Building Survey in Combination with Building Information Modelling for the Architectural Planning Process

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Abstract: The architectural planning process is influenced by social, cultural and technical aspects (Alexander, 1977). When focusing on computer based planning for retrofitting or modification of buildings it becomes clear that many different data formats are used depending on a great variety of planning methods. Moreover, if building information models are utilized they still lack some essential criteria. It is rarely possible to attach individual data from survey systems. This paper will show both a way to add data from building survey systems as an example for special data attachment on IFC files and how to utilize content management systems for IFC files, deviated plans, lists of building components, and other data necessary in a planning process.

Keywords: Planning process; building information modeling; IFC; building survey systems; content management systems.

Data formats used in the architectural planning process

Over the last years it has become a common task for architects in central Europe to plan minor or major conversions of existing buildings which are often connected with a refurbishment of those buildings (Hommerich and Riedel, 2005). It can be difficult and tedious to obtain reasonable building plans and other information about existing buildings. Therefore, in many cases a survey of the building will take place before other activities. The result is usually a set of two-dimensional plans and further documents like pictures, descriptions, or lists - a comprehensive set of information.

Planning processes based on this information with programs supporting building information model technology lead to an incoherent workflow. Due to less advanced ways of information exchange - for instance by using elder data formats - more attention on data consistence is required. This causes additional work and expenses, as well as low reliability for the whole planning process. A possible solution for this problem could be to integrate information from surveys into a commonly accepted building information model for further planning by choosing IFC as a semantic data model (Petzold and Donath, 2005; Li, Isele, and Bretthauer, 2008). Nonetheless, building information modeling can hardly be found in survey systems yet, because of different
ways of setting-up semantic models for new and existing buildings.

For new buildings construction elements like walls or slabs are added part by part as a three-dimensional structure to a building model. In comparison, in existing buildings only the surfaces of construction elements can be perceived. Knowledge of corresponding materials or other information with reference to the construction initially does not exist. Sometimes more detailed information can only be revealed by subsequent explorations, and even this may not always lead to an overall cognition of the whole building. Nonetheless, it was tested how results of a survey could be represented in IFC files.

Besides IFC files (with individual data) other file types are required for architectural planning. Images, sketches, plans, any kind of technical drawings, but also office documents, lists for tendering, etc. must be handled. The more data is based on building information models, the less overlapping can occur. Commonly the corresponding data files are organized into projects, however, inaccurate classification criteria and data storage directives are usual. Thus, a content management system (CMS) was set up which allows dealing with IFC files as standard format but also using any other kind of data format (Figure 1). Architects, other planning staff, owners, and even manufacturers can use such a system to upload and manage their data. For security reasons the data access can be adapted by a manager contingent on predefined roles. A single data pool for a planning office or a planning company with internet access was created.

Planning in existing build context

Basis for all refurbishment activities is always an exact knowledge of the quality and condition of the building fabric. The aim should be to capture all necessary information during the survey in a uniform Building Information Model (BIM) as basis for all further activities (Donath, Braunse et al. 2008).
The IFC are a standard for the exchange of BIM data (ISO 2005). For new buildings they are already extensively defined and are supported by the most current CAAD systems. For systems of building surveying this definition and support is absent up to now. The reasons for this and possible solutions will be discussed in the following.

**Industry foundation classes for building surveying**

The following conditions arise for the mapping of surveying data in the IFCs from planning demands:
- Surveyed building geometry
- Descriptions of the condition for single building components, as well as component assemblies
- Defects on building components in their position and size

**Geometry representation**

In general the survey is carried out room by room. At first the building is measured from the outside and afterwards from the inside of the rooms. Different technologies can be used for measurement: hand measuring, tacheometry, photogrammetry or laser-scanning – often also in combination (Donath and Thurow 2007).

The spatial structure is mapped in the IFC by using derived classes of IfcSpatialStructureElement – site, building, storey and space. With the attribute CompositionType and the relation IfcRelAggregates further divisions are possible, e.g. building complex, building part or space group.

In a survey, only the visible surfaces of construction elements can be perceived. Knowledge of corresponding materials or other information with reference to the construction initially does not exist.

Each single measurement can be put in relation with each other, by defining an overall coordinate system for the whole building. Only in the further course of the survey certain component dimensions arise (e.g. thickness of a wall). This is an essential difference to the planning of a new building in a BIM system, because here the dimensions are known or at least can be assumed.

Hence, a tree-dimensional surface model in which the surfaces represent the rooms, as well as the building components is suited for the geometry representation of surveying data. The IFC contains different types for geometrical representation. For building components the use of SurfaceModel as RepresentationType can be based on instances of IfcFaceBasedSurfaceModel. This also permits the geometrical representation with the help of a not completely closed surface model. Spaces can be represented using BRep as RepresentationType by means of instances of IfcFacetedBrep. The IfcFaceted-Brep entity is a form of a solid-model and permits only closed volumes. Finally IfcFacetedBrep and IfcFaceBasedSurfaceModel build the three-dimensional geometry based on a set of IfcPolyLoops. These are planar regions in space with straight edges and three-dimensional cartesian points forming the vertices of the loop.

Therefore the three-dimensional surface model can be built up from single IfcPolyLoops that are linked to the SurfaceModel as well as the BRep. With it the surveyed data of visible surfaces can be also transferred into the IFC (Figure 2).

**Mapping of conditions and defects**

The construction element structure of the building is of particular interest to evaluate the condition of single building components and component assemblies. For this the IFC provides the abstract class IfcBuildingElement and its subtypes. The relation between spatial structure and construction element structure is described by means of IfcRelContainsInSpatialStructure and IfcRelSpaceBoundary. With the use of IfcPropertySetDefinition additional properties – in this case the condition – can be assigned to elements of the spatial structure as well as to construction elements.

Storing defects as elements is currently not possible in the IFC. Anyhow, undefined objects can be applied by using the IfcProxy entity. This can be
Basic structure
For new buildings the following phases represent that process (depending on the cultural background of different countries, this list may vary):

- Basic evaluation
- Preliminary planning
- Concept planning
- Approval planning
- Implementation planning
- Tendering
- Building construction
- Documentation

In the case of modifications of buildings a prior phase for surveying helps to organize the planning process. This leads to a structure within a content management system where these phases are specified by property sets to describe all characteristics of the defect. The proxy may have a geometric representation assigned to illustrate the size and location of the defect. Using the relations IfcRelAsignsToProduct and IfcContainsInSpatialStructur the proxy object can be linked to the spatial structure as well as the construction component structure.

Information system
Architectural planning is usually organized in projects. Independent from the size of the buildings most planning of them runs through a similar process. Whether small building, mid-size buildings, or very complex and big structures are planned a typical principle rest upon it.
created automatically when a new project is established. A first phase for surveying could contain files like pictures and lists of defects, or IFC-files with data attached via IfcProxy.

Because there are usually some varieties of data that do not fit into a strict timetable of planning phases an extra data folder for independent data is offered in each project called ‘resources’. This folder should be used when data like official site plans, pictures of the site, etc. need to be stored that are necessary in different phases.

Quick search and data parsing
One big advantage of content management systems is the fact that any required content can be found quite easily. Normally additional information to any kind of file can be added during the uploading. With both the filename and the additional information quick search procedures work fast enough (Bonfeld and Quinn, 2007).

Unfortunately IFC-files can get quite big when representing thousands of building parts and any text based search engine would have to browse lots...
of data. If a user of the content management system is looking for attached data in IFC-files, more efficient search procedures are required. Hence, a parser for IFC-files was developed which extracts those building elements. After running the parser the results are displayed and can be copied to the keyword or description part of the file in the content management system. Always a future search will quickly lead to the requested result.

Summary

During a planning process with existing buildings solid models and surface models need to be combined when the data of both building information models (BIM) and building survey systems are required. By using IfcProxy this goal can be reached taking advantage of IFC-files. Further data management like the use of CMS may lead to additional procedures for a swift and convenient access. Therefore, data parsers can be utilized.

References