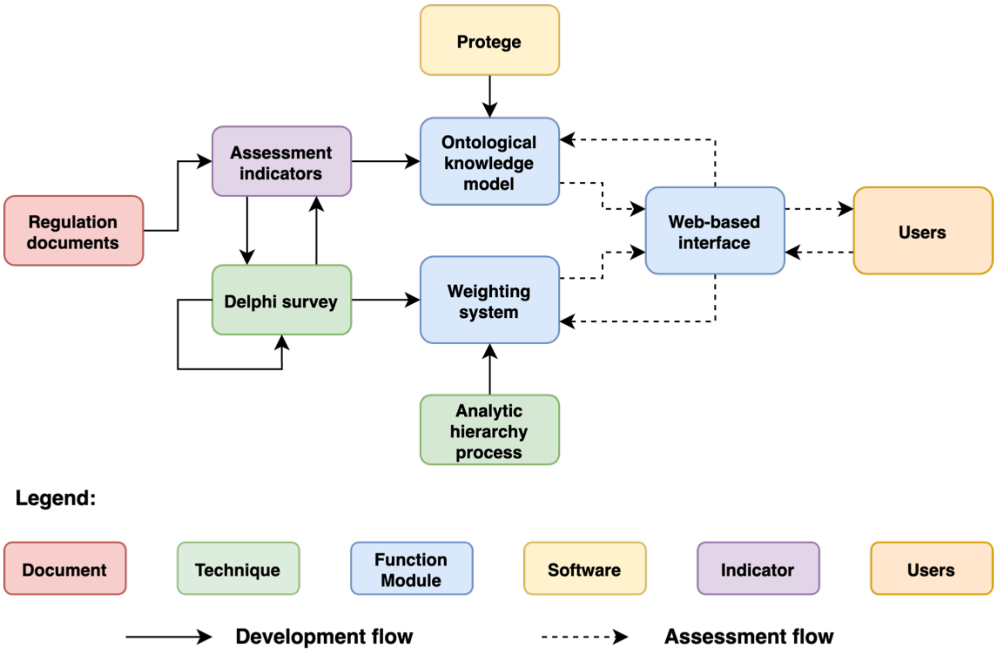


Figure 1 - Overarching framework the proposed ontology-driven maturity assessment method

4. Development

Aligning with the structure of the proposed framework, the development process contains three parts, namely, ontology development, computing framework development, and platform development. To ensure the effectiveness of the proposed framework, a domain expert panel is organised and involved in the development process. This expert panel is composed of seven academic experts and eight industry experts. Academic experts comprise three professors engaged in research related to BIM standards, two researchers involved in the development of BIM standards and two PhD students who have published articles related to BIM standards. The industry experts consist of four senior experts who have been involved in building design and construction for more than 20 years and four technical experts who have participated in the development of China's BIM standards.

4.1 Ontology development

In this research, an open-source ontology tool, Protégé (version 5.6.3), is used to build the ontological knowledge model. The development process follows the instructions listed in "Ontology Development 101" (Noy 2001) and can be divided into the following four steps:

(1) Requirements analysis

Prior to constructing the domain ontology, a requirements analysis was conducted through an interview with the expert panel to determine the aim and scope of the maturity assessment. Through the requirements analysis, it was found that the current demands for BIM maturity assessment in the AEC industry can be broadly classified into four categories: (1) BIM maturity against one or multiple target standards; (2) BIM maturity as a specific role (e.g., appointing party) of the project; (3) BIM maturity of one project or one organisation; (4) BIM maturity against a specific indicator, several indicators or even the whole indicator system.

(2) Classes

To support flexible maturity assessment under the above four scenarios, three high-level classes are predefined in the ontology, which are *Stakeholders*, *Standards* and *BIM maturity indicators*. *Stakeholders* consists of all the roles involved in the project. *Standards* includes all the BIM standards covered by the proposed assessment framework. *BIM maturity indicators* is the collection of all assessment indicators.

In terms of the assessment indicators, the authors carefully reviewed 19 representative BIM standards (Table 1) from different standard systems to guarantee the comprehensiveness of the indicators, which includes American BIM standards (NBIMS series), British BIM standards (PAS 1192 and ISO 19650 series), GB/T and JST/T series from China and some Open BIM standards (ISO 16739, ISO 29481 and ISO 12006). Based on the understanding of the concepts and requirements in these BIM standards, the authors summarised the assessment indicators for each standard, totalling 834 candidate indicators. Through the review work, the authors also found that these BIM standards are not completely irrelevant. Some standards reference concepts or requirements stated in other standards. For example, NBIMS-v2, GB/T 51301, and ISO 19650-1 all stipulate the requirement of defining the level of information need during the information exchange process to clarify the information granularity. Additionally, the naming of the same indicator in different standards may differ. For instance, when delivering a BIM project, there should be a document that defines the requirements for each information exchange, including the format of the information, the granularity of the information, the way the information is exchanged and so on. This document is referred to as the Exchange Information Requirement (EIR) in ISO19650, Exchange Requirement (ER) in NBIMS-v1 and Information Exchange Requirement (IER) in GB/T 51212. Given the above, a manual calibration is implemented to avoid ambiguity and unify the concepts and requirements. Through the manual calibration, the 834 candidate indicators were consolidated into 483 assessment indicators. Based on the structure of the standards and the relations between the concepts, the assessment indicators are eventually organised in a hierarchical structure in the protégé with 6 areas, 97 subdivisions, and 380 measures.

Table 1 - Representative BIM standards involved in the ontological knowledge model.

Number	Name	Issuer
GB/T 51212	Uniform Standard for Building Information Model Application	China
GB/T 51269	Standard for classification and coding of building information model	China
GB/T 51301	Standard for design delivery of building information modeling	China
GB/T 51235	Standard for building information modelling in construction	China
JTS/T 198-1	Unified Standard for Application of Building Information Modeling in Port and Waterway Engineering	China
JTS/T 198-2	Standard for Application of Building Information Modeling in Port and Waterway Engineering Design	China
Q/CCCC GL501	Unified Standard of Building Information Modeling in Highway Engineering	China
Q/CCCC GL502	Standard for Application of Building Information Modeling in Highway Engineering Design	China
ISO 19650-1	Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles	UK
ISO 19650-2	Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 2: Delivery phase of the assets	UK
PAS 1192-3	Specification for information management for the operational phase of assets using building information modelling	UK

PAS 1192-4	Collaborative production of information. Fulfilling employer's information exchange requirements using COBie - Code of practice	UK
PAS 1192-6	Specification for collaborative sharing and use of structured Health and Safety information using BIM	UK
NBIMS-v1	United States National Building Information Modeling Standard - Version 1	USA
NBIMS-v2	United States National Building Information Modeling Standard - Version 2	USA
NBIMS-v3	United States National Building Information Modeling Standard - Version 3	USA
ISO 16739	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries	buildingSMART
ISO 29481	Building information models - Information delivery manual	buildingSMART
ISO 12006	Building construction - Organization of information about construction works	buildingSMART

(3) Properties

In the ontology, the properties are divided into three categories: object property, datatype property and annotation property. In this research, 6 types of object property and 1 annotation property are defined in the ontological knowledge model (Figure 2). The object properties are defined to cooperate with Classes to achieve the BIM maturity assessments under different scenarios. The object properties can be divided into two groups according to the high-level properties (*standardAndIndicator* and *stakeholdersAndIndicator*). *standardAndIndicator* defined the properties between BIM standards and assessment indicators, which is designed for the first scenario, illustrating the source of each assessment indicator. *stakeholdersAndIndicator* is the group designed for the second scenario, which identifies the assessment indicator for each type of stakeholder. The third and fourth scenarios can be directly resolved without defining specific object properties. For annotation properties, one of the pre-defined properties in RDF Schema (*rdfs: comment*) is adopted in the ontology, which is used to annotate the weights, the explanations of each indicator and the questions that users need to answer during assessment.

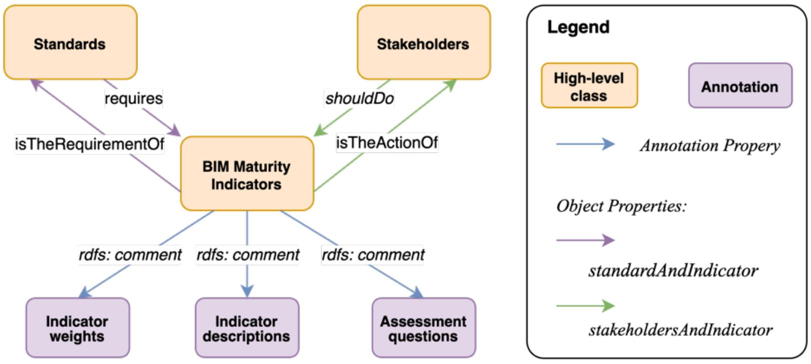


Figure 2 - Properties defined in the ontological knowledge model

(4) Delphi validation

The Delphi method (Dalkey and Helmer 1963) is essentially a feedback-anonymous correspondence method, which was pioneered by O. Helm and N. Dahlke in the 1940s. This method obtains relatively objective information, opinions and insights through the independent and repeated subjective judgment of several experts. Therefore, the Delphi method is often used to validate the reliability of subjective judgements. Figure 3 illustrates the detailed process for the Delphi method.

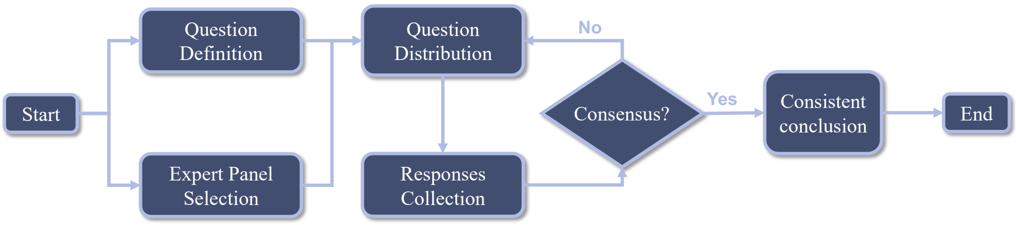


Figure 3 - Process of Delphi survey adopted for indicator validation

In this research, the Delphi method was applied to validate both the assessment indicators and the relations between these indicators. The validation process follows the above flowchart, and is elucidated as follows:

(1) Design a questionnaire for validation based on the indicators in the ontology.
(2) Distribute the questionnaire to domain experts and ask them to complete it independently.
(3) Collect responses from experts and modify the indicators accordingly.
(4) Reiterate steps (2), and (3) until all experts' responses are consistent.

Regarding the number of experts, 5 to 8 experts are sufficient (Beiderbeck et al. 2021). To ensure the reliability of the outcomes, the whole expert panel was invited to participate in the survey. Following four rounds of survey and modification, consensus among the 15 experts was ultimately achieved.

4.2 Computing framework development

Considering different indicators contribute differently to BIM maturity, the proposed framework uses the weighted summation to calculate the maturity score. Therefore, two algorithms were developed to calculate weights and maturity scores for the assessment indicators, respectively.

4.2.1 Indicator weight updating

The global weights for assessment indicators were calculated through the analytic hierarchy process (AHP), which is a structured technique designed for quantifying the weights of different decision criteria for complex decision-making (Saaty 1990). The relative significance of the indicators is estimated via pairwise comparisons conducted by experienced experts. The authors conducted a pairwise comparison survey with domain experts in the panel after they reached a consensus on indicators. Based on their responses, the global weight of each indicator was determined by calculating the normalised eigenvector of the pairwise comparison matrix. These global weights can be directly used for maturity score calculation under the third and fourth assessment scenarios. For the first and second scenarios, the extracted assessment framework is no longer the subset of the original ontology. Hence, the global weights need to be replaced by relative weights (calculated by Formula (1)) in the calculation.

$$W_i^* = \frac{W_i}{\sum_i^j W_i} \tag{1}$$

where W_i and W_i^* represent the global weight and the relative weight of ith indicator among all j selected indicators that belong to the same superclass and indicator level in the ontology.

4.2.2 Maturity score calculation

The calculation of maturity scores follows the arrows in Figure 4. The scores for measures are directly determined by the response from users. Then the weights for indicators are updated based on the selected scenario. The score of divisions, areas, and overall BIM maturity are calculated according to weighted summation (Formula (2)) from higher level to lower level.

$$S = \sum\nolimits_j \sum\nolimits_i W_i^{j+1} * S_i^{j+1} \tag{2}$$

where i, j represent the ith indicator in the jth level (where the level counts down from 5 to 0). W_i^{j+1} and S_i^{j+1} stands for the weight and score of the ith indicator in the jth level.

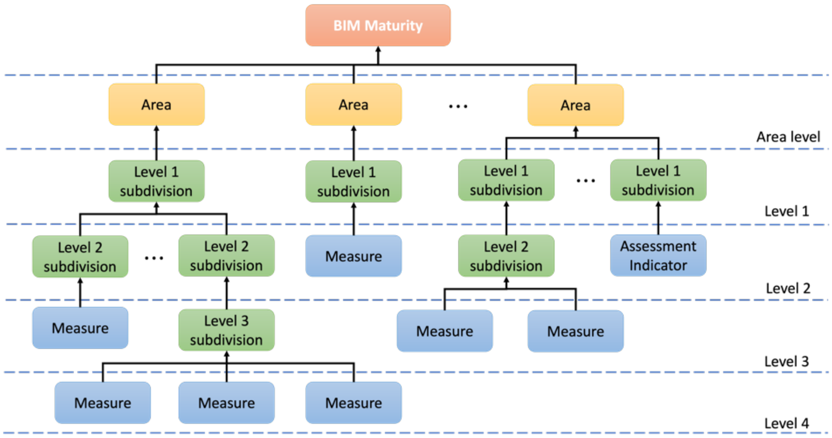
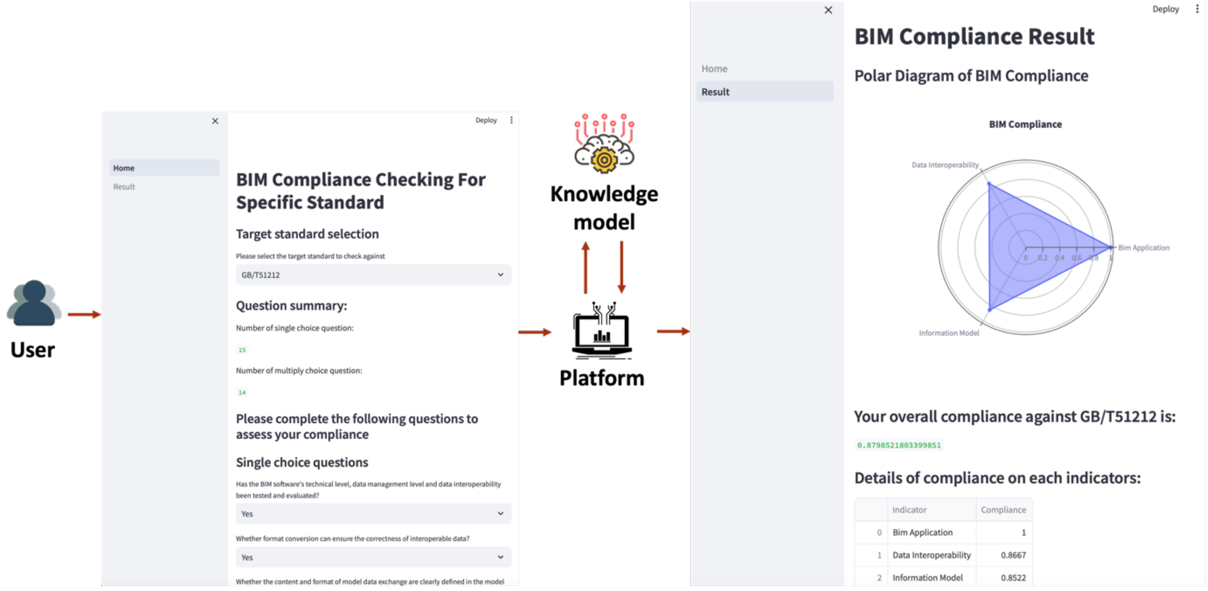


Figure 4 -The hierarchical computing framework designed in the proposed assessment framework

4.3 Platform development

To integrate all functional components and provide the user with intuitive results, a web-based platform was developed. The platform is developed based on Python and several open-sourced libraries, such as Owlready2, Streamlit, etc., are adopted to help the platform interact with frontend users and the backend knowledge model.



BIM Compliance Checking For Specific Standard

Target standard selection

Please select the target standard to check against

GB/T51212

Question summary:

Number of single choice question:

15

Number of multiply choice question:

14

Please complete the following questions to assess your compliance

Single choice questions

Has the BIM software's technical level, data management level and data interoperability been tested and evaluated?

Yes

Whether format conversion can ensure the correctness of interoperable data?

Yes

Whether the content and format of model data exchange are clearly defined in the model

BIM Compliance Result

Polar Diagram of BIM Compliance

Your overall compliance against GB/T51212 is:

0.8798521803399851

Details of compliance on each indicators:

	Indicator	Compliance
0	Bim Application	1
1	Data Interoperability	0.8667
2	Information Model	0.8522

Figure 5 - Process of the assessment through the interactive platform

The specific evaluation process (Figure 5) through the developed platform follows three steps: (1) the user sets the criteria for the assessment in the platform's interface, including specific

BIM standards and roles; (2) after setting the criteria, the platform will query the ontology to extract corresponding assessment indicators and questions. The indicators are then fed into the computing framework to calculate weights for each indicator. The questions are presented on the interface to form a questionnaire; (3) the users answer all the questions objectively based on the actual situation when delivering a BIM project: (4) the platform collects all the responses and sends them to the computing framework to calculate the score of each area and overall maturity. The results are displayed on the interface as a radar chart and corresponding; (5) based on the assessment results, the platform queries the knowledge model and presents the corresponding recommendations for improvement.

5. Validation

To validate the proposed framework, a case study of BIM maturity assessment for the first scenario is implemented in this research. The Hassyan Clean Coal Power Plant project is chosen as the actual use case and ISO 19650 is selected as the assessment criteria. This project has been audited by the BSI for ISO 19560 kitemark certification. The feedback from BSI is considered as the ground truth for validation.

To ensure objectivity, three project managers who were deeply involved in the project were invited to participate in the validation work and respond to relevant inquiries independently. The final results of the BIM maturity assessment were determined by the average of the three evaluation outcomes. Table 2 presents the details of the assessment results generated by the proposed framework. The assessment results given through the responses of the three BIM managers were 0.714, 0.702 and 0.733 respectively and the maturity score of the Hassyan project against ISO 19650 is about 0.72. The proximity of these two results can further substantiate the reliability of both methods to a considerable extent.

Table 2 - Assessment result generated by the system based on the user's response

	Participant 1	Participant 2	Participant 3	Average
Maturity score	0.714	0.702	0.733	0.719

Since BSI's experts did not provide quantified maturity scores, the validation was implemented by mapping the gaps listed by the domain expert with the optimisation suggestions generated by the proposed platform. Table 3 illustrates the mapping results of experts' feedback and some representative optimisation suggestions.

Table 3 - Mapping of the gaps provided by domain experts and the optimisation suggestions generated by the system

No.	Gaps outlined by experts from the BSI	Corresponding optimisation suggestions
1	As the lead appointed party delivers EPC projects, it intends to establish a standard PIR for the project. (5.1.2).	A complete set of project information requirements shall be established and take into consideration the information requirements which are needed at each key decision point.
2	The appointing party intends to introduce a process to host, support and / or manage a CDE for the client if requested to do so (5.1.7).	Appointing party shall establish a CDE specifications to explain the workflow.
3	The appointing party intends to develop its EIR document to ensure all requirements of ISO 19650- 2 are included. (5.2.1).	Appointing party shall establish their exchange information requirements.
4	The lead appointed party intends to create an EIR when receiving and confirming an appointing parties EIR. (5.2.1)	The lead appointed party shall establish their exchange information requirements for each appointed party.
5	The lead appointed party intends to merge its Pre and Post Appointment BEP templates to produce one Project BEP and intends to review this fully to remove any "PAS 1192-2" references. (5.3.2 and 5.4.1).	–

6	The lead appointed party intends to enhance its mobilisation plan and delivery activities to better describe how it will ensure these activities are completed. (5.3.5 and all of 5.5.X).	–
7	The lead appointed party does not create a "Lead Appointed Party EIR" to identify these requirements in its Post Contract BEP. (5.4.3)	The lead appointed party shall establish their exchange information requirements for each appointed party.
8	The lead appointed party intends to establish a TIDP template. (5.4.4)	A task information delivery plan (TIDP) shall be established by the lead appointed party and maintained throughout task team's appointment
9	The appointing party intends to develop a CDE, and create a process guide to describe how the CDE functions in accordance with the UK national annex and how information is contained, approved and authorised between task and delivery teams. (5.6.X, 5.7.X and UK National Annex).	A common data environment shall be established for the projects.
10	The lead appointed party intends to create a process to ensure lessons learnt from the appointing party and task teams is effectively controlled. (5.8.2)	Appointing party shall capture lessons learned during the project and record them in a suitable knowledge store.
11	The appointing party intends to identify its file naming and protocols.	A project information protocol shall be established.
12	–	A Common data environment should be established before the invitation to tender stage.
13	–	Appointments should have the information protocol incorporated into them
14	–	Appointing party's information requirements shall consider: organizational information requirements, asset information requirements, and project information requirements;

As shown in Table 3, the generated optimisation recommendations and the feedback of gaps from experts show a high degree of consistency. 9 of the 11 listed gaps find a counterpart in the generated results of the optimisation recommendations. Moreover, the proposed framework provides some other recommendations beyond the experts' feedback - Suggestion 12 to 14. The reason for this is that, in practice, the failure of a high-level indicator can lead to the omission of the assessment of its secondary indicators, thereby resulting in a missing of gaps. For example, if the project's common data environment (CDE) is not established, all further assessments for the CDE will be omitted, which means the gaps in the CDE specifications will be lost. However, when enterprises improve their workflow, these gaps are vital in establishing a qualified CDE. At this point, the proposed framework is more nuanced and comprehensive than the expert assessment. In terms of quality assessment, this framework is flawed. It can only check whether the documents have been created but not the quality of the contents in the documents - Gaps 5 and 6. Based on the above analysis, it can be concluded that the proposed framework is effective for flexible BIM maturity assessment.

6. Conclusion

In this research, an innovative ontology-driven comprehensive BIM maturity assessment framework is developed, which addresses the shortcomings of existing methods in comprehensiveness, flexibility, and extensibility, and fulfils the demands of multi-scenario BIM maturity assessment for enterprises in the AEC domain. This framework innovatively adopts multi-module architecture. The domain ontology is utilised as the knowledge container, where the domain knowledge can be easily modified, maintained, updated, and expanded. The web-based platform cooperates with the computing framework to provide flexible and rapid BIM maturity assessments with comprehensive results and optimisation recommendations. The effectiveness of the framework has been preliminary validated through a case study. The proposed framework may have a profound impact on the BIM maturity assessment. Its revolutionary multi-module structure dramatically increases the flexibility of maturity assessment. The adoption of the ontological knowledge model greatly improves the carrying capacity and extensibility of domain knowledge. The advent of a sustainable BIM maturity assessment method is of great significance for enterprises in the AEC industry, as it can constantly facilitate the optimization of workflows and enhancement of productivity.

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