A generic framework for BIM component naming

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Abstract: The advent of Building Information Model (BIM) has established a new paradigm of project management. BIM contains more and more information generated with the evolution of projects. Most of the information in BIM is organized in an object-oriented way. Thus, the unit of information management is every single component in BIM. The name of every component, one of the metadata, provides an efficient tool to manage a wealth of information. However, there are very few studies and standards focusing on the component names. In practice, the disorder in component names and incompatibility with stakeholders' requirements can be easily identified. To solve these problems, this study proposed a list of criteria that component names should fulfill and developed a naming framework following these criteria. The major contribution of this study is the generic framework that can help to formulate an appropriate naming convention and facilitate information management at a project level.

Keywords: Building information modeling (BIM); name; naming; component.

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1 Introduction

Building Information Modeling (BIM) has been regarded as a disruptive technology in Architecture, Engineering, Construction (AEC) industry. It is widely accepted that BIM is defined as a digital representation of the physical and functional characteristics of a facility[1]. BIM not only serves as a shared database to store huge volumes of data, but also has the potential to achieve more intelligent and automated functions by making the most of the data[2]. Extensive studies have demonstrated these possible applications, such as 3D visualization[3], clash detection[4], cost management[5], facility management[6], schedule management[7], and simulation[8]. All these applications are based on structured and well-organized data in BIM, which is represented in a machine-readable form. Towards the target of digitization and automation, extensive work has focused on translating the human-readable documents (e.g., PDF, Word) into machine-readable data format (e.g., XML, JSON). The value of BIM lies in its structured data. However, the amount of data in BIM keeps increasing and becomes more and more unmanageable as the project evolves[9]. Therefore, tools that are capable of handling large volumes of data are needed. Metadata is the primary one of these tools[10][11].

Metadata, in short, is the data that describes other data[12]. It has become a pervasive and indispensable part of people's daily lives. Exemplary usages of metadata include the index numbers to books in libraries, the prices of products on online shopping platforms, and the tags of photos on social media. Metadata can be utilized to categorize, filter, identify, and locate data items quickly[13]. For data management, metadata often provides information about name, creation, modification, size, type, and other features[14]. Among these metadata, names are the most common and important piece of metadata. Names serve as the primary identity tags, often using natural language that can be understood by human[15][16]. In BIM models, there are various names, such as component names, object names, material names, layer names, and others. This study has a focus on BIM component names.

Previous literature has underlined the role of names in project management[17][18]. Given a prominent naming convention, names are able to disambiguate by explicitly displaying features of components. Therefore, when implementing BIM, practitioners begin to value a standard naming convention. BIM Execution Plan (BEP) is a plan that describes the process of information modeling in detail with the aim of promoting information management throughout the life cycle of a project[19]. BEP pinpoints a checklist of requirements for BIM of a project, among which component naming is one of the most important considerations[20].

However, the practical implementation of naming components is still not ideal. Reasons for this could be disorder in component names[21] and incompatibility with project requirements[22]. To solve these problems, this study aims to propose a generic component-naming framework for information management at a project level. The rest of this paper is organized as follows. Section 2 is the literature review revealing some basic concepts, the current status of naming components, and problems of current practices in construction projects. Section 3 will introduce the method used in this study. A generic framework for naming components is proposed in Section 4. Finally, conclusions are drawn in the last section.

2 Literature Review

2.1 Basic concept of name

The Merriam-Webster dictionary explains the noun “name” as “a word or phrase that constitutes the distinctive designation of a person or thing”[23]. This definition delineates the most important characteristic of a name to be distinctive. A name virtually serves as a searchable metadata tag of an item. In a BIM model, a component name is utilized to reveal the primary information and distinguish it from other components. Here, it is worth noting that some IDs, such as Element ID in Revit and Globally Unique Identifier (GUID) in Industry Foundation Class (IFC), function as an identifier of components[24]. This is what names and IDs have in common. The differences lie in two aspects. First, a name contains more semantic information, making them easier to be understood by a human, while an ID is a string of alphanumeric characters that are hard to remember. Second, a name can be changed, but an ID has to be constant throughout the whole life cycle[25]. Preferably, a name reflects the current states or properties of the component in real-time. In other words, a name should be modified, if needed, as the properties change. An ID must be preserved, regardless of software platforms and stages.

It's worth noting that there is often confusion between component names and object names in most cases. It should be clarified that, according to NBS[26], components refer to “specific instances of each type that may require management such as inspection, maintenance, service or replacement during ‘in-use’ phase”, also known as “instance”, “occurrence” or “element”. Objects refer to “items having state, behavior and unique identity”, also known as “entity” or “element”[26]. An example of objects can be a wall object, while a component can be an instance of the wall object in a particular project. Object names can help to build and develop an object library to retrieve and reuse BIM objects and expedite the modeling process[16], which is beyond the scope of this study. This study focuses on the component names, i.e., the names of instances, to facilitate the management of a particular project.

2.2 Current status of naming components

The importance of consistent and semantically rich names has been highlighted at every stage of a building's life cycle in previous studies. In the planning and design stages, Merschbrock & Munkvold[27] pointed out that a consistent and unique naming convention for parametric components, containing information about the location and type of components, enables designers to perceive the components easily. In the phases of construction, the unique component names pave the way for users’ instant recognition to establish the component records[28] and for software tools’ identification to generate construction schedules[29]. For facility management (FM) stages, Becerik-Gerber et al.[30] derived the data requirement structure for BIM-enabled FM from expert interviews, of which names and IDs are the primary data and situated at the top. It is worth noting that names also play a key role in information exchange among these stages. Throughout the life cycle, extensive efforts have been paid to facilitate information flow by reusing the data created in previous stages and avoiding the process of data re-entry. Construction Operations Building Information Exchange (COBie) is one of the salient data exchange standards which defines the information transfer from design and construction phases to FM phases. COBie practices require rigorous procedures to name a component for retrieving and validating data from various phases[31]. Therefore, the seamless flow of accurate information among stakeholders can be enhanced, by simply establishing and implementing an appropriate naming convention.

It is widely admitted that the problem of naming components is of fundamental importance in project management, while very few academic and industrial efforts have been paid on solving this issue. Table 1 summarizes some of the existing naming conventions for BIM components. These conventions often specify that an informative name contains several fields of semantic information, such as category, type, location, sequential number, and so on. A final name is obtained by sorting the semantic information in a certain order. For example, Chen et al.[22] proposed a naming convention in the form of "<Function> _ <Type> _ <Location> _ <Sequential number> _ <Description>". An example provided by Chen et al. (2017) is "PF_TX8_2/F_2_M1", where "PF" means precast façade (Function), "TX8" means the façade shape (Type), "2/F" means the second floor (Vertical Location), "2" means the second room (Horizontal Location), and "M1" is the mold type (Description).

Table 1. Summary of naming conventions for BIM components

Reference	Country or Region	Naming Convention
ISO[32]	Global	<IfcSubtype><Sequential number>
USC[33]	USA	<Type>-<ID>
Chen et al.[22]	Hong Kong	<Type>_<Subtype>_<Location>_<Sequential number>_<Description>
USGSA[34]	USA	<Type>-<Description>
MOHURD[35]	China	<Project name>_<System>_<Location>_<Component type>_<Design phase>_<Description>

2.3 Problems of current practices

With very few available naming conventions, BIM component names in practice can be confusing and harmful to the efficiency of project management. Two major reasons can be identified. The first possible reason can be non-conformance between existing naming conventions and project requirements[22]. Names may contain a lot of unessential information, while the information in need is not available. One should take the practitioners' needs into full consideration when designating a naming convention. The second reason is about the disorder of component names. In most cases, arbitrary component names are assigned. Table 2 shows some examples of such names exported from a particular BIM model. Moreover, the same component can be labeled with different terms, i.e., synonyms, by different stakeholders. These inconsistent names require additional work for manual mapping and hinder the information exchange between multiple stakeholders[21]. Practical experiences also show that the disparities in BIM component naming could be the trigger for coordination issues and conflicts[15]. To address these problems, this study aims to propose a generic component-naming framework to help various projects develop their own suitable conventions.

Table 2. Examples of arbitrary names in a BIM model

No.	Names of BIM components
1	Steel-Stainless-NA
2	M_1000
3	9 Meters High
4	01 Cotton
5	800 x 2100
6	Standard

3 Method

As a pioneering and innovative exploratory research, this study developed a fundamental naming system for the whole supply chain of modularized construction using design think methodology. Design thinking is an approach of technical and social innovation to solve complex problems in a user-centric way[36]. It emphasizes the designer's thorough understanding through direct close observation of what is wanted, needed, and liked[37][38]. It uses the designer's sensibility and methods to provide a solution-orientated approach to solving complex problems that are new. The design thinking methodology has five stages, i.e., empathize, define, ideate, prototype, and test, that adopt multiple research methods. The 'empathize' stage aims to gain an empathic understanding of what people do, how they think, and what they need. The 'define' stage states what the problem is, what the constraints are, and what to change. The 'ideate' stage thinks about how new innovations can help and what the innovation should look like. At the 'prototype' stage, creative frameworks and ideas will be built. Finally, the innovation will be executed, verified, and communicated in the 'test' stage. The different stages are non-linear and not always sequential. For example, the 'prototype' stage may inspire new ideas. The test results can help create new ideas, reveal new insights about the problem, and learn more about users.

Under the umbrella of design thinking, literature review, archival study, brainstorming, and survey were used as methods for inspiration (empathize and define), ideation (ideate and prototype), and implementation (test). For the research purpose, we first explored the concept of name and the current status of naming components through literature review and archival study in the empathy stage. Then we identified the problems in current practice based on results from the last stage and survey. Afterward, the naming criteria were derived from the defined problems. Based on these explorations, we proposed a generic naming framework by brainstorming and surveys. The test stage is not covered in this study. Future work should be validated and refined the proposed naming framework by exploratory case study.

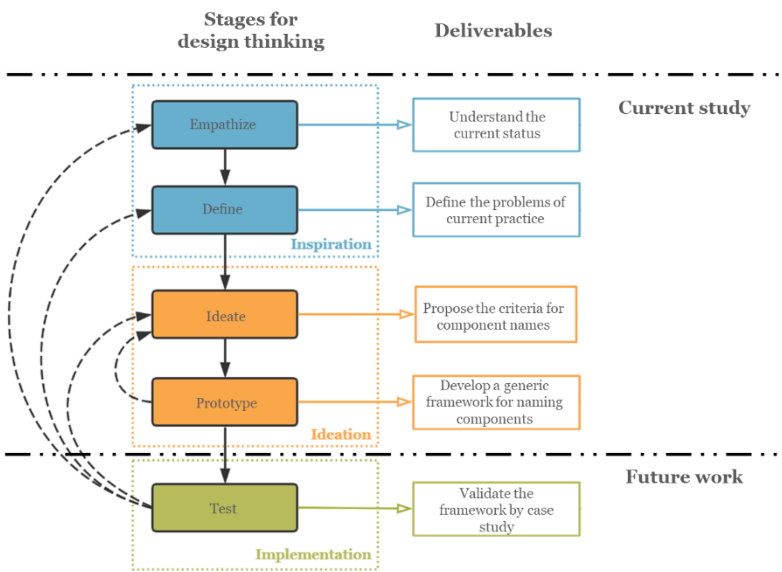

Figure 1. Research method in this study

4 Framework for naming components

4.1 Criteria for component names

After synthesizing the previous naming practices and the current problems of naming components, we summarized the following criteria for naming BIM components:

(1) *Uniqueness*. Every BIM component is supposed to have a unique name. Duplicate information can be detected directly by name.

(2) *Informativeness*. Every component name should contain enough information that is understandable for a trained worker.

(3) *Conciseness*. The name should contain only necessary information. Any extra characters or spaces should be removed.

(4) *Accuracy*. The wrong and ambiguous information should not be contained in the name. The name should describe the component accurately.

(5) *Consistency*. All component names in the BIM model should follow the same naming convention and the same taxonomy system.

(6) *Conformance*. The information in the name and the order thereof should conform to the requirements of specific projects.

(7) *Machine-readableness*. In order to automate name management, component names should be machine-readable.

4.2 The proposed framework

Based on the above criteria, this study derived a generic framework for naming BIM components (Figure 2).

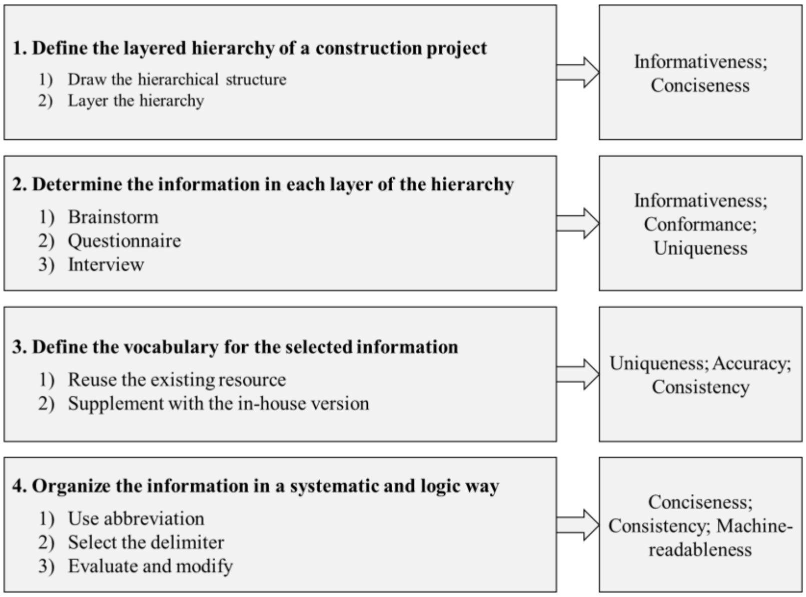

Figure 2. The generic framework for naming components

The first stage is to define a layered component hierarchy of a particular construction project. The rationale is that an analogy can be drawn between a project made up of components and a society made up of people. People in society are organized to form a hierarchical structure, such as the individual-family hierarchy. Similarly, a construction project can be broken down iteratively into simple and unitary parts by product, space, or others. Such a hierarchy clearly clarifies the relationship. Names that contain the relationship can be informative and easily perceivable by a human. In this stage, two steps are required, i.e., drawing the hierarchical structure of a construction project and layering the hierarchy. To draw the hierarchical structure, one can learn from the existing results of decomposition, such as the hierarchy in IFC (IfcProject - IfcSite - IfcBuilding - IfcStorey), and adapt it in line with the project characteristics. The granularity of the bottom level within the hierarchy should be every single component. As the hierarchy is layered, names should convey information from each layer to demonstrate the relationship. Thus, it should keep as few layers as possible for the conciseness of names. Examples of the layered hierarchy can be building-story-component, or story-unit-component. This stage mainly considers two criteria, namely, informativeness and conciseness. The relationships between components are explicitly defined to pave the way for an informative name. For conciseness, the hierarchical structure is divided into as few layers as possible.

The second stage is to determine the information in each layer of the hierarchy. For conformance, the information in each layer should be determined by due consideration of all the stakeholders' requirements. For example, under the hierarchy of building-story-component, building number (e.g., 01), loading level of story (e.g., high level of loading), and component type (e.g., door) can be selected for each layer. Individually, information from each layer is not necessarily unique, but together, all the information can identify a unique component. In this stage, methods of brainstorm, questionnaire, and interview may help to come up with plenty of information for each layer. Then, the information of each layer that needs to display in names is determined jointly by all stakeholders. This stage mainly takes into account three criteria, i.e., uniqueness, conformance, and informativeness.

The third stage is to define the vocabulary for the selected information. Each information should be represented by a term selected from a predefined vocabulary. Each term in the vocabulary should be unique in form and meaning. To be consistent, a predefined vocabulary can be controlled to follow the same classification system and avoid the dilemma where multiple taxonomies are adopted. There are many existing resources, e.g., IFC, UniClass and OmniClass, that can be reused to save a lot of time for defining the vocabulary. Some modifications and additions may also be needed to make the vocabulary more accurate to describe the components. The criteria of uniqueness, accuracy, and consistency are embodied in this stage.

The final stage is to organize the information in a systematic and logical way. Before organizing the information, the abbreviation is strongly recommended for the sake of brevity. Then the delimiter should be chosen to connect different pieces of information. Consistent use of delimiter can help machines separately read names. The initially formed name should be evaluated and revised by stakeholders as appropriate. In this stage, conciseness, consistency, and machine-readableness are the main considerations for naming components.

5 Conclusion

Component names are primary tools to manage voluminous information during the lifecycle of buildings. However, little research has paid effort on what kind of name is qualified and how to formulate a qualified naming convention. This study adopted the method of design thinking to propose the criteria for component names and develop a generic naming framework. The criteria include uniqueness, informativeness, conciseness, accuracy, consistency, conformance, and machine-readableness, which guide the development of the naming framework. The generic framework contains four stages, i.e., define the layered hierarchy of a construction project, determine the information in each layer of the hierarchy, define the vocabulary for the selected information, and organize the information in a systematic and logical way. It is generic enough that almost all types of projects can follow this framework and formulate an appropriate naming convention for a specific project. Future research should focus on the validation of the framework by case study.

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