

Managing Indoor Movable Assets in 3D using CityGML for Smart City Applications

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ABSTRACT:

Smart Cities are the extensive use of the Internet of Things (IoT) and open data to optimise the flow of energy, people, and data, especially in city infrastructure, management, and services. Nowadays, city or building management has become widespread regarding smart city development. Moreover, Asset Management is becoming increasingly important for cities to have the conditions for continuous development, buildings and urban infrastructures that must be planned more efficiently and sustainably. On the other hand, asset management is no longer appropriate since the appearance properties, textures, and materials attached to city models drastically increase the loading time for visualisation and spatial analysis. Besides, different applications or users demand different Level of Details (LODs); hence, a suitable 3D indoor model is needed. However, the available models representing indoor spaces' geometric and semantic information are rarely described. Thus, to achieve effective asset management, we proposed organising indoor movable assets of indoor building models using CityGML. This paper aims to model the indoor movable assets based on Level of Detail 4 (LOD4) using CityGML concept. There are several limitations of current indoor movable asset management practice, such as the unavailability of asset visualisation, outdated asset information, and a tedious filing system. Therefore, integrating indoor asset management and the CityGML seems to be a better option to manage the 3D asset management information efficiently. This study uses the 3D building model in level 4 (LOD4) to conceptualise and organise the indoor asset information and visualisation. The final output of this study is indoor asset information in LOD 4. Each of the components can be viewed individually together with its information. For future use, the model can be used to serve various smart city applications such as indoor navigation, design, and planning.

1. INTRODUCTION

Today, people continue to move to or visit cities, despite the coronavirus pandemic, for various reasons, including employment prospects, lifestyle, and more. Due to the sudden influx, cities will need to become more efficient to keep up with the growing population if this migration pattern continues (Azri et. al. 2018). As a result, smart cities powered by the Internet of Things (IoT) applications have become the standard in major urban regions worldwide (Stefanini, 2020). There are five top applications in Smart Cities: Smart Infrastructure, Air Quality Management, Traffic Management, Smart Parking, and Smart Waste Management. In addition, to reduce costs and improve the quality of their buildings, building managers around the world are starting to incorporate IoT solutions and devices into their infrastructures.

In today's competitive world, asset management in many countries has begun to move into a more dynamic approach. Moreover, asset management has become one of the important factors toward smart city development in Malaysia. An asset is a resource controlled by an entity, resulting from past events, and providing future or potential economic benefits. Its services are expected to flow into the entity (Malaysia Treasury, 2007a). In Malaysia, there are two types of the asset being used in asset management: Immovable Asset and Movable Assets. Moreover, Government assets can be divided into current assets and non-current assets. Existing assets can be converted to cash in a short-term period, while non-current assets can only be converted to currency after one (1) year (Malaysia Treasury,

2007a). Therefore, Immovable Assets are permanent assets that cannot be removed from the place. An asset that is permanent in place, non-removable or difficult to remove or requires technical expertise can be categorised as immovable. Immovable Assets are land, infrastructure, and building. Immovable Asset Management Procedures are subject to relevant circulars. Movable Assets are assets or equipment that can be moved or transferred easily from one place to another, including Movable Assets supplied with the provision of buildings or other infrastructure (Malaysia Treasury, 2007b). In Movable asset categories, the Movable Assets are divided into two (2) groups: Capital Assets and Low-value Movable Asset. The Capitalised assets are Movable Assets with an original acquisition price of RM2,000 (Ringgit Malaysia Two Thousand) or more per unit. In contrast, Low-Value Movable Assets (Uncapitalised Movable Assets) are Movable Assets whose original acquisition price is less than RM2,000 (Ringgit Malaysia Two Thousand) per unit.

Nowadays, 3D building models are becoming increasingly popular and widely used. This is due to the accurate representation of the 3D environment. For example, identifying locations in high-rise and multilevel building require 3D modelling and new approach compared to 2D (Ujang et. al., 2013, Keling et. al. 2017 and Azri et. al. 2020). 3D modelling of buildings using modern tools and techniques is an important objective for the management and planning urban areas (Costantino, Grimaldi, & Pepe, 2022). The widespread of complex and high-rise buildings, as well as the increasing number of infrastructures above or underground, requires new

methods for efficient land property management (Hajji, Yaagoubi, Meliana, Laafou, & Gholazauri, 2021). As 3D geospatial data becomes more widely available, the demand for visualisation, analysis, and simulation of 3D city models is growing (Salleh et. al., 2021). Cities are expanding due to rapid population increase, necessitating 3D models for better communication, town planning, and disaster management. Moreover, the building model is the most detailed thematic concept in CityGML. City Geography Markup Language (CityGML) is an open standard for semantic information models with a modular structure. The level of detail of the CityGML standard satisfies the increasing need for storing and exchanging virtual 3D city models (Groger, Kolbe, Nagel, & Hafele, 2012);(Blut & Blankenbach, 2019). The new OGC standard CityGML defines a standard for the ontology of buildings at four different Levels of Detail (LODs). The building models at different LODs differ in the complexity and granularity of the geometric representation and the thematic structuring of the models into components with a special semantic meaning.

In this research, we introduced the managing immovable asset management in the level of detail 4 (LOD4) using CityGML. The model describes the geometric information of building indoor spaces with semantic and corresponding topological information. Thus, the paper is organised as follows. Section 2 discussed the previous study and research on the Level of Detailed for indoor building modelling. Then, in Section 3, the current practice of movable asset management in Malaysia. The detailed descriptions and information of CityGML's LODs and Immovable Asset indoor modelling are in Section 4. In Section 5, the CityGML dataset results are discussed. Some conclusions and future work are given in Section 6.

2. PREVIOUS STUDIES

Studies related to Level of Details (LOD) cover a large scope. Numerous researches have explored this topic. Some topics related to the study will be discussed regarding Level of Details (LOD) 4.

First, (Tah, Oti, & Abanda, 2017) introduced LOD and the level of development. The study that variations have been acknowledged between the GIS and BIM domains. In addition, LOD in BIM applications is concerned with information requirements at various phases of the building process's life cycle. In contrast, LOD in GIS is involved with geometric features for supporting multiple applications. Figure 1 shows the data structure difference in both CityGML and BIM domains that need to be understood as their various LOD specifications differ significantly.

Besides, the information on Level of Detail (LOD) 4 is also being explained by (Sun, Zhou, & Hou, 2020) in the study about 3D indoor space models for indoor applications. The survey on this topic covers the indoor level of detail (LOD) of buildings in detail for simplified building components and indoor spaces. In CityGML 2.0, the LOD4 details the furniture's position, shape, and size, which is far too detailed for indoor navigation, resulting in data duplication. Furthermore, some furniture, such as chairs, can be moved about, changing the available area at any time. While the LODs concept of CityGML 3.0 allows describing of a detailed indoor space structure with a rough exterior building shape or even a user-defined geometric and semantic LOD (Biljecki, Zhao, Stoter, &

Ledoux, 2013);(Kutzner, Chaturvedi, & Kolbe, 2020);(Sun et al., 2020).



	Virtual 3D City model (CityGML)	BIM (Revit/IFC)
Graphical illustration		
Information details	<ul style="list-style-type: none"> Surfaces (wall, floor, roof) Installed objects (windows, doors) Edges and object demarcation lines Visible internal details (e.g. floor slabs) 	<ul style="list-style-type: none"> Surfaces (wall, floor, roof) Installed objects (window, doors) Edges and object demarcation lines Visible internal details (e.g. floor slabs) Detailed outline for edges of objects (e.g. frame around windows) Partition lines for surfaces of an object (e.g. double doorpanels, window panes) Can be used for construction purposes as dimensions are accurate

Figure 1: The differences between LOD 4 for CityGML and the BIM Counterpart.

On the other hand, (Lei, Lin, & Yuan, 2018) also explain a full level of detail specification for 3D building models for 3D indoor models (LOD4). This study introduces the different LODs for indoor spaces (LOD4). Different LODs provide distinct geometries for corresponding objects. Compared with CityGML LODs, the indoor LODs has their characteristic and geometry. In ILOD0, a generalised model provides an inner shell for indoor spaces. The CeilingSurface, FloorSurface and InteriorWallSurface bound the geometry in the ILOD0. In ILOD1 level, the interior architectural structures with specialised functions or semantic meaning cannot be moved or permanently attached to the building shell (ILOD0). Then, in ILOD2, the features would influence the connectivity of the interior spaces as in IndoorGML, such as *Door* or *Windows*. Next, in ILOD3, the characteristic of the indoor LOD representation of *BuildingFurniture*. Until now, interior spaces have been considered empty boxes with no furniture occupying specific interspaces. However, in ILOD3, we restore these spaces. Then, in ILOD4, the highest level of accuracy and resolution for the indoor building is equivalent to the LOD4 defined in CityGML. This LOD level has the most comprehensive and detailed structures of interior installations and furniture. Figure 2 shows the full level of detail (LOD) specification to describe indoor LODs for a 3D indoor building model.

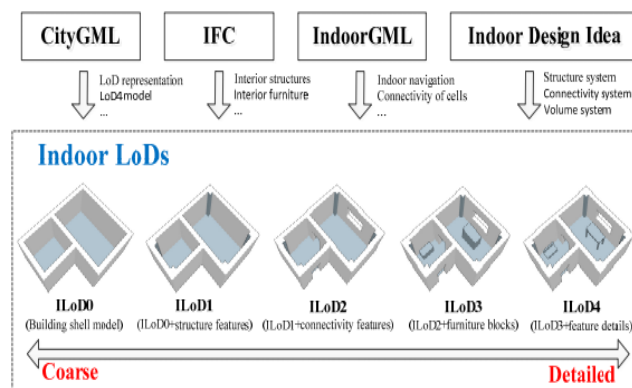


Figure 2: Full level of detail (LOD) specification for 3D indoor building model

Thus, in this section, related works that have been reviewed were carefully described to show various aspects of the study related to asset management. The research in related works has helped introduce the concept that shows the study's advantages and benefits for future research.

3. CURRENT PRACTICE OF MOVABLE ASSET MANAGEMENT IN MALAYSIA

3.1 Movable Asset Management Practices in Malaysia

Government Asset Management is currently managed and monitored by the Malaysian Treasury. Moreover, the Malaysian Treasury has published the Government Asset Management Circular (AM) and Government Movable Asset Management Procedure (TPA) as the guideline and responsibilities of asset management in Malaysia. The Government Asset Management Circular (AM) contains the Introduction to Government Asset Management, Responsibility of Control officers, Head of Department Responsibility, Government Asset Management Division/ Section/ Units, Appointment of Asset Officers, Asset Management Committee (JKPAK) at the Ministry/ Department/ State/ Level, Asset and Store Management using Computerized Systems, Asset and Store Information Reference Center, Interpretation and Application of Asset Circulars. This circular clarifies the rules related to Movable Asset Management, Living Assets, Intangible Assets, and Federal Government Stores (Malaysia Treasury, 2007a). Moreover, the Government Movable Asset Management procedure (TPA) is one of the Malaysian Treasury Circulars of the Ministry of Finance.

In addition, the Government Movable Asset Management (TPA) Procedure is intended to manage Capital Assets and Low-Value Movable Assets. It covers the Acceptance, Registration, Use, Storage, Inspection, Maintenance, Amendment, Disposal, Loss and Write-Off as shown in Figure 3 (Malaysia Treasury, 2007b). Asset Management Division/Section/Unit (UPA) is responsible for managing all Movable Assets, Living Assets, and Stores in the Ministry/Department under his control. There is seven (7) part of the movable asset procedure circular that can be identified as Government Movable Asset Management Procedure: Acceptance (AM 2.2), Government Movable Asset Management Procedure: Registration (AM 2.3), Government Movable Asset Management Procedure: Use, Storage and Inspection (AM 2.4), Government Movable Asset Management Procedure: Maintenance (AM 2.5), Government Movable Asset Management Procedure: Amendment (AM 2.6), Government Movable Asset Management Procedure: Disposal (AM 2.7), Government Movable Asset Management Procedure: Loss and Write-off (AM 2.8).

3.2 Issues on Current Movable Asset Management Practices in Malaysia

Asset Management is a systematic approach for government or private section especially asset manager to realize the value or asset and responsible for the asset lifecycle from asset registration until asset disposal. From the study, there are a few issues in the current movable asset management in Malaysia that can be identified. There has been identified that the current practice of movable asset management in Malaysia that involving the government and its agencies are seen to be rather disjointed and incomprehensive (Abdullah, Razak, Hanafi, & Pakir, 2012). Nevertheless, the government is currently dealing with a variety of problems and drawbacks when managing those

property assets, including the rise in property management and maintenance costs, the occurrence of incompatible maintenance tasks, underutilization of property, end-user dissatisfaction, and others (Abdullah, Razak, Hanafi, & Salleh, 2011). This inefficiency will affecting the work performance of authorities or asset related organizations. Therefore, an effective and efficient asset management can help increase the efficiency of government assets management and help asset manager to maintain their asset with minimal cost. Thus, it is important to have an effective and synchronize asset management system in between government agencies.

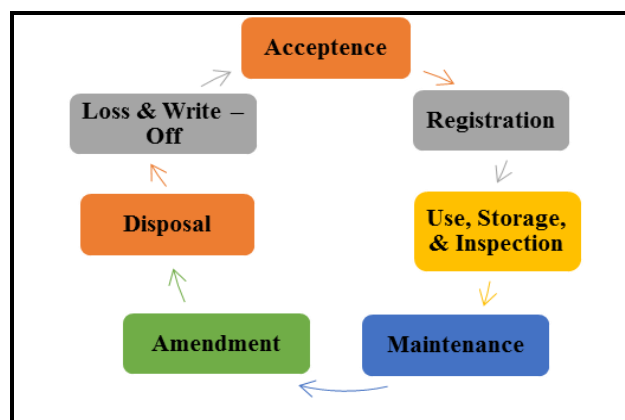


Figure 3: The Contents of the Movable Asset Management procedure (TPA)

In Malaysia, an electronic based asset management system has been introduced to manage movable asset management. The Asset Management Monitoring System (SPPA) is an application developed for the purpose of asset control and monitoring for all Federal Ministries and Departments (Financial Ministry, 2007). However, even with system development, the movable asset management is applying manual practice for asset registration and management. In addition, manual asset management and tracking of thousands of assets is expensive, takes lots of time and effort, and still prone to human error and manual asset tracking methods are disorganized especially when there are a lot of assets (AssetInfinity, 2020). Therefore, it is necessary to update the asset management process by utilizing existing technologies (Saptari, Hendriatiningsih, Bagaskara, & Apriani, 2019). The recent advancements in digital maps and GIS (Geographic Information System) technology have improved the efficiency of asset and inventory management (Sairam, Nagarajan, & Ornitz, 2016). With that, the integration of movable asset system with current GIS technology is needed to improve the quality of asset management in Malaysia.

In recent years, the development of numerous property assets, including office buildings, roads, bridges, and other structures and infrastructure, has demonstrated the government's dedication to carrying out its duties. However, this development increases the complexity in managing asset management for government authorities and asset managers. Moreover, the absence of 3D based asset management is hindering the development of smart city asset management culture in higher constitutions. Therefore, a new concept must be introduced to support 3D asset management. One well-known international standard for developing, storing, and exchanging 3D city models is CityGML, which was created by the Open Geospatial Consortium (OGC) (Groger et al., 2012). CityGML will therefore be crucial to the development of 3D asset management

in the future. Therefore, there is a need for integration of CityGML with movable asset management system

4. MOVABLE 3D ASSET MANAGEMENT

4.1 Representations of Level of Details (LOD) based on CityGML

In CityGML, the level of detail (LOD) indicates how closely the model mirrors its real-world counterpart. Additionally, the CityGML's LOD is accepted and widely used in various applications, including the 3D building modelling, as there is a newly published OGC CityGML version, CityGML 3.0. Thus, the differences between CityGML 2.0's LOD concept and the new CityGML's 3.0 LOD.

CityGML 2.0, the CityGML, support different Levels of Detail (LOD). Moreover, LODs facilitate efficient visualisation and data analysis, as shown in Figure 4 (Groger et al., 2012). The coarsest level is LOD0, represented by footprint or roof edge polygons. LOD0 also represents the dimensional Digital Terrain Model (DTM), an aerial image or map. Then, the LOD1, which consists of a block model of prismatic buildings with flat roof structures, is well-known. A building in LOD2, on the other hand, includes unique roof structures and thematically differentiated border surfaces. Next, LOD3 refers to architectural models with detailed wall and roof structures, doors, and windows. Finally, LOD4 completes a LOD3 model by adding inner building structures. Buildings in LOD4, for example, are made up of rooms, inside doors, staircases, and furnishings.

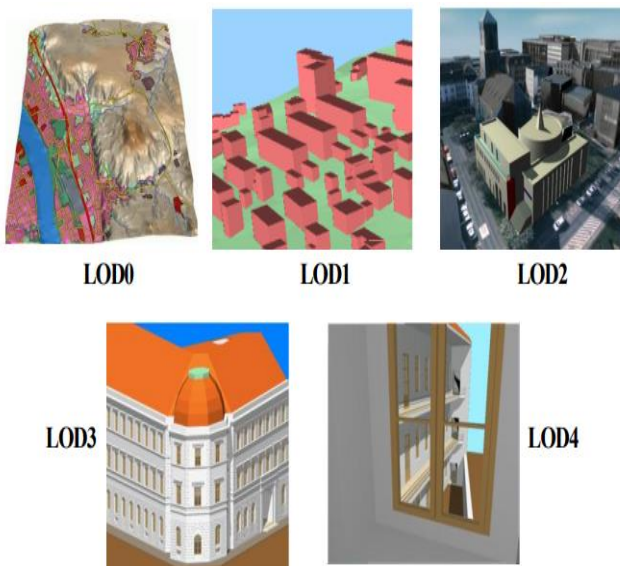


Figure 4: The five levels of details (LOD) defined by CityGML (Groger et al., 2012)

While in CityGML 3.0, the CityGML Conceptual Model differentiates four consecutive Levels of Detail (LOD 0-3), where objects become more detailed with increasing LOD concerning their geometry (Kolbe et al., 2021). In the new CityGML concept, the LODs can have but do not have to contain multiple geometries for each object in different LODs simultaneously. Thus, the LOD concept facilitates the multi-scale modelling of those varying degrees of spatial abstractions suitable for various applications or visualisations. Figure 5 shows the representation of levels of detail in CityGML 3.0.

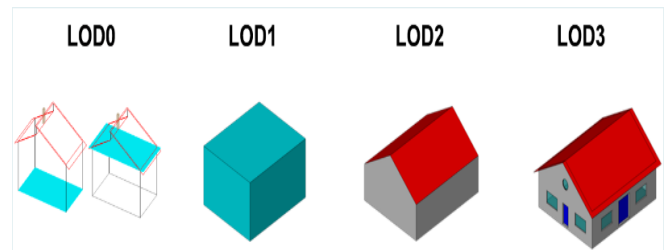


Figure 5: The representation of the same real-world building in Levels of Detail 0-3 (LOD0-3) (Kolbe et al., 2021).

Moreover, CityGML 3.0 allows various geometrical representations for objects as their classifications are based on semantics, not their used geometry. In addition, the biggest change between CityGML 3.0 and CityGML 2.0 is that LOD4 is dropped. In CityGML 3.0, the Levels of Detail (LOD) only contain LOD0 until LOD3. All feature types can have outdoor and indoor elements in LOD0-3. For example, the outside shell of a structure might be represented spatially in LOD2. Still, the interior features, such as rooms, doors, hallways, and stairs, could be represented spatially in LOD1. Building floor plans, which are LOD0 representations of building interiors, can now be described using CityGML (Konde, Tauscher, Biljecki, & Crawford, 2018);(Kolbe et al., 2021).

In CityGML 2.0 and earlier versions, the thematic surfaces only started from LOD2, openings such as doors and windows began in LOD3, and interior spaces such as rooms and furniture in LOD4. However, in CityGML 3.0, the LOD is no longer associated with the degree of semantics that allows the buildings to have thematic surfaces like *WallSurface* and *GroundSurface* can also be recognised in LODs 0 and 1. At the same time, windows and doors can be represented in all LODs from LODs 0 until 3.

4.2 3D Movable Asset Management using CityGML Approach

Previous study by (Mohd et. al, 2017), proposed the idea of maintaining and monitoring the heritage house using 3D modelling. The study proposed to use Application Domain Extension (ADE) of CityGML to create specific classes for heritage application. However, the study only propose the conceptual idea and not deeply discuss on the asset management of the heritage house. In this study, the CityGML approach is used to integrate and utilise the uses of GIS in asset management. The CityGML standard is an application-independent information model and exchange format for 3D geospatial data about objects like buildings or digital terrain models (DTM) (Gröger, Kolbe, Nagel, & Häfele, 2012); (Janecka, 2019). In addition, CityGML is an information model and exchange format that is not dependent on the application. As a result, different users can access the 3D city model using CityGML applications. Moreover, Figure 6 shows the application and schematic diagram of the CityGML database. Five (5) components are involved: Existing Datasets, Database Server, Desktop GIS, Web Services, and 3D Web Client. Then, with this component, the data processing workflow can be conducted.

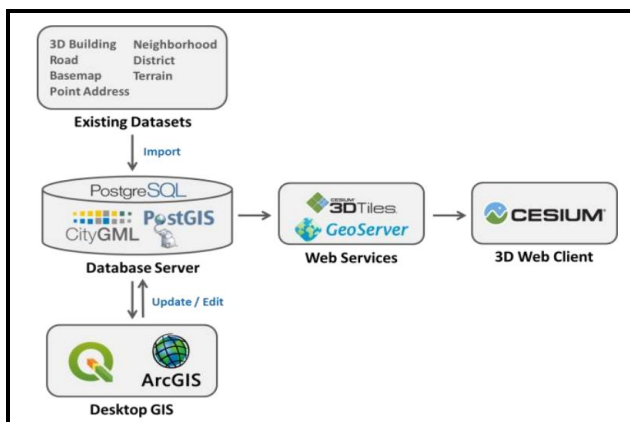


Figure 6: CityGML Schematic Diagram (Rahman et al., 2019).

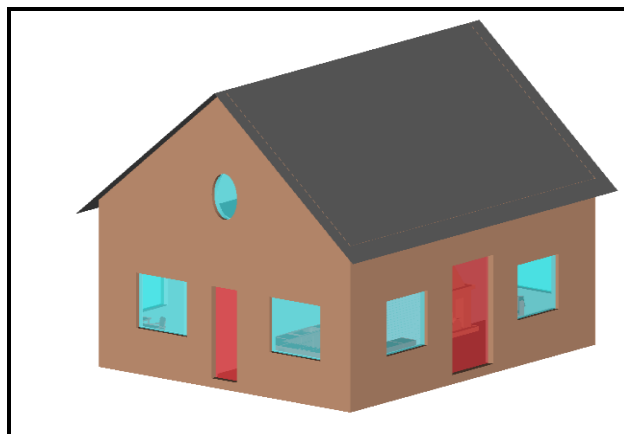


Figure 8: Exterior Building Model

4.3 Methodology

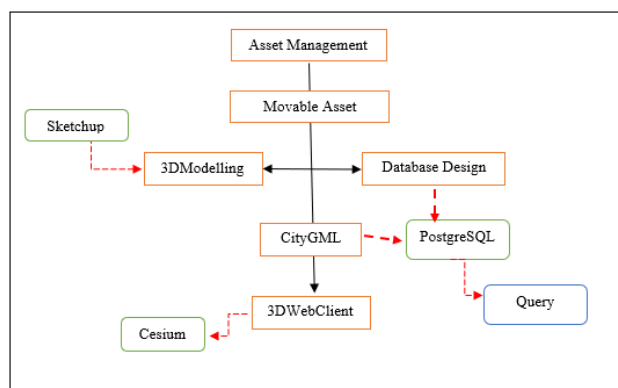


Figure 7: The Flowchart of Process involving Movable Asset Management.

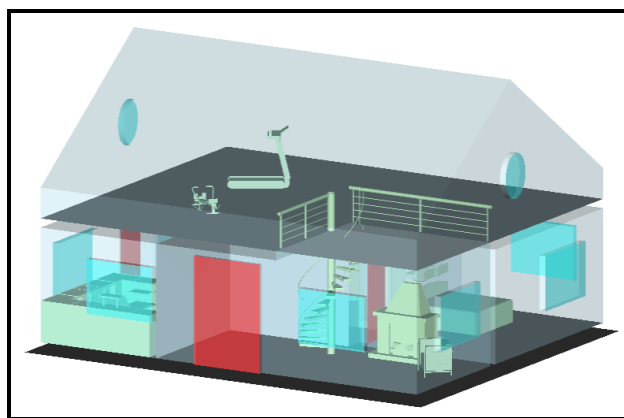


Figure 9: Interior Building Model

Figure 7 shows the method involved in conducting this study. The process involves a few phrases such as data acquisition, modelling, and analysis. In data acquisition, the data used is 3D building data that fulfils the requirement of movable asset management. This study uses no real-world data, but a self-generated building model. Moreover, the acquired data contains immovable asset management complexities that must be displayed following CityGML standards. Then, data modelling is where the 3D building model is generated. The building model is produced according to CityGML 3.0 standards. This is because CityGML 3.0 is the latest and newest CityGML approach that can support asset management. Figures 8 and 9 show the Exterior and Interior of Building 3D models in LOD4. Next, Data Analysis is the part where the 3D building model is being analysed for CityGML information. In this phase, the CityGML 3DCityDB application is being used. 3DCityDB is an application that stores, manages, imports, exports, and visualises 3D information and models.

Moreover, 3DCityDB is also being supported by PostgreSQL tools for database creation and connection. Moreover, CityGML-generated files imported into the CityGML database scheme enable more efficient management and querying of CityGML data (Janecka, 2019). Furthermore, the visualisation of the CityGML model using 3DWebClient can be explored.

5. RESULTS AND ANALYSIS

5.1 Visualisation of Movable Assets

An effective asset management system must include a maintenance management system that focuses on lowering maintenance costs while prolonging the asset's useful life (Khadim & Khushi, 2015). Thus, a study must be implemented to investigate the current asset management practice. Moreover, asset management is more than just knowing where your assets are; it also entails keeping track of their performance. Furthermore, it can be costly to hire enough people to cover all of your sites and assets if your assets are dispersed throughout a big area. (Srivastava, 2021). So, an implementation and data simulation can be conducted to investigate the asset management application. Much research on immovable asset management is being conducted, but only a few are being implemented. This happens because movable asset management involves a large scope of asset application and procedures, especially Government movable assets. In addition, organising and arranging all the assets can be difficult if done using manual methods (Srivastava, 2021). Thus, this study is conducted to modelling movable asset management using the CityGML approach. CityGML is an open-source application that can support smart city and asset management concepts. Figure 10 shows the result of CityGML 3D modelling. This CityGML 3D building model contains information regarding semantic properties that can related to movable asset management. The semantic properties that can be identifying are *WallSurface*,

GroundSurface, RoofSurface, CeilingSurface, ClosureSurface, Room, Wall, Door, BuildingInstallation and BuildingFurniture.

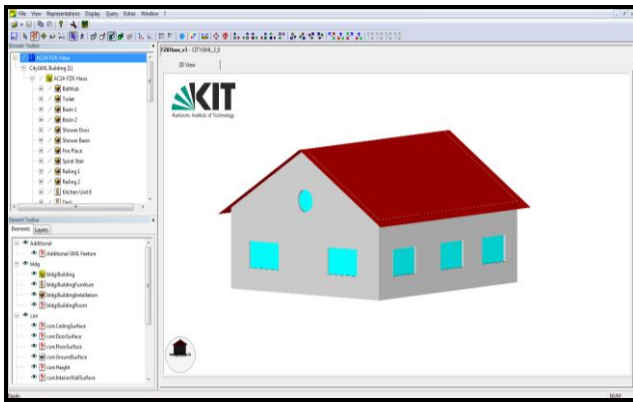


Figure 10: Building 3D Modelling in CityGML 3.0

This CityGML 3D Building is represented in CityGML 3.0. Furthermore, these datasets being portrayed in CityGML 3.0, particularly the 3D building model, needed to be imported into 3DCityDB applications. Moreover, Figure 11 shows the interior components of the 3D building model for the Movable Asset Management study. From the figure, two different types of assets can be identified. The Red colour represents the Movable Assets such as Cabinets, Chairs, Tables, and Gym instruments, while the Yellow represents the Immovable Assets such as Stair, Bathtub, Sink, and Shower Room. In the CityGML concept, both colours represent the difference between the *BuildingInstallation* and *BuildingFurniture*.

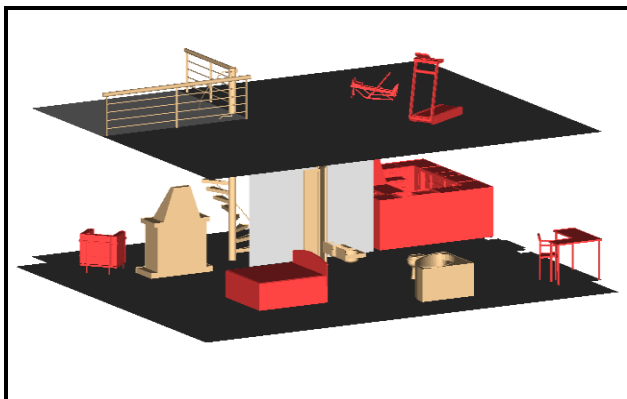


Figure 11. Building Interior Components.

5.2 Movable Asset Registration

During 3DCityDB processing, a database is created using PostgreSQL tools. PostgreSQL is an open-sourced database software that enhances relational database management systems (RDMS) with SQL Compliance (PostgreSQL, 2021). PostgreSQL is primarily used for data storage or data warehouse applications in web, mobile, geospatial, and analytics. Then, the database is linking and connected to 3DCityDB software as PostgreSQL acted as the database server for the CityGML application. After the database is created, the CityGML 3D model is being imported in the 3DCityDB tools for data store and management. Then, the information on the 3D Model is being portrayed in the PostgreSQL tools used which is

PgAdmin4. In PgAdmin4 tools, the movable asset being recognized by asset registration.

Asset registration is conducted to classify the asset identity and categories from different type of CityGML semantic properties. In CityGML properties, the 3D model is being displayed as *WallSurface, GroundSurface, RoofSurface, CeilingSurface, ClosureSurface, Room, Wall, Door, BuildingInstallation* and *BuildingFurniture*. This information does not represent the which one of these properties related to movable assets. Thus, asset registration in PostgreSQL help to identify this type of assets. The Figure 12 and 13 shows the Building Identification (ID) and Movable Asset information registration.

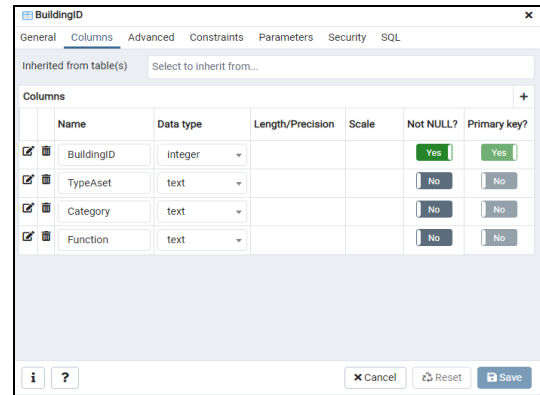


Figure 12. Building ID information

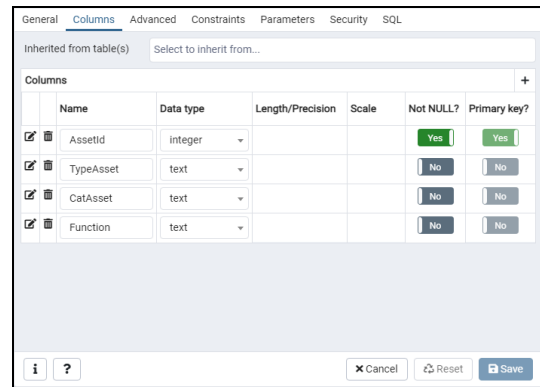


Figure 13. Movable Asset data information

So, with the asset registration the asset information such as asset id, asset category and asset function can be identify. This method is very useful to the users such as asset managers and officers in conducting asset management and maintenance. Moreover, asset register also help in fast data query and information retrieval regarding movable assets.

5.3 Movable Asset Information Retrieval

In addition, in this study, PostgreSQL is being used for spatial data and asset management queries. Figures 14 and 15 respectively show some simple queries being conducted to identifying movable asset information. The query and information retrieval are being conducted using PgAdmin4 tools of PostgreSQL. In PgAdmin 4, the query is conducted using SQL language search. Select and typing the information that need for the display and data retrieval.

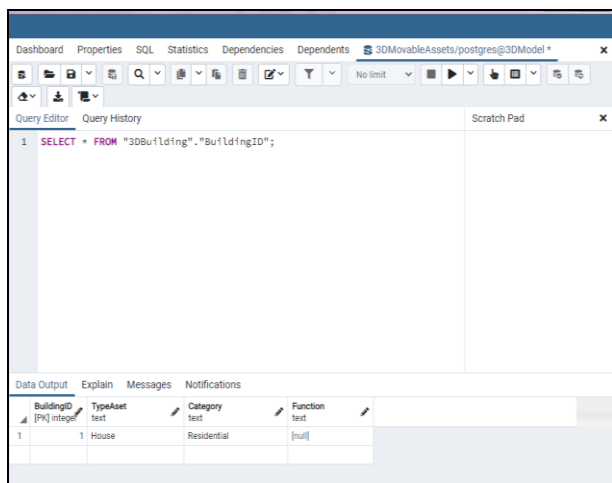


Figure 14. Simple Query about building model

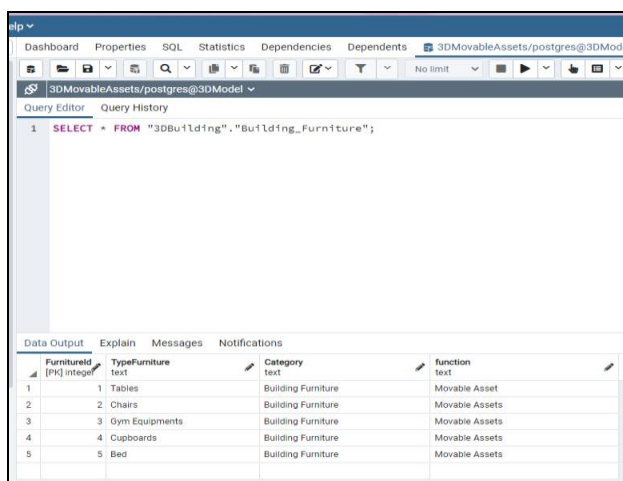


Figure 15. Query on asset information

Moreover, data such as AssetId, Asset Type, Asset Category, and Asset Function are the entities of asset information created. This function and information can help regarding spatial information of each asset and make the asset can be identified quickly and faster. Thus, the integration of this asset management with the CityGML application and approach may help in the process to measure and determining asset management plans, management, monitoring, or even maintenance. Furthermore, the study can be more expansive and advancing towards 3D visualization to improve the efficiency and effective asset management practices and implementation. In the CityGML approach, the 3D model can be visualized using CityGML 3DWebClient that integrates with Cesium web-based viewer. This method can produce a new idea and concept for movable asset management.

6. CONCLUSIONS

In conclusion, Smart City is an application integrated with the current urban management and monitoring technology. Moreover, recent technological development has moved human activities from the physical to the virtual world, such as online banking, e-commerce and more. Along with that, smart urban management is already moving toward smart operation. The Government and citizens needed to engage together to utilise

more efficient smart city applications. In urban or building management, decision making, improved transportation, and safer communication are the selected factors in a smart city. Moreover, 3D asset management is one of the applications that can help in smart city development

Nowadays, applications like environmental and training simulations, urban planning and facility management, disaster management and homeland security, and personal navigation require additional information about the city objects in a standardised representation (Kolbe, 2009). In a CityGML dataset, the same object may be represented in different LOD simultaneously, enabling the analysis and visualisation of the same object regarding different degrees of resolution. Furthermore, two CityGML data sets containing the same object in different LOD may be combined and integrated (Groger et al., 2012).

This paper describes movable asset management that can be used in the smart city application by integrating with the CityGML approach. The 3D building's LODs are developed in CityGML for better data management and analysis. The attributes of the LODs make asset management simpler and more cost-effective as they help manage, monitor, and maintain. Furthermore, the data-sharing information is improved with the CityGML 3D model format.

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