INTEROPERABILITY BETWEEN MUNICIPAL COUNCIL PROPERTY TAX INFORMATION SYSTEM (MCPTIS) AND GIS USING SEMANTICS TRANSFORMATION

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ABSTRACT

This research paper describes how attributes in the IFC file are extracted and transferred to GIS application like QGIS from Municipal Council Property Tax Information System (MCPTIS). Attributes in IFC can be divided into two groups, i.e. default attributes and hidden attributes, depending on whether an attribute is directly defined in the object. While default attributes are easy to retrieve, transferring hidden attributes poses a real challenge. This research has the capability of reducing semantic information loss by developing an advanced IFC attribute search algorithm with the ability to collect all related attributes, including hidden ones.

Keywords: *Interoperability, Semantic Transformation, Express-based IFC, ifcXML, GIS.*

1.1 Introduction

The most recent twenty years have demonstrated a significant move from stand-alone programming frameworks to network frameworks. Similarly as with all data framework spaces, Geographic Information Systems (GISs) have been impacted to a huge degree by ongoing web advancements, bringing about an expanding accessibility of client/server applications utilizing conveyed geo-(web) administrations, for example, interactive maps, gazetteers and route planners. There is an expanding need for internet based organizations to perform on interest geo-processing assignments by incorporating and reusing geo-data and geo-spatial services from the inside and outside the organizations. These exercises are normally acted with regards to purported Geo-Information Infrastructures (GIIs).

Property tax is the assessment that a proprietor of land, real estate or other property pays on the estimation of the thing taxed. Municipal Council or Corporation is characterized as the act of coordinating or controlling the utilization of something.

Property tax is having huge portion of all state and local taxes and is one of the significant sources of income for our administration. Each area's property tax framework is unique, with varieties in the kinds of property available, and the ways taxes are collected. Generally, to calculate property tax, the Municipal Council or Corporation requires carrying out an estimation of the monitory as well as rental estimation of the property and tax is evaluated with respect to that esteem. All taxable property is evaluated at regular intervals, and the property tax esteem is changed after the examination. Aside from monitory and additionally rental value of taxable property, property tax likewise relies on PRI (Property Richness Index) of the region. The estimation of PRI is defined and approved by board members from Municipal Council or Corporation. The estimations of PRI are different for each zone in the region.

Municipal Council Property Tax Information System (MCPTIS) is responsible to steer the affairs of the property tax within the city. Its statutory duties are to provide the most efficient and effective method to list, assess and collect taxes on all taxable properties (unimproved and improved land) situated within the city. Determination of taxes on real estate requires accurate information on individualized property structure, location, ownership, condition, size, and its use classification. Moreover, today's communities are undergoing rapid developments and so, is the need to regularly piece together those changes to keep the assessment records up-to-date. At the Division, the existing method of property mapping is not parcel based and thus is increasingly incapable of supporting unique parcel identification. Additionally, these property records are maintained in various types like filing cabinets, on paper maps of varying qualities and different sizes, and in computers using different software. This makes paramount the importance of bringing full information communication technology (ICT) into the Division's day-to-day workings, especially the need to capture, store, retrieve, update and manage large amounts of data within a unique system. Further, any system that can visualize data and analyze trends in spatial context can enhance the efficiency and effectiveness of the taxation procedures. Remote sensing and Geographic Information System (GIS) provide a whole new dimension to ICT as they bring the spatial elements to it (ICT).

A large number of the pre-construction exercises don't completely exploit the advantages Building Information Modeling (BIM) gives to the design and construction practice, basically due to the variety of spatial relationship among topographic and temporal objects in a Building Information Modeling (BIM) environment. Most Building Information Modeling (BIM) tools are intended to deal with huge number of perpetual structural items of building and impermanent structures have gotten far less consideration.

Modeling of temporary components inside a Building Information Modeling (BIM) tool can offer generous advantages in site layout 4D visualization. Also, the lack of spatial analysis capabilities in Building Information Modeling (BIM) underlines the need for utilizing spatial data analysis tools. For instance, the location of temporary structures is closely related to the spatial characteristics of the building elements and the obstacles existing in construction sites. There are factors, such as closeness (or proximity) relationships among the temporary structures and the building elements, which influence the desired location of temporary structures, but cannot be modeled with Building Information Modeling (BIM).

There are numerous data frameworks that can be utilized to break down, screen, and deal with the huge measure of information (both spatial and non-spatial) associated with the ideas of acquisition and pre-development the board. Notwithstanding, they depend on Building Information Modeling (BIM) models for the smart data about the venture degree, materials and volumetric (mathematical) properties. Specialists in the plan and development network use Building Information Modeling (BIM) to create building frameworks and oversee plan math and site measures, and once the structure model is finished, assembling information can be used as a contribution to the data framework instruments to smooth out however many strides in the acquirement and preconstruction measures as would be prudent. While this shows the presence of a hole in investigating and handling impermanent and spatial information inside a Building Information Modeling (BIM) framework, it additionally demonstrates the expected estimation of a coordinated Building Information Modeling (BIM) model that can be utilized to improve the current act of combination and sharing of spatial data.

This spatial information can be examined in enormous sums by Geographic Information Systems (GIS). The GIS has been utilized effectively to fathom the complexities of site format arranging and to help the wide scope of spatial investigation utilized in the coordinations viewpoint of the pre-development exercises. Having thought about various definitions, GIS is characterized in this as an arrangement of equipment, programming, individuals, association and institutional plan for gathering, putting away, dissecting, and spreading data about territories of the earth [3]. In spite of the useful uses of GIS innovation to development arranging, it's anything but a simple assignment to move information from Building Information Modeling (BIM) to GIS or the other way around without thought of information organization and significance.

Methods of joining information from various sources should be found in light of the fact that there are an assortment of data set structures which can be utilized to store information about spatial (for example geography, office area) and non-spatial (for example building material's carbon impression) highlights. These incorporate progressive information structures, network frameworks, and social data set structures [2]. Information in progressive information structures have one-to-numerous or parent-kid relationship, in which every relationship should be unequivocally characterized before the structure and its choice principles are created. The articles or substances (for example building components) in a Building Information Modeling (BIM) model are masterminded in a progression structure [3].

1.2 Workflow for Semantic Transformation

Figure 1.1 shows the general workflow for semantic transformation from GIS web application like QGIS to Municipal Council Property Tax Information System (MCPTIS) and vice versa, comprising three main parts:

1. transformation from Express-based IFC to ifcXML,
2. attribute extraction using MATLAB, and
3. joining attributes with the geometry model through GlobalId.

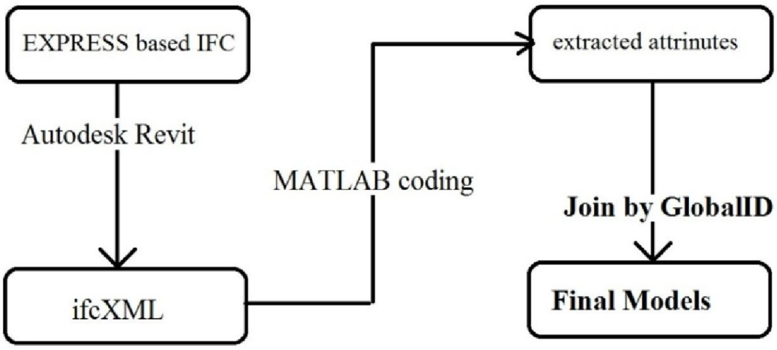

Figure 1.1: Workflow for semantic transformation

The EXPRESS-based IFC is first transformed into ifcXML in Autodesk Revit, because ifcXML is both human and machine readable. Then an attribute searching algorithm is developed, with which the attributes of an object can be extracted from ifcXML and finally attached to the geometry model.

1.3 An Algorithm for Attribute Identification and Extraction

The relationship entity is a key to determining the attributes of an object. All entities, including object entities, relationship entities, and attribute entities are defined separately in IFC. However, relationship entities connect attribute entities to object entities. Therefore, to extract the attributes of geometry (object), relevant relationship entities first have to be identified.

As previously mentioned IFC attributes can be divided into default and hidden attributes. Hidden attributes are stored in two types of attribute entity - property set entity and taxable property entity. The corresponding objectified relationship entities that connect them to objects are IfcRelDefinesByProperties and IfcRelAssociatesTaxable property, respectively.

To efficiently and thoroughly extract attribute entities through those relationship entities, an automatic attribute searching algorithm was developed, shown in the Figure 1.2, 1.3 and 1.4. The DOM of the ifcXML file was first built using MATLAB, allowing for retrieval of all contents of the IFC.

This algorithm has three sub algorithms:

1. File assessment algorithm;
2. Property set attribute extraction algorithm; and
3. Taxable property information attribute extraction algorithm.

1.3.1 File assessment algorithm

During file assessment, the algorithm checks whether the input file is an XML file, and whether it has the necessary “ifc:uos” tag, then checking each entity to determine whether it has an ‘id’ attribute; if yes, ‘id’ is set as its unique identifier (ID). File check is included to make sure the input file fulfils the requirements of property set and taxable property information extraction.

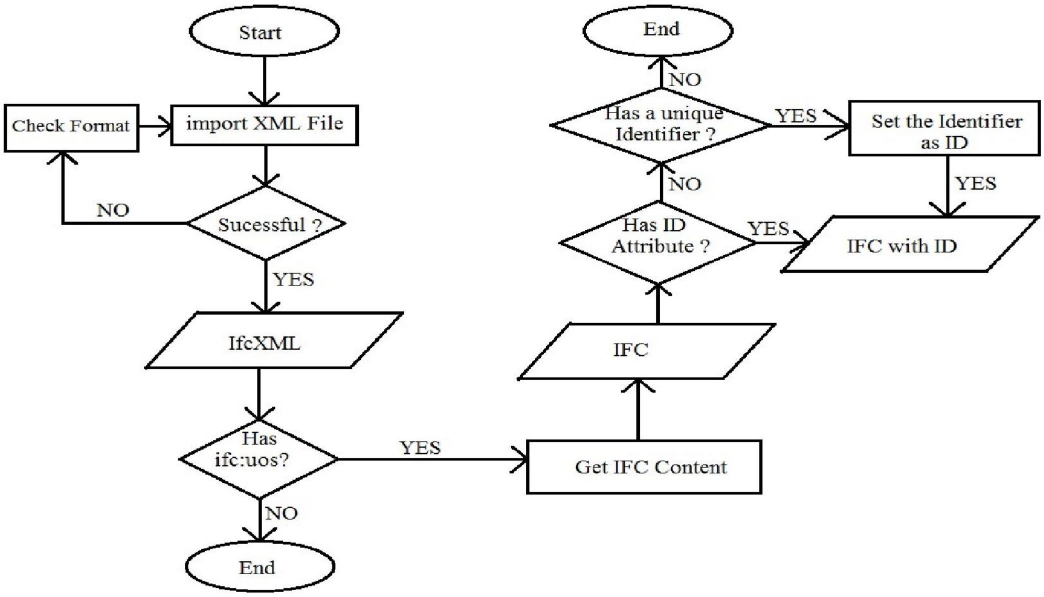

Figure 1.2: Flowchart of File Assessment Algorithm

1.3.2 Property set attribute extraction algorithm

Property set attributes defines all dynamically extensible properties. The entrance to the property set is IfcRelDefinesByProperties, an objectified relationship entity that defines the relationships between property set definitions and objects. It stores IDs, pointing to an object and its corresponding property set. Properties are aggregated in property sets. For a specific object, IfcRelDefinesByProperties defines a one-to-one relationship between the object and a property set. The detailed procedure for extracting properties in a property set is illustrated in Figure 1.3.

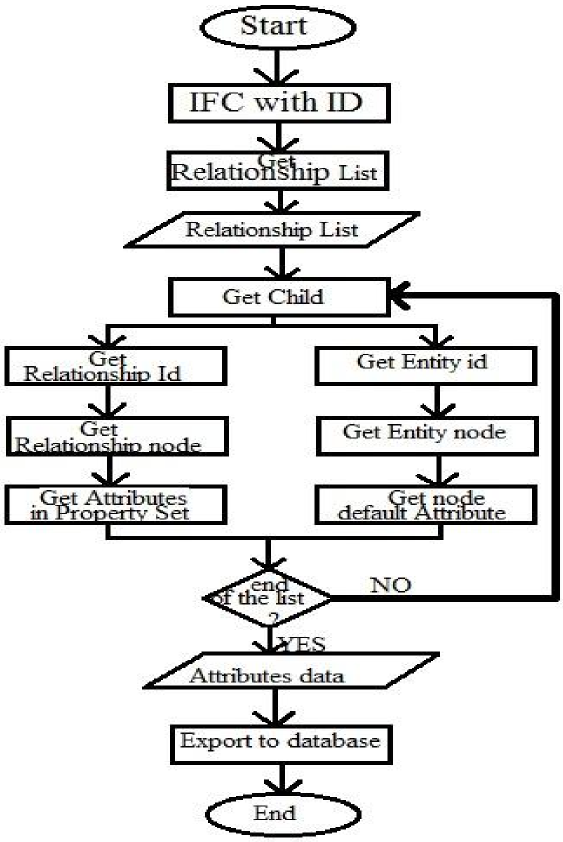

Figure 1.3: Flowchart of Property set attribute extraction algorithm

The process begins by acquiring the list of relationship entities, IfcRelDefinesByProperties, in the bridge model. Each entity records the ID for a bridge element and the ID for its corresponding property set. After that, there are two relatively separate processes; one is to obtain all possible attribute titles, the other is to obtain attribute values for every object. Three additional attributes are also added, i.e. 'id_XML' for recording the unique identifier (ID), 'IfcType' for recording the type of element defined in IFC, and 'taxable property' that is reserved for further taxable property information to be extracted in the next step.

1.3.3 Taxable property information attribute extraction algorithm

The entrance to the taxable property attribute algorithm is the relationship entity IfcRelAssociatesTaxableProperty. IfcRelAssociatesTaxableProperty stores the ID of a specific taxable property entity and a list of IDs of objects that use that taxable property. Figure 1.4 shows the taxable property information extraction flowchart.

The first step involves obtaining the list of relationship entities, IfcRelAssociatesTaxableProperty. For each entity, two tasks are conducted. The first is obtaining taxable property information, which is stored under the "RelatingTaxableProperty" attribute of the entity. Since a taxable property can be a single taxable property, a taxable property list, a taxable property layer set, or a taxable property layer set usage, i.e. the wanted taxable property entity, "IfcTaxableProperty", may not be the direct child of the "RelatingTaxableProperty" node, and the search for "IfcTaxableProperty" should therefore be conducted among all descendants of the "RelatingTaxableProperty" node, not only its direct children. The pseudo code for the search is given as below. The pseudo MATLAB code for searching taxable property node among all the descendant nodes.

```
function getChildTaxable
propertyElement(node)
nodeName = node.getNodeName;
if strcmp(nodeName,'IfcTaxable property')
taxable_property_id = node.getAttribute('ref');
save('id', 'taxable_property_id')
else
if hasElementChild(node)
children = getElementChildren(node);
for i = 1 : length(children)
getChildTaxable propertyElement(children{i});
end
end
end
end
```

The second task is to obtain all related bridge elements and assign the taxable property to them. Since a taxable property can be assigned to more than one element, this is completed with the assistance of the id_XML attribute obtained in the previous section.

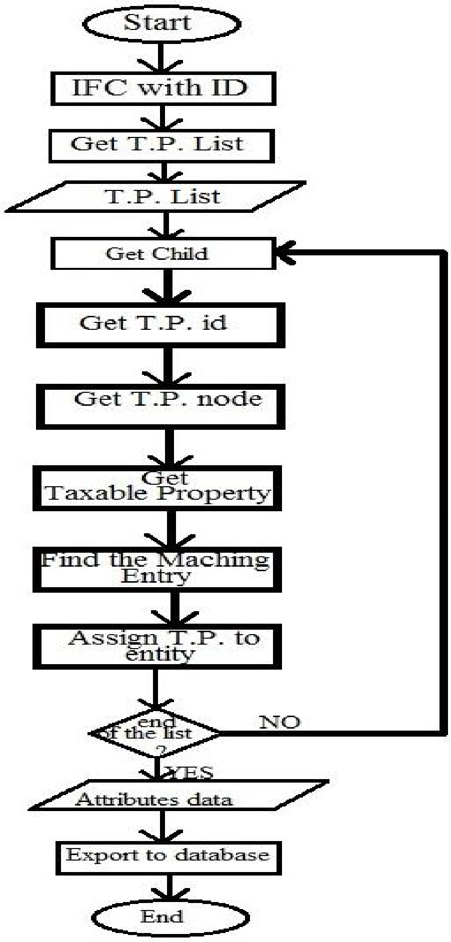

Figure 1.4: Flowchart of Taxable property information attribute extraction algorithm.

Finally, after all attributes have been retrieved, these are merged and then exported into an Excel (.xls) file and joined with the geometry through the unique GlobalId. All development work was completed in MATLAB, and a set of customized functions for XML DOM manipulation were developed in this study to improve process efficiency.

1.4 Conclusion

To make GIS interoperable, a few issues must be settled. We contend that these issues can be separated onto three level of integration, the syntactic, structural and semantic level. As we would like to think it is vital to take note of that the issue of interoperable GIS must be settled if methods (modules) on each of the three levels of integration are working together [4]. In this research paper we focus on the third level of integration i.e. semantic level.

For semantic transformation three sub algorithms:

(1) file assessment algorithm; (2) property set attribute extraction algorithm; and (3) taxable property information attribute extraction algorithm plays the vital role.

References

1. Cromley, E. K., & McLafferty, S. (2012). GIS and public health, Guilford Press, 2nd ed., International Journal of Geographical Information Science, 27(5), pp. 1040–1041.
2. Crowther, P., & Hartnett, J. (2001). Handling Spatial Objects in a GIS Database-Relational v Object Oriented Approaches. Proc., CD Proceedings of the 6th International Conference on GeoComputation, University of Queensland, Brisbane, Australia, Citeseer, 24-26.
3. Ebrahim P Karan, (2014). Extending Building Information Modeling (BIM) Interoperability to Geo-Spatial Domain Using Semantic Web Technology. Ph.D. Thesis, https://smartech.gatech.edu/handle/1853/53213
4. Ubbo Visser, Heiner Stuckenschmidt, Christoph Schlieder (2002). Interoperability in GIS – Enabling Technologies. 5th AGILE Conference on Geographic Information Science, Palma (Balearic Islands, Spain), April 25-27, 2002
5. Sheth, A.P. (1999). Changing Focus on Interoperability in Information Systems: From System, Syntax, Structure to Semantics, in Interoperating Geographic Information Systems, Springer, Interoperating Geographic Information Systems, pp 5-29.
6. Goguen, J.A. and R.M. Burstall, (1992). Institutions: abstract model theory for specification and programming. J. ACM, 39(1): pp. 95-146.
7. Goguen, J, (2005). Information Integration in Institutions. Retrieved on December 2020, from http://www.cs.ucsd.edu/users/goguen/pps/ifi04.pdf.
8. Mark, D.M. and A.G. Turk, (2003). Landscape Categories in Yindjibarndi: Ontology, Environment, and Language in Spatial Information Theory Foundations of Geographic Information Science, COSIT 2003, Kartause Ittingen, Switzerland. Springer, Lecture Notes in Computer Science 2825: pp. 31-49.
9. Montello, D. and S. Freundschuh, (2005). Cognition of Geographic Information, in a research agenda for geographic information science, CRC Press: pp. 61-91, http://www.opl.ucsb.edu/~montello/pubs/ucgis.pdf
10. Kuhn, W, (2002). Modeling the Semantics of Geographic Categories through Conceptual Integration. Second International Conference, GIScience 2002, Boulder, CO, USA, September 2002 : Springer, Lecture Notes in Computer Science 2478: pp. 108-118, https://link.springer.com/chapter/10.1007/3-540-45799-2_8
11. Fonseca, F.T., (2002), Using Ontologies for Integrated Geographic Information Systems. Transactions in GIS, 2002 6(3): pp. 231-257.
12. Onsrud, H., Poore, B., Rugg, R., (2005). The Future of the Spatial Information Infrastructure. A Research Agenda for Geographic Information Science, CRC Press: pp. 225-255.
13. Harvey, F., Kuhn, W., Pundt, H., Bishr Y., & Riedemann, C., (1999). Semantic Interoperability: A Central Issue for Sharing Geographic Information. Annals of Regional Science, 1999. 33 (2) (Geospatial data sharing and standardization): pp. 213-232.