www.itcon.org - Journal of Information Technology in Construction - ISSN 1874-4753

FROM BUILDING INFORMATION MODELING TO CITY INFORMATION MODELING

SUBMITTED: December 2013
REVISED: April 2014
PUBLISHED: September 2014 at http://www.itcon.org/2014/17
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SUMMARY: *With the development of Geographic Information System (GIS), the concept of digital city is implemented widely. However, in practice, most of the GIS models are relatively poorly attributed, semantically. Building Information Modeling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of building, which is most used in small scale projects. In order to address the target problem of completing the semantic attribution of 3D digital city model, a framework of integrating BIM technology into GIS is demonstrated. A new concept of city information modeling (CIM) is proposed with the goal of bringing great benefits to the urban construction and city management. The composition of city information model is discussed. The data schema behind BIM and GIS (i.e. IFC and CityGML) are compared and mapped with each other. A case study of land planning of campus is demonstrated to present the potential benefits of CIM.*

KEYWORDS: *City information modeling, BIM, GIS, IFC, CityGML, Semantic mapping*

REFERENCE: *Xun Xu, Lieyun Ding, Hanbin Luo, Ling Ma (2014).* From building information modeling to city information modeling, *Journal of Information Technology in Construction (ITcon), Special Issue BIM Cloud-Based Technology in the AEC Sector: Present Status and Future Trends, Vol. 19, pg. 292-307, http://www.itcon.org/2014/17*

1 INTRODUCTION

In recent years, 3D city models have developed so fast that 3D city models have to meet different requirements of clients. A characteristic of some of the recent applications of 3D models is that their effectiveness depends not so much on visualization, but upon good quality annotation and attribution of the features of the model so that this information can be associated with images displayed or described to the user. In practice however most of the 3D models currently available are relatively poorly attributed, semantically (Stadler and Kolbe, 2007). 3D city model is a concept derived from DE (digital earth), there have been some great attempts. In a 3D city model, there are data supported models representing the city's surface and its related spatial objects in this city. In existed 3D city model, models can be divided into design models and real world models. Design models are the models made by engineers and they are designed to fulfill the needs of AEC industry and in this extent, these models are designed to represent the maximum level of detail of the geometric representation. As to real world models, they are mostly representing the existing objects in the form of geospatial information systems. They are mostly represented in the Geographic Information Systems (GIS) world (de Laat and van Berlo, 2011).

Most of the effort in the 3D city modelling area, including Web services, focuses on representing graphical or geometrical models; however semantic and topological aspects are often overlooked (Brenner and Haala et al., 2001). Nowadays our cities are witnessing the unprecedented urbanized construction scale, along with the increasingly scarce land resources; city continues to develop into comprehensive three-dimensional space utilization from height and depth. In addition to building construction, a large number of urban infrastructure projects, such as integrated transport hub and underground transportation hub have been increased from day to day. These infrastructures are dispersed in different sectors and areas, resulting in a lot of problems such as the sunshine calculation, landscape indivisibility, underground tube network management, underground space management and so on, which can't be solved only relying on the two-dimensional plane data. Therefore, the development of 3D city model is imperative. The current digital city model is an urban digital information model, which based on urban infrastructure geospatial data by making use of GIS technology. Currently, lots of researchers have paid their attention to the development of 3D city modelling, for that it is acting more and more important in some applications such as urban planning, land use management, traffic administration and so on (Benner and Geiger et al., 2005). While 3D city is in using, lot of problems have been exposed, the most serious one is the information sharing between different specifics, so it is very urgent to set relevant standards and norms as guidelines for construction of digital city and authoritative, scientific data support for decision-making in city planning.

In this paper we proposed a new thinking of 3D digital city. We try to build a semantic information rich model for the city. In order to address the target problem of completing the semantic attribution of 3D digital city model, lots of data enriching attempts have been done such as OpenStreetMaps (Goetz, 2013). Considering the shortages in information expression of these methods, BIM modeling can support the detailed semantic of building parts or other city function parts (Azhar, 2011). BIM-tech can store the designing information in the database in digital form for timely updating and sharing. It can also set up a real-time and conforming relationship between data so as to present a relative phenomenon when any data changed. BIM can guarantee the efficiency and qualification of the projects. While the BIM application is limited in the building field, it does not involve the transportation and other fields, and it cannot represent the geospatial information. GIS is also widely used in 3D information modeling, most of the information of GIS can be acquired by laser scanning, so it has the advantage of rapid modeling, it can build the surface model of city quickly. But when it comes to the Internal modeling, GIS has to represent the material by chartless. Based on this situation, we try to integrate BIM and GIS to provide an effective solution for city information modeling (CIM).

2 CITY INFORMATION MODELING

The city environment is very complicated, which includes not only static model, but also dynamic objects. In addition, the people, company, organization, and transportation also have to be taken into consideration. A large amount of information has been produced, which is dazzling but useful for us if it was put to good use. In the age of information explosion, it is important to sort through masses of sources and sort out the needed. In order to effectively extract useful data from massive information, we should organize this information orderly first. CIM is put forward as a useful method to organize the city information.

2.1 The structure of CIM

In this paper, we divide the city system into several sub-modules: buildings section, roads section, piles section, drainage section etc. Use BIM-tech to build these parts into information models, and then use GIS-tech to locate every part of city.

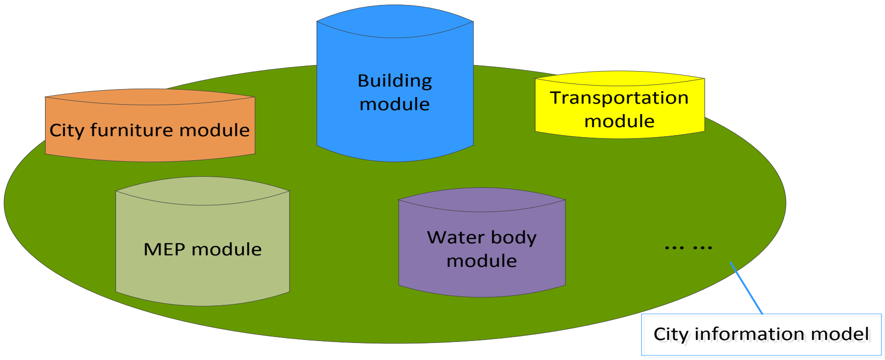

Figure 1: Sub-module of city information model

- Building module

As we all know, in a big city, the buildings have their own characters: buildings in the same period are of the same architectural style and structure, and in different period, the building information is stored in different ways. Contra pose the phenomenon mentioned above, we need use different methods to collect the building information. For example, building in recent years have a complete building information stored in CAD or Revit formats, so we can put it directly into our city building information model; as to the old buildings, we cannot find their design drawings or other information, we could use rapid scanning technologies to get inside and outside information of buildings. After the work has been done, we will get a complete city buildings information model. This model contains building information such as exteriors, materials, structures, etc.(Chapin, 1970).

- Transportation module

This part contains the roads information such as the length, the trend, the cost, etc. Based on the former buildings' position, we can also locate the city's roads or traffic system in the city. In the city traffic information model, real-time road monitoring, vehicle positioning, traffic management and routes consulting would be realized.

- City furniture module

This part contains the ancillary facilities of the city, such as public garden, public utilities, etc. These ancillary facilities play an important role in people's life, it can provide entertainment and rest rooms for people, and it also can bring many conveniences to people. Collecting the information of the ancillary facilities can make it easier for the government to management and provide a better life for the residents.

- MEP module

For the past few years, BIM-tech has been penetrate into construction industry, in order to make the whole construction information modeling integrated, BIM-tech should also be introduced into MEP system. Revit MEP has done a good work in this part; it contains the HVAC system, the underground piping system, the electric lighting and circuit system. Using Revit MEP can provide us a model of segmental information. Other information can be acquired by using RFID and GIS. For example, the piles and drainages section information model building can be separated into four stages.

1) Piles and drainages information standardization.

Piles and drainages model involves multiple industries, so it is a complex information system. When integrating information from different collecting techniques, IFC should be the information exchanging standard to guarantee the accuracy and unity of information.

2) Building an information exchanging and write-in access.

Under the guideline of IFC, we need to develop an information exchanging and write-in access for information updating and other information that we couldn't get from the existing methods.

3) Piles and drainages information aggregation.

Some piles and drainages projects were finished lately, so we can get the information from project completion data. While some projects were too old that the completion data was lost, we could using RFID or GIS to collect information under this situation.

4) Setting up a dynamic update mechanism.

We can set up a dynamic mechanism to realize MEP management and data timely updating.

- Water body module

This part contains the water body of the city, such as river, lake, sea, etc. As we all know, water play an important role in our life, but the water pollution is a serious problem, and the water can be used by us is becoming less and less, on the other hand, the water body is also important for the ecosystem. Collecting of this information makes it possible for us to make good use of water.

There are some elements have not been taken into consideration, such as the city refuse disposal system. On the one hand some of these systems cannot be built in models using the existed methods, as the city model has an access for information writing in and city model has a IFC standard, so when the needed information could be collected, it can be easily wrote in. On the other hand, some of these models can be got from existed methods, so the information needed can be easily imported into the city information model.

2.2 The construction of CIM

One of the major difficulties in CIM is the information modeling, which need both the outdoor information and the indoor information. There are some possible approaches may be used to solve this problem, one is to measure existing objects and construct 3D models, but it needs a lot of work; the second approach is to integrate CAD models and GIS models, but this method cannot provide the indoor information; the third is to obtain the obtain the indoor information from the existing BIM models and obtain the outdoor information form the GIS models which can be combined with different techniques such as 3D laser scanning and photo grammetry. Among these, the third one is the most feasible method. What we need to do is try to integrate BIM and GIS automatically.

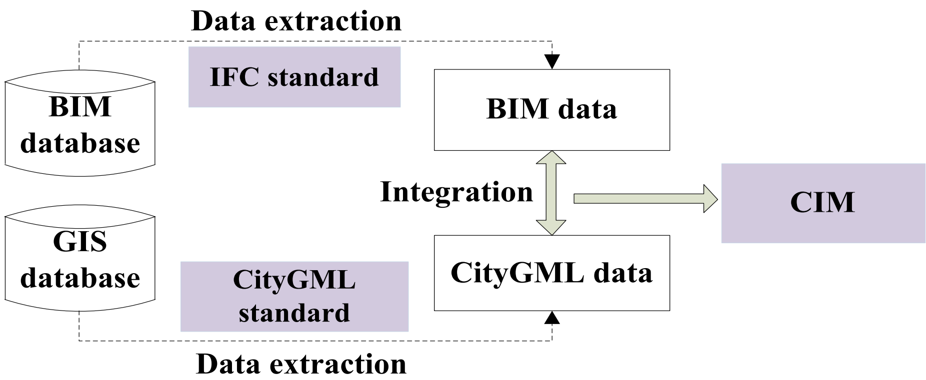

Figure 2: The data collecting of CIM

3 THE KEY TECHNOLOGY OF CIM -- INTEGRATION OF BIM AND GIS

The BIM model and GIS model are quite different, and both worlds have special strengths (Irizarry and Karan et al., 2013). The integration of BIM and GIS will be of great significance. In order to integrate them, we analyzed their respective characteristics, and then put forward a methodology for integration.

3.1 Semantic and geometric information

Most of the existing 3D city models focus on the geometric information of the city; these models can be applied in many areas, but they cannot be used for visualization and simulation because lacking of semantic information.

More detailed and semantic rich models are needed (Wang and Love et al., 2013).
Geometric model uses spatial objects, such as points, lines and surface, to define the geometric objects and elements types and represent their properties. While semantic model use class definitions for the representation of spatial objects within the virtual 3D city models to defines entities and their non-spatial characteristics and relationships among the entities (Stadler and Kolbe, 2007). BIM and GIS are seen as means for building 3D city models. Many geometric models have been developed, while the number of semantic models is relatively few. IFC（Industry Foundation Classes）and cityGML（City Geography Markup Language）are the two most prominent semantic models in digital city(Isikdag and Zlatanova, 2009).

GIS is mostly used to model spatial objects that already exist in urban and regional areas. Most of the CityGML data come from laser scanning data, aerial Images and cadastral data while the IFC data come from the model built by engineers, it is much easier to collect cityGML data than collect IFC data (Kolbe and Gröger et al., 2005). Their main purpose was to define the urban and regional scale and geospatial without focus much on details, it use the methods of sweeping and boundary representation (BRep) to represent building parts and spatial objects. BIM is good at details, but not has been used for other fields. We think the BIM and GIS world can create strong synergy.

In consideration of these problems, we take the CIM as solution, which absorbs the advantage of BIM and GIS. In CIM, what we get from the GIS-tech is the city’s geospatial information including space, latitude, and longitude. The detailed information can be acquired from BIM.

3.2 IFC and cityGML

3.2.1 The framework of IFC and cityGML

IFC is the key standard of BIM, which aims to define a common language for technology to allow the communication and delivery throughout the lifecycle of buildings, and share information models with other participants. The IFC is object-oriented data model, it has defined about 900 classes，with 60 to 70 classes has the similar semantic representation to cityGML. The IFC schema is layered and modular, it was divided into four layers, and each layer contains several modules with many classes (Kolbe and Nagel et al., 2009). The framework of IFC is shown in Figure 3.

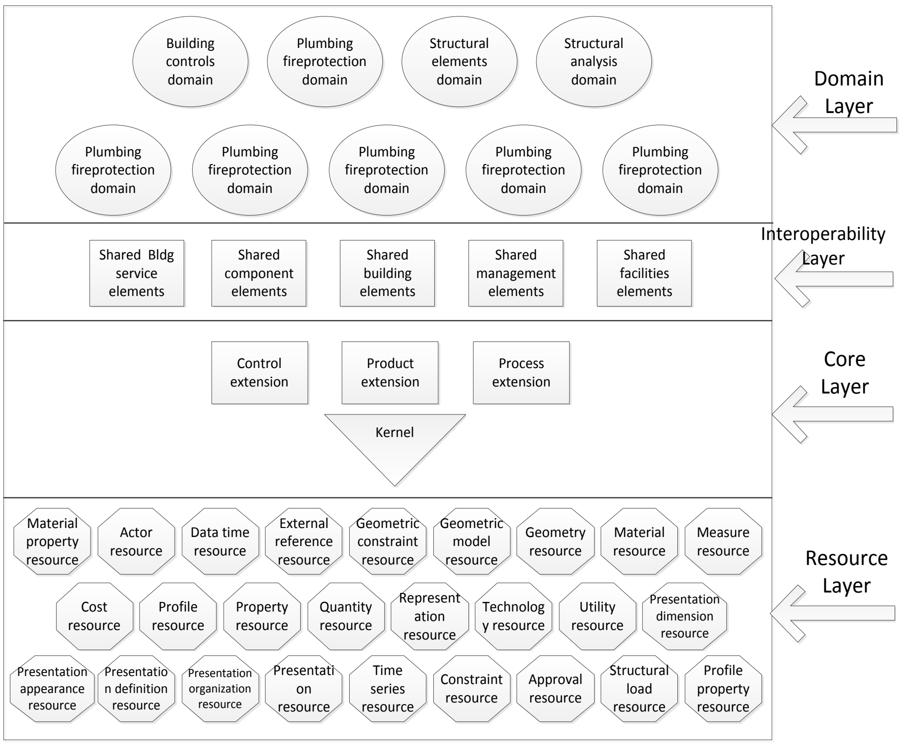

Figure 3: IFC schema

CityGML is a generic information standard for 3D city models, including GIS model (Kolbe and Nagel et al., 2009). CityGML represent elements with modularize information, the whole cityGML file was consist of 12 modules, 11 thematic modules and one core module which is the foundation of the other modules and it defines the basic concept and element of data model, as shown in table 1.

Table 1: The module of cityGML

CityGML module	Description
Core	The basic structure of the data model
Appearance	Providing the model display method for cityGML objects
Building	Providing a semantic and spatial description of building, building local and building installation
CityFurniture	Description of city furniture
CityObjectGroup	Providing a grouping rule for cityGML data
Relief	Description of surface model of the city
Transportation	Description of the transport feature of the city
Vegetation	Description of the vegetation of the city
WaterBody	Description of the water system of the city
TexturedSurface	Providing visibility property and texture of the surface of 3D models, such as color, light and transparency, this module can be merged with appearance module
LandUse	Description of land use
Generics	Extending the data model of cityGML, allowing adding new property and elements

The relationship between IFC and cityGML is shown in Figure 4.

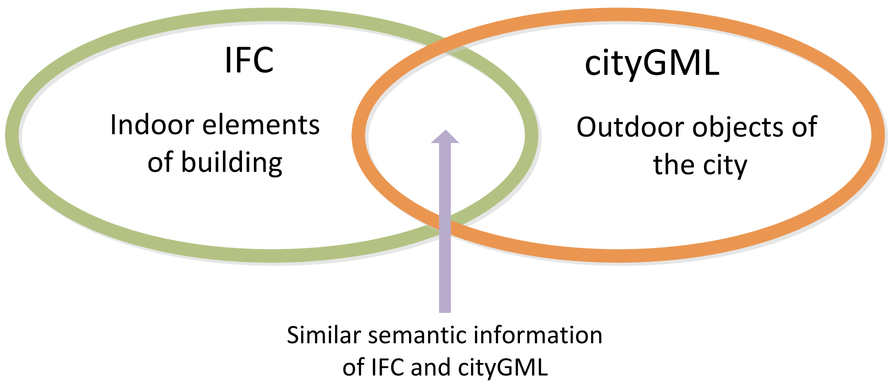

Figure 4: The relationship between IFC and cityGML

3.2.2 The structure of cityGML file

Not all the modules will be included in one model, as we can see in figure 5, this CityGML data set including the following feature types: Land Use, City Furniture, Vegetation, Transportation, Building and Relief. In addition, building object is modeled on the basis of five sub-modules.

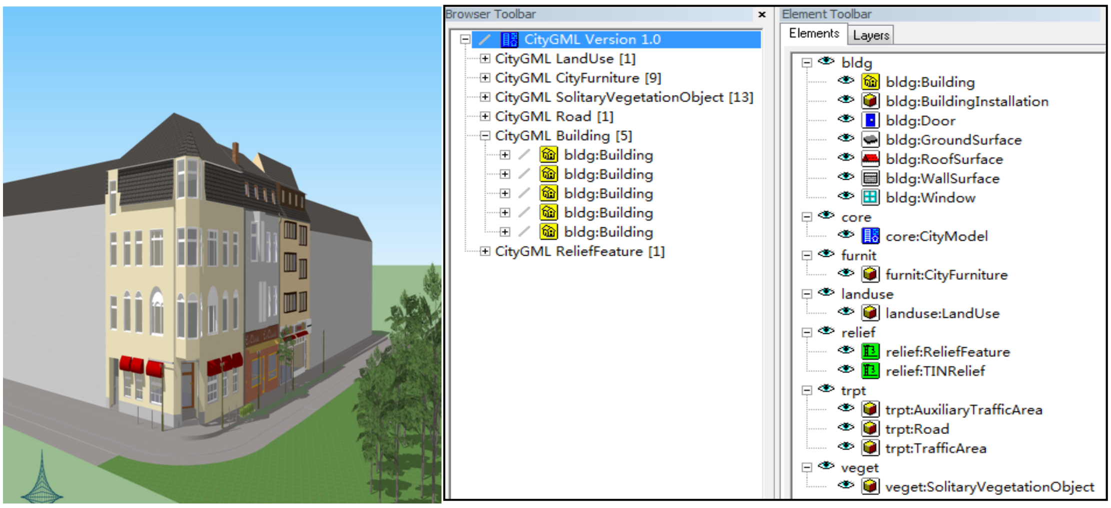

Figure 5: The cityGML data set

The cityGML file is quite different from the IFC file, following is the head file of the cityGML model, which has defined the XML specification version and the character set of the cityGML file, and has defined the dimension of the model and the coordinate range of the model.

```
<core:CityModel
xmlns="http://www.opengis.net/citygml/profiles/base/1.0" xmlns:core="http://www.opengis.net/citygml/1.0" xmlns:bldg="http://www.opengis.net/citygml/building/1.0"
xmlns:grp="http://www.opengis.net/citygml/cityobjectgroup/1.0"
...
...
xsi:schemaLocation="http://www.opengis.net/citygml/1.0 http://schemas.opengis.net/citygml/1.0/cityGMLBase.xsd
...
...
http://schemas.opengis.net/citygml/relief/1.0/relief.xsd">
<gml:boundedBy>
    <gml:Envelope srsDimension="3" srsName="urn:ogc:def:crs,crs:EPSG:31467">
        <gml:lowerCorner>3499943.625415 5399989.574138 0.0</gml:lowerCorner>
        <gml:upperCorner>3500026.358571 5400069.880516 20.0</gml:upperCorner>
    </gml:Envelope>
 </gml:boundedBy>
```

The entity information will be described next. Different elements were capsulated, the information of each element can be extracted separately. Following is the example of road in the cityGML file, which has two levels in detail. The data set also includes a Road object that consists of various TrafficArea as well as AuxiliaryTrafficArea features.

```
<core:cityObjectMember>
<tran:Road gml:id="GMLID_3260444_166090_1429">
<tran:function>1050</tran:function>
<tran:trafficArea>
<tran:TrafficArea>
<tran:function>1</tran:function>
<tran:lod2MultiSurface>
<gml:MultiSurface>
<gml:surfaceMember>
<gml:Polygon gml:id="PolyID1_1033_428609_389294">
```

```
<gml:exterior>
<gml:LinearRing gml:id="PolyID1_1033_428609_389294_0">
<gml:pos>3500000.0 5399998.5 -0.200000000000069</gml:pos>
...
...
</gml:LinearRing>
</gml:exterior>
</gml:Polygon>
</gml:surfaceMember>
</gml:MultiSurface>
</tran:lod2MultiSurface>
<tran:lod3MultiSurface>...
<gml:MultiSurface>
<gml:surfaceMember>
<gml:Polygon gml:id="PolyID180_1440_279791_269221">
<gml:exterior>
<gml:LinearRing gml:id="PolyID180_1440_279791_269221_0">
<gml:pos>3500004.17334187 5400018.15311966 -0.0999999769476025</gml:pos>
<gml:pos>3500004.17334187 5400015.98311966 -0.0999999769476025</gml:pos>
<gml:pos>3500004.65334187 5400015.98311966 -0.0999999769476025</gml:pos>
<gml:pos>3500004.65334187 5400018.15311966 -0.0999999769476025</gml:pos>
<gml:pos>3500004.17334187 5400018.15311966 -0.0999999769476025</gml:pos>
</gml:LinearRing>
</gml:exterior>
</gml:Polygon>
</gml:surfaceMember>
</tran:lod3MultiSurface>
</tran:AuxiliaryTrafficArea>
</tran:auxiliaryTrafficArea>
</tran:Road>
</core:cityObjectMember>
```


3.3 Current approach for integration of IFC and CityGML

3.3.1 IFG

IFG is a project that aims to use IFC and GML (Geography Markup Language) to exchange the information between GIS and CAD, which was one of the first efforts for the integration of IFC and GIS. Firstly, it identified all the IFC entities that might support GIS applications, then mapping these entities to GML. The IFG project has created a mapping specification for the exchange of IFC to GML.

3.3.2 3D conversion

The Technical University of Berlin has proposed a 3D conversion framework for integration of IFC and cityGML. The framework contains two steps as following:

1) Gathering existing 3D graphic models and integrated spatio-semantic data with them to build cityGML models.
2) Converting cityGML models to IFC models based on the similar concepts of IFC and cityGML(Benner and Geiger et al., 2005; Isikdag and Zlatanova, 2009).

3.3.3 Conversion of IFC to cityGML

A research has been conducted by Research Centre Karlsruhe and Hochschule Karlsruhe develop an algorithm to make it possible to automated transforms IFC models into cityGML models. But it can only realize on LOD1 and LOD2 of cityGML.

3.3.4 FME (feature manipulation engine)

FME is a kind of spatial information extracting, transformation, and integration solution used by Safe Software Inc., which provides consulting services for people to exchange data of different formats. CityGML can read and write through the FME platform.

3.3.5 Generation of buildings in GIS using IFC

Isikdag and Zlatanova (2009b) have built a framework for conversion of IFC to cityGML automatically. The main point was to transform semantic and geometric information, which has provided a new method for integration of IFC and cityGML, while some problems remain unsettled. Mapping between the two models may be difficult because one object may have different name in two models, for example, in order to build a model in LOD1, the facade information can be got from both IfcWall and IfcSlab entities.

3.4 A framework for integration of cityGML and IFC

The key point of integration of BIM and GIS is to integrate IFC and cityGML. The existing approaches mentioned above have made many contributions to the integration of IFC and cityGML. However, they only build a framework for unidirectional transformation. El-Mekawy has proposed a unified model-based approach to allow the interoperability of IFC and cityGML; it tries to build a unified building model (UBM) to allow capturing information from both cityGML and IFC models(El-Mekawy, 2010). The UBM has laid a foundation for the interoperability of IFC and cityGML, which allows the bidirectional conversion. While the UBM has some limitation:

1) The UBM is a two-stage method in which the cityGML models are converted to UBM, and then is converted to the IFC models, and vice versa. The UBM is act as intermediate to allow the conversion between the IFC and cityGML model, while it does not describe how to integrate and manage information obtained from both IFC and cityGML models.
2) The semantic mapping is not demonstrated in the UBM, which needs to be improved.

Therefore, this paper tries to build a city information model (CIM) based on the UBM, the CIM do more than just integrate the IFC and cityGML, but aims to build a semantic rich and geometric rich information model for urban planning. In addition, the semantic mapping was defined in this paper.

3.4.1 Classification of cityGML and IFC

Both IFC and cityGML have their own domain classification, while their criteria are quite different, and the cityGML contains much more fields. When we transform the cityGML model into the IFC model, only the building module can be mapped to the IFC module directly, the other module was seen as proxy element and the model changed a lot because many information was lost, as shown in figure 6. Compared to Figure 5, the road, city furniture, vegetation has change a lot, only the building remain almost the same, even though the color has changed， most of the parts keep the same.

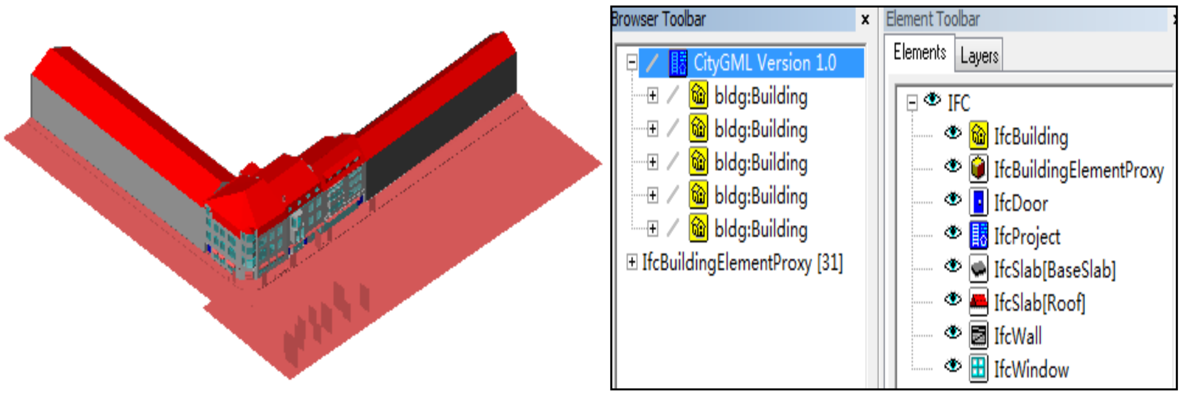

Figure 6: The IFC model transformed from the cityGML

In order to solve this problem, we think first we should unify the classification rule of IFC and cityGML according to the function of the city. This part divided the IFC and cityGML into 5 classes according to the sub-module of city, which is building, transportation, city furniture, MEP and HVAC, and water body. It also defined the mapping relationship between the cityGML module and the CIM module, as we can see in Figure 7.

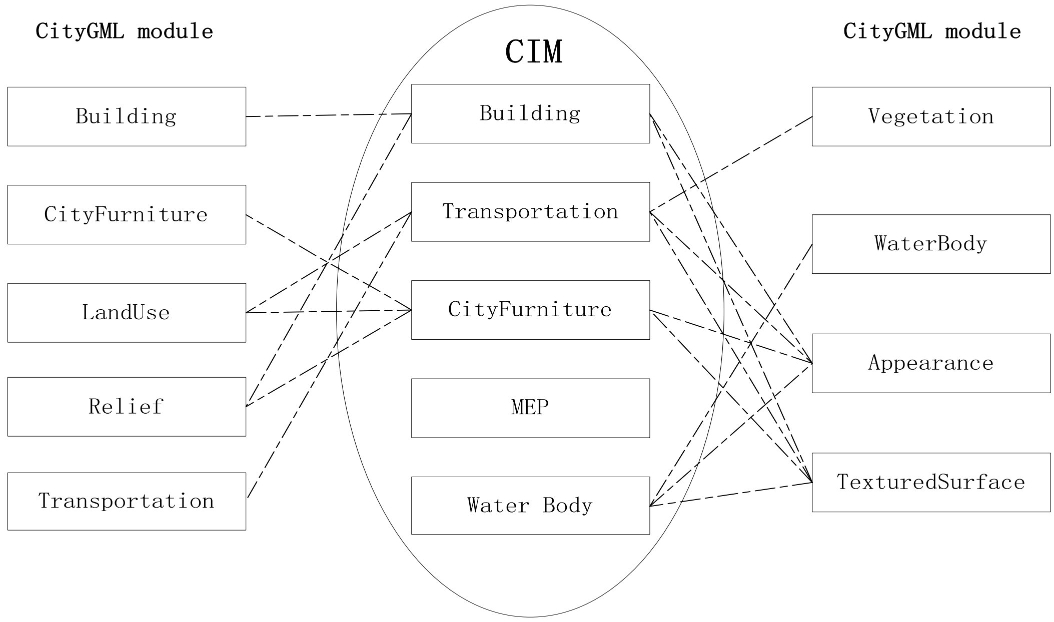

Figure 7: The mapping relationship between cityGML and CIM

There are 9 modules has defined the city entities, which can be mapped to the CIM module, for example, the building module in the cityGML can be mapped to the cityGML module in the CIM, while the appearance module may involve building appearance, transportation appearance, city furniture appearance and water body appearance, so the appearance module should be divided into four part in order to make it possible to be mapped to CIM. In addition we can see that the MEP module in CIM has not been mapped to any cityGML module, since the cityGML focus on the surface model of the city and has not involved the MEP module, the information of this module can be got from the generics module or the IFC data, such as Revit MEP.

The IFC module also has to be mapped to the CIM module, the mapping relationship between IFC and CIM can be seen in Figure 8.

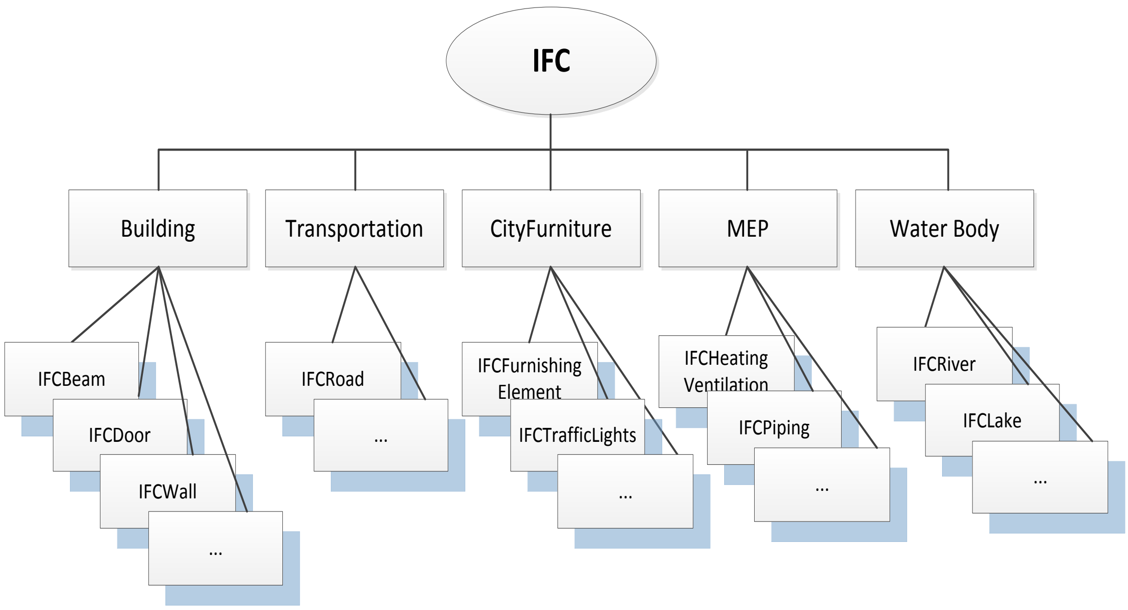

Figure 8: The mapping relationship between IFC and CIM

3.4.2 Semantic mapping of cityGML and IFC to CIM

The other problem is that same object has different semantic representation in IFC and cityGML, for example, the road was represent as "trpt:Road" in cityGML, while it was represent as "IfcFooting,IfcSite and IfcSlab(Floor)", there isn't a special defines road, which may lead to mistake and information lose. Applied research has shown that 15 classes have the similar semantic representation with cityGML, which are listed in Table 2 (de Laat and van Berlo, 2011).

Table 2: Mapping of CityGML types to IFC classes

cityGML type	IFC class	cityGML type	IFC class
Building	IfcBuilding	Address	BuildingAddress
WallSurface	IfcWall	Door	IfcDoor
FloorSurface	IfcSlab	Column	IfcColumn
RoofSurface	IfcRoof	BuildingFurniture	IfcFurnishingElement
FlowTerminal	IfcFlowTerminal	Room	IfcSpace
Railing	IfcRailing	Annotation	IfcAnnotation
Beam	IfcBeam	Stair	IfcStai
Window	IfcWindow		

The IFC schema has about 900 classes in total, most of the classes cannot map to cityGML element. The non-correspondence of semantic representation between different 3D modes has disabled the interoperability. It is important to unify the classification criterion of IFC and cityGML. The OmniClass is a classification system for the construction industry, which has been used for many applications, from organizing library materials, product literature, and project information; it can be provide a classification structure for CIM. Some elements may have not been included in OmniClass, we need to extended this element according to the classification rule of OmniClass.

4 THE APPLICATION OF CIM: A CASE STUDY

Teaching building, laboratory building, research buildings, office buildings and dormitories in schools are crowded places, it will cause serious security incidents and great property losses once a fire, gas leak, electrical short circuit and other events happened (Lu and Wu, 2007). In this paper, we take the frequent fire incidents as an example to explain how CIM system works in the campus fire emergency. According to relevant statistics, almost all 1000 full-time school have experienced the fire. In these schools, when fires happen, it may make damages to school buildings, laboratories, dormitories and our students or even claimed the lives of students. There are several thousands of small fire cases happen on campus each year, more disconcerting is the rising trend of campus fire. From the past incidents, we can recognized on basis of the good safety management campus fire prevention, how to reduce the threat of the fire and how to make a correct rescue plan is particularly important.

CIM system contains campus geographic location information, campus building information, campus water supply pipeline information and building ancillary facilities information, these four functioning module will play an important role in campus fire emergency, as is shown in Figure 9.

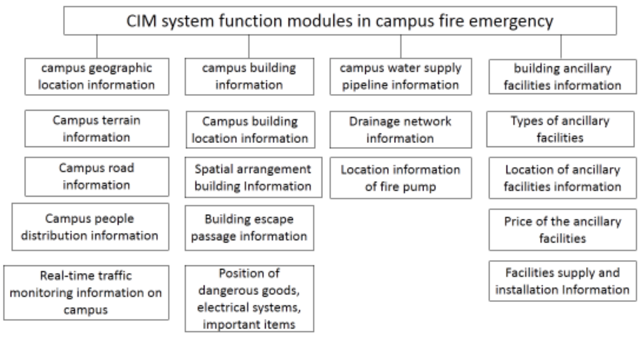

Figure 9: CIM system function modules in campus fire emergency

After the incident occurred on campus, (we take the dormitory fire case as an example), the dormitory's automatic fire alarm system would send the alarm to the connected CIM system as soon as the fire happens in the dormitory, after receiving the message, CIM system will do its reacting: on one hand, CIM give order to dormitory management center so as to notify dormitory the staff escape route，on the other hand, CIM will alarm the nearest fire station; on the next, the staff in fire dormitory would quickly escape under the guidance of broadcast, CIM system will calculate the best and quickest rescue route through the city's real-time traffic and road condition, the fire squadron could calculate the needed quantity and requirements of rescue staff and rescue vehicles, the firefighting forces could arrive at the scene of the fire with the fastest speed and lowest cost. As the firefighting force arrived the scene, they started the crowed evacuation and firefighting job. The fire man can also locate the nearest fire hydrant, thus lead to savings in time and manpower. Then the rescuers would put out the fire, and if there is still someone who couldn't escape staying in the fire scene, the fireman could conduct rescuing through escape routes. In the reconstruction after disaster, the constructers could extract the building information from CIM system, which could save some designing cost. The procedure of campus fire emergency is shown in the following Figure 10:

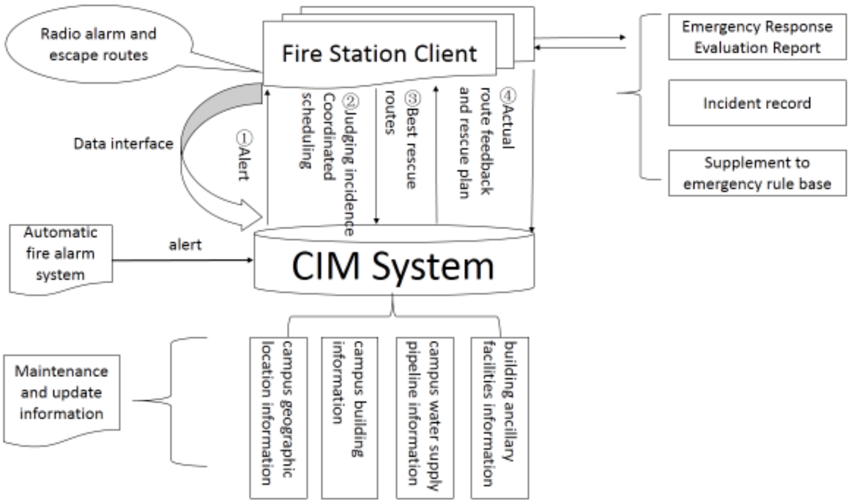

Figure 10: Process of campus fire emergency

In the next paragraph, let's take Huazhong University of Science and Technology as an example to show how CIM system works in the campus fire emergency. At the time of half past six on one Monday, a fire happens in the west 15 dormitory in HUST for the misfeasance of a student. The thick smoke triggered a dormitory fire automatic alarm, this alarm signal was sent to Wuhan CIM system which is connected to the dormitory fire automatic alarm. CIM system immediately give order to school's radio, the radio broadcast the escape information and emergency notification as soon as it received the order; at the same time, CIM send the fire information to Wuhan city's firefighting center, the center quickly decided to let the Hongshan fire department to deal with this case for it's the nearest one. Hongshan fire department could judge the severity of this fire case through the real-time camera and pictures, and compared to the period cases, Hongshan fire department send one team which contains 10 firemen and 2 fire trucks. After these decisions, this team have to find a nearest way to the scene, as is illustrated, A is the location of Hongshan fire department, the red point is the fire scene, and the CIM system provides two routes to the destination, the blue route and the green route, as shown in figure 11:

Figure 11: Two alternative routes

Considering the green road goes through the Jiedaokou commercial district and Guanggu commercial district, and these two commercial districts are full of cars and people, the team possibly run into the traffic jam, so the fire team choose blue route, the blue route goes through the Luoshi road and Bayi road which contains little cars flow.

The firefighting team finally arrived at the fire scene through the northwest gate (figure 12 and 13). And the firemen have chosen the parking and working place on the road by studying the campus water supply pipeline information, the team park the fire trucks besides the most appropriate fire hydrant. After the fire was put out, the fire team returned by the way it came.

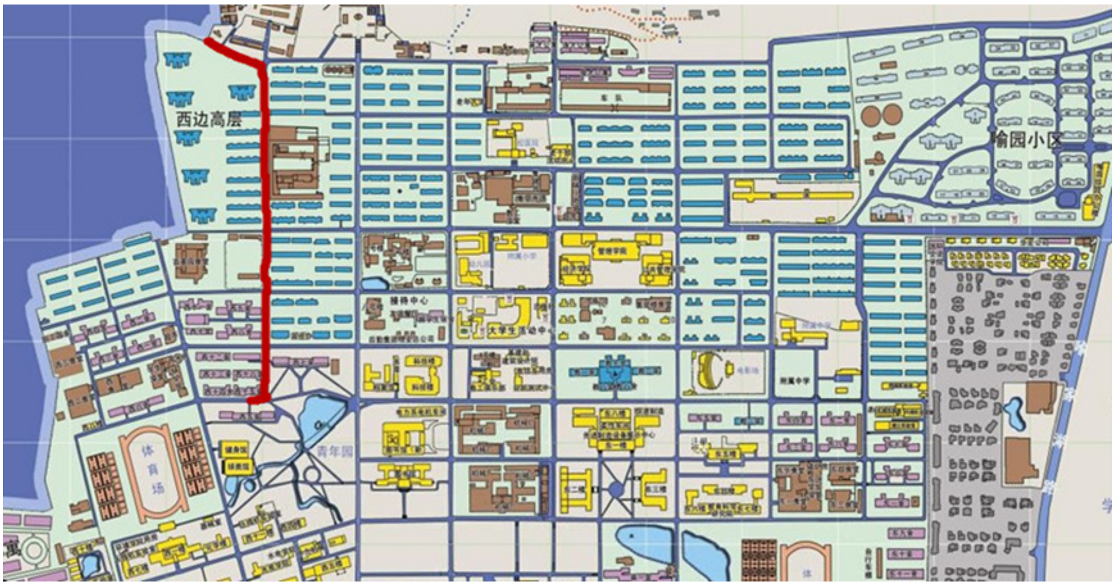

Figure 12: The route in school

Figure 13: The location of west dormitory 15

After the disaster, the west 15 dormitory have to do repairing and renovation work, the contractor could apply the original designing and renovation information such as indoor distribution information; goods display images and so on. By using this information, the builders can change the building back to what it used be good and fast.

In this example, we could divide the fire emergency case into four phases: alarm phase, decision phase, action phase and reconstruction phase. In each phase, the operators need different kind of information and the information should be timely updated and maintained. In the following table, we can see it clearly.

Table 3: Information needed in each phase

Phase	Information	Managers
alarm phrase	Campus location, the distance between fire station and campus, fire information, available rescue force information, trapped people information	Dormitory managers, fire station managers and campus managers
decision phase	Real time traffic information, road map of wuhan, campus road information, fire cases information, people flow in fire scene, Campus people distribution information, Campus building location information	City's traffic department managers, fire station managers and campus managers
action phase	campus building information, spatial arrangement building Information, building escape passage information, position of dangerous goods, electrical systems, important items, campus water supply pipeline information, drainage network information, location information of fire pump	Campus managers, campus facilities managers, drainages supply managers, campus planners
reconstruction phase	building ancillary facilities information, types of ancillary facilities, location of ancillary facilities information, facilities supply and installation Information	Materials suppliers, school infrastructure, construction contractors

5 CONCLUSION

In this paper, aimed at the shortages of exited 3D digital city model we propose a new thinking of city model building. The existed 3D city model is based on the GIS. However, when more and more interest has been introduced in the exploitation of 3D city models, the effectiveness of such applications are limited by the poor semantic annotation.

CIM (City Information Model) is inspired from the BIM, compared with the old city model, the most highlighted difference is the semantic function. City Information Model (CIM) should be a highly efficient, multi-functional, integrated management system, its data is more complete, the model is more accurate and efficient, its focus is to achieve information sharing and multi-service and multi-field collaboration, and achieve digital city full range of horizontal and vertical management, improve the overall efficiency of urban management. There is a good attempt in integrating IFC and CityGML to make a good union of geometrical information and detailed building information. The integration of IFC and CityGML is quite necessary in the long term. Following the background literature review in this thesis, different approaches to the integration of IFC and CityGML have been tried. Existing approaches, however, do not provide complete integration as they tend to offer only unidirectional transfer, mainly from IFC to CityGML. Additionally, the number of semantic models that support this integration is relatively small compared to the number of geometric models. What's more, with the development of GIS, some semantic information can be included; there is an obvious overlap in terms of information content for mapping IFC and CityGML. A data identification work still needs to be done.City information model (CIM) should include all aspects of city information, such as geographic information, buildings, infrastructure, property information, and so on. It can integrate a variety of disparate data sources by creating an integrated and interoperable in different data sets. What should be emphasized is that CIM is an information integration framework, which is based on the optimization model of the digital city model and BIM-tech.

Further work regarding CIM should be divided into two parts: Work 1 is to set an available data interface to all kinds of subjects which may be included in the city information. From the literal meaning, CIM is city information model, in the future, CIM should be a city manage platform, and it will help the managers to supervise the city and manage it. And in nowadays, many aspects of the management work such as city green work, and city public facilities management couldn't be modeled. So we should set data interfaces to integrate different data formats or even different models. In future work, we need to collect information of different fields and then build models or write into CIM. And this CIM platform must be easy to operate and communicate. Work 2 will be the realization of city real-time management. In order to do the real-time management by CIM, it may be necessary to make a supervising system on the roads or other place in the city, this system can return the information we need to manage the city. It's a very hard work, but we think it's very interesting and worthy to have a try.

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