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The Role of Open Standards in Digital Building Permitting, 3D Registration of Condominium, and Update of 3D City Models

Dogus Guler*, Tahsin Yomralioglu

Department of Geomatics Engineering, Istanbul Technical University, 34469, Istanbul, Turkey (gulerdo, tahsin)@itu.edu.tr

*Corresponding author

Abstract

Digitalization is being adopted in many public services to increase the efficiencies of the required operations. Regarding this, there is an important interest in digitalizing the current building permit procedures since most of the buildings are designed digitally and as three-dimensional (3D). In addition, several countries are making an effort to realize the transition from two-dimensional (2D) cadastre to 3D cadastre. This is because 2D delineation of the legal rights may remain incapable to reflect the reality with respect to property ownership in multipartite buildings. The 3D city models should also be kept updated to effectively manage the occasions (e.g. natural disasters) and services (e.g. waterworks) in the living areas. In this sense, the open data standards (e.g. CityGML and Industry Foundation Classes (IFC)) have a vital role to enable interoperability between different domains such as Architecture, Engineering, and Construction (AEC) and Land Administration (LA). In this context, this chapter aims to show the current situation and opportunities on how to efficaciously benefit from open data standards for three significant issues. The issues can be listed as, 1) digitalizing the building permit procedures, 2) registering the condominium as 3D, and 3) updating the 3D city models. The examination in the chapter concerns the cases for Turkey.

Keywords: Digital Building Permit**,** Condominium Rights, 3D City Models, IFC, CityGML, LADM, IndoorGML, LandInfra

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Introduction

Thanks to the convergence between social, mobile, analytics, and cloud computing (SMAC) technologies, digitalization is an important agenda item in the policies and strategies of administrators from different levels. Digital government transformation is one of the primary goals of countries all around the world [1]. For example, European Union (EU) is carrying out projects that strengthen countries' abilities for e-government and digital public services [2]. Consequentially, it was first suggested officially to be used Building Information Models (BIMs) for building permit procedures [3] and recently announced that European Commission (EC) will develop an EU framework for digital permitting in the built environment [4]. This is because the digitalization and automation of building permitting, which is a significant public service, promise various benefits in terms of economy, transparency, and quickness. For instance, it is mentioned in a report that BIM-based digital building permitting that started to be used in Estonia will generate a profit of €500,000 in a year [5]. In light of this information, the European Network for Digital Building Permits (EUnet4DBP) that aims to provide a common strategy for the digitalization of building permit issuing was founded recently [6].

Managing the cities has become difficult owing to urban sprawl and the multilayered structure of buildings. In this connection, Geographic Information Systems (GIS) are vital due to their modeling and analysis capabilities with respect to the built environment. Furthermore, two-dimensional (2D)-based cadastral registration might be insufficient in the delineation of condominium rights and controlling the issues regarding ownership rights [7]. Therefore, with the proliferation of digitalization, there is a need for a three-dimensional (3D) city model to be able to be made the best decisions with regards to occasions in urban areas [8]. Similarly, it is also needed to benefit from 3D cadastre for better administration of lands and buildings [9]. Open standards, which might be a conceptual or data standard, are very crucial for making available 3D city model and 3D cadastre databases [10, 11]. In this context, this chapter as a whole focuses on how to benefit from open standards in the framework that integrates digital building permitting, update of the 3D city models, and 3D delineation of condominium rights. It was recently proposed for Turkey by the authors of this chapter [12]. This chapter also specifically concentrates on an integrated model that makes possible the 3D depiction of condominium rights in Turkey.

Current State in Turkey

In Turkey, there are several laws and regulations related to building permit issuing. Zoning Law (İmar Kanunu) mandates that building permit should be gotten to start new construction [13]. As a complementary to this law, Planned Areas Zoning Regulation (Planlı Alanlar İmar Yönetmeliği) describes the required conditions that should be met [14]. The authorities that are responsible for issuing the building permit should adhere to the rules regarding feedback time of permit application. For example, if some revisions are demanded in the permit application, the revised submission should be finalized by contact organization within thirty days. After getting the building permit, the firms can start the construction of the building. The buildings are also inspected by authorized building audit firms during construction to check whether the buildings are constructed in accordance with the content of the approved building permit. This issue is mandated in Law on Construction Inspection (Yapı Denetimi Hakkında Kanun) [15]. Once the construction of the building is completed, the firms should apply the authorized organizations to obtain an occupancy permit that allows the dwelling of residents and use of public infrastructure facilities such as electricity, natural gas, and water. There is also a similar rule for occupancy permit application in respect to feedback time of permit application.

Issuing the building permit requires to be controlled a wide variety of rules with respect to the design of the buildings; for example, the width of the entrance and elevator doors, the height of the buildings and floors, and availability of water tanks. Yet, the operations related to building permit issuing are generally carried out manually in Turkey [16]. Notwithstanding, the use of

IFC models of buildings in both building permit issuing and facility management took place in the newest strategy and action plans on the governmental level in Turkey [17]. Besides, it is mentioned in the latest strategic plan that facilitating the building permitting procedures is one of the significant objectives of the Ministry of Environment and Urbanization (MoEU) [18]. This means that the projects in relation to the digitalization of building permit issuing are very important and will be carried out possibly in the not-too-distant future.

The Turkey National Geographic Information System (TNGIS) project that is being carried out by the General Directorate of Geographic Information Systems (GDoGIS) provides application schemas in different themes (e.g., building, cadastre, and transportation networks) to ensure interoperability between organizations and stakeholders that use and produce spatial data in the country. The 11th Development Plan includes the achievement of the complete national spatial data infrastructure (SDI) for the whole country, which is the primary objective of the TNGIS project [19]. Furthermore, the e-Plan project that enables production and exchange of zoning plans in Geography Markup Language (GML)-based data standard was put into practice recently.

With regard to 3D city models and 3D registration of condominium rights, there is an ongoing, integrated project titled "3D City Models and Cadastre (3DCMC)", which is carried out by the General Directorate of Land Registry and Cadastre (GDoLRC) [20]. This project aims to create 3D spatial data models of cities, and 3D representation of ownership rights within buildings using these models with the aim of creating the 3D cadastral database. There is also another project that aims to provide 3D building models and city topography, which is carried out by the GDoGIS [21]. Producing the 3D city models is very significant and promising progress since these models will be helpful for applications that need 3D data and are directly related to managing cases in the cities; for example, emergency response. Turkey has a solid background in terms of land registry and cadastre. The digital cadastral database of the country is nearly completed thanks to numerous projects that aim to modernize and perform the cadastral operations electronically (e.g., sale). Currently, the registration of property rights is made as 2D even though there are different rights that are defined as 3D in the laws; for example, the right of superficies. In Turkey, Condominium Law is the main law on the registration of condominium rights [22]. There are also a couple of laws related to land registry and cadastre. Some of these laws are Land Registration Law, Cadastre Law, and Zoning Law.

Overview of the Relevant Standards

Land Administration Domain Model (LADM)

LADM is an International Organization for Standardization (ISO) standard containing a conceptual schema that provides an extensible basis for effective land administration and enables an ontology for communication between and within countries. The first version of the standard was published in 2012 and attracted a great deal of attention in numerous countries that aim to improve their land administration systems. LADM includes three packages (i.e., *Party*, *Administrative*, and *Spatial Unit*) and subpackage (i.e., *Surveying and Representation*) [23]. The second version of the standard will be published in the next couple of years and contain new packages related to land administration such as property valuation and spatial planning [24].

CityGML

CityGML is an Open Geospatial Consortium (OGC) standard that allows to model, store, and exchange of 3D city models [25]. The standard is widely used for a broad range of applications regarding cities, including energy demand estimation and visibility analysis [8]. The latest version of CityGML (2.0) was published in 2012, and the further development of the standard continued after that. Recently, it was announced that the new version of CityGML (3.0) is almost ready to be published, and the conceptual model and applicable GML schemas are shared publicly in GitHub [26]. The new version of the standard is developed such that it facilitates the integration with other international standards, namely Industry Foundation Classes (IFC), LADM, LandInfra, Infrastructure for Spatial Information in Europe (INSPIRE), and IndoorGML. The new *space* concept is used to depict the logical and physical spaces more accurately within cities and related objects. The *Building* (Figure 1), *Transportation*, and *Generics* modules are revised, and the *Construction* module is introduced as a new module alongside *Dynamizer*, *Versioning*, and *Pointcloud* [27]. Moreover, the interior of city objects can be represented as independent from the level of detail (LoD) by means of the revised LoD concept, which has now four LoDs as 0, 1, 2, and 3.

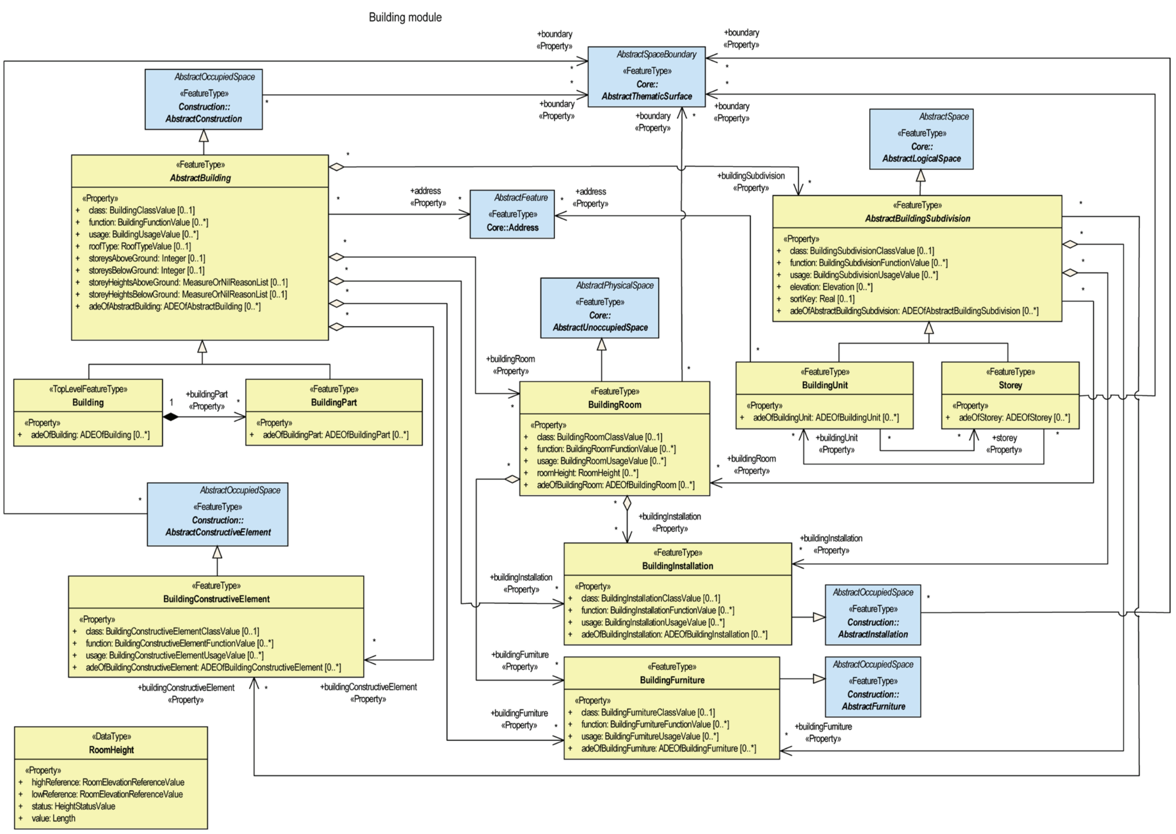

Fig 1. CityGML 3.0 *Building* module [28]

LandInfra/InfraGML

LandInfra and InfraGML are integrated OGC standards that are developed to support data-driven applications in relation to land and infrastructure activities. LandInfra and InfraGML are published in 2016 and have one version currently so that they are relatively new standards. The conceptual model of LandInfra has ten requirement classes as *LandInfra*, *Facility*, *Project*, *Alignment*, *Road*, *Railway*, *Survey*, *LandFeature*, *LandDivison*, and *Condominium*. InfraGML is developed for the GML-based implementation of LandInfra and has eight parts as *Core*, *Land Features*, *Facilities and Projects*, *Alignments*, *Roads*, *Railways*, *Survey*, and *Land Division* [29]. Since LandInfra holistically concentrates on modeling the built environment, it can take on the role of connector for GIS and BIM domains [30].

IndoorGML

IndoorGML was published as an OGC standard in 2014 with the intent of providing a common data schema that enables the modeling of indoor spaces for principally navigation purposes. The latest version of the standard (1.1) was published in late 2020. IndoorGML is developed by using the minimum number of features to prevent duplicates with features available in other related standards, namely CityGML, Keyhole Markup Language (KML), and IFC. Although these standards allow for 3D depiction of the inner and outer parts of buildings, they might be insufficient for indoor navigation. Therefore, IndoorGML provides required encoding features for spatial information in indoor navigation and is a complementary standard to these standards [31].

Industry Foundation Classes (IFC)

IFC is an ISO standard that provides data interoperability by codifying the identities, semantics, characteristics, attributes, relationships, objects, processes, and involved people for whole lifecycle stages, including planning, design, construction, and operation of buildings and civil infrastructures. The latest official version of the standard (i.e., IFC4 ADD2 TC1) was published in 2017 and there is a candidate version (i.e., IFC4.3 RC2) right now. As an open BIM standard, IFC allows for 3D modeling of a wide range of physical elements such as doors, slabs, walls, and windows [32].

How to Benefit from Open Data Standards

The works aiming to digitalize or automate the building permitting procedures are almost all based on the IFC standard. This is because BIM provides lots of semantic and spatial information regarding buildings and their different parts and is broadly adopted in the AEC industry. Using this information, numerous controls that are mandated in the laws and regulations can be done in the compliance checking phase of the building permitting. In this regard, there is a need for machine-readable rules to make these controls. Translating the rules manually is the first and widely used approach. The extensible markup language (XML) is one of the solutions that were investigated in previous studies. The natural language processing (NLP) techniques as a branch of artificial intelligence (AI) are also studied by different researchers with the aim of automating the conversion of rules to machine-readable format.

Recently, the integration of GIS and BIM, so-called GeoBIM, has gained importance in terms of digital building permitting since there are rules to be checked with respect to the built environment; for example, the availability of bicycle parks. Besides, zoning plans that are essential for building permitting are generally formatted with GIS-based data. There are studies in the literature that aim to carry out the building permitting by benefiting from the integrated GIS and BIM approach. This approach is also connected with the update of the 3D city model database because the as-built models of the buildings can be integrated into this database after the necessary conversions. IFC is the most widely used open data standard in the BIM domain and CityGML has a similar characteristic in the 3D-GIS domain. Due to the fact that 3D city models are created using CityGML in a widespread manner, the reuse of IFC data of constructed buildings was scrutinized in different countries; for example, Switzerland [33], Sweden [34], and Turkey [12].

LandInfra has an important potential to be used in building permitting since it is developed as encapsulating the applications in relation to BIM and GIS domains, particularly built environment. To benefit from this potential and extend the use of the LandInfra, researchers endeavor to augment its harmonization with other relevant standards such as CityGML [35]. IndoorGML is another important open standard in terms of the city and facility management and related to the update of 3D city models. This is because if these models are compatible with the IndoorGML, the applications that need up-to-date spatial data for accurate navigation in buildings can be put into practice readily.

3D registration of condominium rights, which is part of the 3D cadastre, is often researched in the literature since 2D-based delineation of ownership rights might be insufficient in detecting who owns or responsible for which parts of the multipartite buildings. The availability of 3D representation of ownership rights will be efficient for various land administration applications, for example, property valuation. Open standards are, of course, pivotal for realizing the 3D registration of condominium rights as they not only provide the integration between different organizations but also enable the interoperability for other processes that are needed the same data. In this connection, LADM is the first standard that comes to mind because it aims to provide a common language for land administration systems and supports 3D representation through boundary face and boundary face strings. Since standards like CityGML focus on 3D modeling of buildings more deeply, there are attempts that integrate the CityGML (2.0) and LADM by exploiting advantageous features of each of the standards for better depiction of ownership rights as 3D [36]. Moreover, the new version of CityGML will be more useful for 3D delineation of the condominium rights due to the revised *Building* module that permits the modeling of logical spaces. In addition to CityGML, IndoorGML was researched with the intent of 3D representation of ownership rights by linking with the LADM since it permits to model spaces in buildings [37]. These spaces can be represented as legal spaces.

Due to the fact that the increasing adaption of BIM in the AEC industry and IFC's ability for detailed 3D modeling of buildings and their parts, numerous studies investigated the use of BIM in the 3D representation of apartment rights. Whereas some of these studies use default IFC schema for modeling, some of them extend this schema by considering requirements in a specific country or jurisdiction [38]. There are also works that focus on integrating the IFC and LADM. LandInfra has a notable advantage for 3D representation of apartment rights because it contains a requirement class called *Condominium* that is developed for modeling condominium rights specifically.

Integrating the Standards for 3D Registration of Condominium Rights: The Case of Turkey

This section focuses on the 3D registration of condominium rights by integrating the relevant standards for the case of Turkey. The *Building* and *Cadastre* themes that are produced within the context of TNGIS describe the relationship between related features, namely parcel, building, building blocks, and condominiums [39]. These features are modeled such that they allow for integration with other standards such as CityGML and IndoorGML so as to enable the efficient reuse of spatial data in different applications. To enable better interoperability and 3D depiction of condominium rights, an integrated model is developed (Figure 2). The proposed features that are adapted from LADM permits the 3D representation of ownership rights. In other words, *BAUnit*, *SpatialUnit*, and *LegalSpaceBuildingUnit* are used to compose *RegistrationObject*, *SpatialUnit*, *Parcel3D*, *BuildingLegalSpace3D*, *BuildingCondominium3D*, *BuildingAnnexes3D*, and *BuildingCommonParts3D* features in the integrated model. According to Condominium Law in Turkey, there are annexes such as coal cellar and garage that are directly allotted to the independent section for use, and they are deemed to complementary parts of those independent sections. There are also common parts such as elevators, stairs, and walls that separate the independent sections. The annexes and common parts where specific independent section has the right of use can be modeled using *BuildingAnnexes3D* and *BuildingCommonParts3D*.

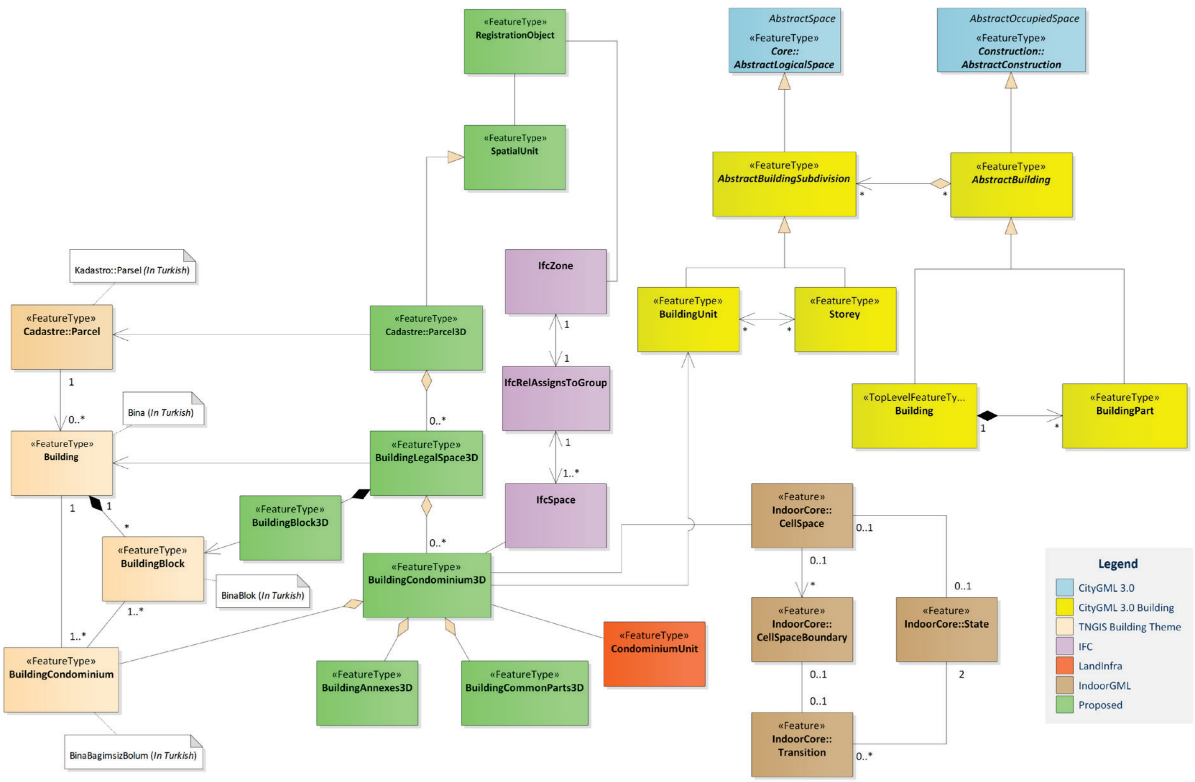

Fig 2. An integrated model for 3D registration of condominium rights

As can be seen from Figure 2, proposed features are linked with the IFC entities, namely *IfcZone*, *IfcRelAssignsToGroup*, and *IfcSpace* to provide integration with IFC. The approach that uses these entities is adapted from previous studies [40, 41]. Whereas *IfcZone* is linked with the *RegistrationObject* to represent basic administrative units, *IfcSpace* is linked with the *BuildingCondominium3D* to delineate the legal spaces related to condominium rights. It can thus be said that spatial data that will be produced based on the proposed model can be integrated with IFC data. Another important integration is provided with CityGML. As mentioned in the previous section of this chapter, the new version of CityGML will allow modeling of logical spaces more easily through *AbstractBuildingSubdivison* and its subclasses *BuildingUnit* and *Storey*. As shown in Figure 2, *BuildingUnit* is linked with the *BuildingCondominium3D* feature, and hence the integration with CityGML data is provided. It can be mentioned that *BuildingCondominium3D* corresponds to the *LegalSpaceBuildingUnit* feature of LADM. Linking the *BuildingUnit* and *LegalSpaceBuildingUnit* features was implemented in a previous study [42], so this approach is also applied in the proposed integrated model. As highlighted in the definition document of the *Building* theme, the integration of spatial data that is produced based on the data schemas within TNGIS, with other international standards such as IndoorGML is highly crucial in terms of efficiency of national SDI. For this reason, the proposed model incorporates the integration with IndoorGML by means of the link between *BuildingCondominium3D* and *CellSpace* features. Using IndoorGML for 3D representation of ownership rights was investigated by different researchers. Whereas some of the researchers link LADM and IndoorGML [37], some of them proposed a new model that includes new features, namely *IndoorSpace* and can be integrated with *CellSpace*, *CellSpaceBoundary*, *Transition*, and *State* features of IndoorGML [41]. All of these researchers used the connection between *SpatialUnit*, including its subclass *LegalSpaceBuildingUnit*, and *CellSpace* features. That is why the proposed model in this chapter utilizes a similar approach. The *Condominium* class of LandInfra, which is based on the previously proposed CityGML ADE for taxation processes in Turkey [43], is linked with the *BuildingCondominium3D* feature. By this means, the connection with the LandInfra is also enabled in the proposed integrated model.

Discussion

Due to fact of the inevitable proliferation of digitalization, the processes related to land and city management need to be accomplished more digitally and fast. There is an important potential to be practiced building permit issuing, as one of the important public services, in the sense of improvement and automation of the process. Open data standards have a quite crucial role in realizing this potential. This is because these standards enable the standardization of information flow between designers and organizations that are responsible for compliance checking. In other words, applicants can prepare their submissions according to required information for building permit issuing. For example, Information Delivery Manual (IDM) [44], which is an ISO standard developed by the buildingSMART, can be used to provide interoperability on information communication between different stakeholders in building permit issuing that comprises obtaining the occupancy permit in Turkey. The adaptation of BIM is increasing in Turkey day by day and consequently, there are more IFC data available pertaining to buildings. This is of importance with regards to creating the Building Information Repository (BIR) where the IFC data of all buildings in the country are stored. This repository not only can enable efficient facility management after the construction phase but also provides a substantial database where the data can be converted to different spatial data standards (e.g., CityGML and IndoorGML) for further use by urban and land administrators.

Some countries such as Singapore have very developed systems for digital building permit issuing. They started to use and integrate BIMs into building permitting a long time ago. Thus, both the AEC industry and governmental organizations could adopt digital building permitting. It is important to note that the governing structure and size of the countries are highly effective in the digitalization of building permit procedures. To clarify, some countries deal with more than 100,000 building permits in a year, and therefore the transition to digital building permit requires a lot of effort. Besides, whereas some countries have a central submission system and common rules and regulations with regards to building permitting, some of them have separate systems and different rules and regulations due to the availability of distinct administrative units such as cantons and municipalities. In Turkey, there are 81 city municipalities, and these municipalities can have different zoning regulations on the condition that these plans are compatible with Planned Areas Zoning Regulation. There are a few academic studies that focus on the automation of compliance checking and implement a case study for Turkey. For example, [45] proposed a model for representing the building codes in a machine-readable format and evaluated their model using the zoning regulation of Izmir city. It is obvious that more research studies that concentrate on digitalization and automation of building permit issuing in Turkey will be helpful to be put into practice the goals in the governmental strategy plans. Moreover, the collaboration between academia and governmental bodies can avail to enabling the digitalization of building permitting in Turkey since it is needed to reveal the current state in terms of real-world applications that are carried by authorized agencies. This issue is important because compliance checking is highly related to the interpretation of rules and regulations.

There is a strong interrelation between digital building permitting and the update of 3D city models because if the as-built IFC data of buildings are available, these data can be converted to CityGML, and thus the 3D city model database can be kept up-to-date. In addition to this, an up-to-date 3D city model database can be used for digital building permitting as there is a need for built environment data for integrated and comprehensive compliance checking. For example, rules with respect to infrastructure facilities can be checked using 3D city models. In Turkey, governmental bodies are cognizant of the fact that 3D city models are needed for better management of urban areas. This can be understood from the latest strategic plans and carried projects (e.g., 3DCMC). The important point here is to keep up-to-date the 3D city model database. To achieve this, the framework that associates digital building permitting with updating the 3D city models and benefits from open data standards (e.g., IFC) can be useful for projects that are planned to carry out. It should be noted that the conversion and georeferencing issues between CityGML and IFC are still being investigated to achieve lossless transformation [46].

3D registration of condominium rights is researched all around the world since current land administration systems need to be upgraded to having 3D spatial data management capabilities. This issue is much important to fulfill the requirements of today's societies that are highly complex because of societal, economic, and environmental occasions. Similarly, Turkey aims to have 3D cadastre in the near future by benefiting from holding long-established organization and quite experience regarding land registry and cadastre. Open standards are effective to be successful in practicing the 3D cadastre. Therefore, countries aim to establish or upgrade their land administration systems based on these standards. With the increasing trend in BIM, there are proposed approaches that use the IFC schema for 3D delineation of apartment rights in multipartite buildings. In parallel, this chapter concentrates on a model that provides the integration with IFC data in the 3D representation of condominium rights in Turkey. The misinterpretations regarding who is responsible or owns of which parts of the buildings can be prevented using the IFC-based depiction of ownership rights [47]. The semantic information pertaining to independent sections can be queried using the produced IFC-based models. These models will also be quite helpful for property valuation applications in Turkey that exploit 3D variables such as size, volume, position, and material quantities since they provide very detailed information on indoor parts of the buildings. 3D property valuation approach that benefits from GeoBIM was recently investigated by El Yamani et al. [48]. Also, there is an important potential to serve and visualize created 3D models in a web platform thanks to the 3D JavaScript libraries [49].

Conclusion

This chapter presents an examination on the usability of open standards for the framework that contains digital building permitting, update of 3D city models, and 3D presentation of apartment rights. Particularly, it proposes an integrated model for the 3D delineation of condominium rights in Turkey. It can be underlined that open standards provide a common basis, and countries can develop their model that fulfills the requirements specific to the country. However, further investigation is needed to show the applicability of the proposed model as it is a conceptual model. For this reason, near-future work will include modeling the condominium rights as 3D by benefiting from the IFC schema and integrating these models with features within the proposed model.

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