Two Approaches to BIM: A Comparative Study.

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Abstract. The ultimate goal of the BIM concept is to create a complete digital model of the building to insure the generation of an accurate bill of material and cost estimate along with coordinated drawings and details. This goal might need the contribution of various disciplines to provide the needed level of information.

The development of capable specialized systems to model specific building elements will definitely challenge the all-purpose architectural CAD. The specificity of these systems will enable fulfilling the needs than a general purpose architectural BIM system.

This will lead the industry into creating either a powerful fully integrated BIM system that can handle all required information, or a referential BIM system that depends on passing the information to other programs (and other people) that are capable of handling specific tasks more efficiently.

Keywords. Building Information Modeling; CAD; Internet; Smart objects.

Building Information Modeling BIM

There is nothing inherently architectural neither in the core geometry concepts embedded in general drafting CAD engines, nor in the methods adopted for interacting with these geometry engines. Computer Aided Drafting (CAD) has always meant manipulating geometry by a computer. When CAD vendors became determined to make computers useful for basic drafting tasks, geometry was the problem to solve.

Both industry and academia devoted countless hours of research and development to the problem of describing geometry digitally. The resulting geometry engines from these efforts were, and remain, the core technology in CAD products.

In the decade or so since the geometry problem has been solved, however, geometry in computers has become a commodity (Revit White paper).

The next paradigm shift is BIM, Building Information Modeling. The idea of object oriented CAD is not new, it has always been foreseen as the ideal way to represent the building digitally, but it has never been realized commercially until recently mainly due to the increased capacity of personal computer. Graphisoft's ArchiCAD "Virtual Building" may have been the first commercially available package to utilize the building model. Now, increasing number of CAD software is being built around this new concept.

In BIM CAD, the building components are objectified. Digital objects are coded to describe and represent real life building components. For example, a wall object is an object that understands the properties of walls and acts as one. Instead of representing a wall two-dimensionally with two parallel lines, the wall object has properties that describe geometrical dimensions such as length, width and height as well as materials, finishes, specifications, manufacturer and price which are also included. Doors, windows, slabs, structural members, and stairs can be objectified in the same way.

An object may have a finite set of parameters that dictate its shape. The coding of the object has to include these parameters, and this requires previous knowledge of the parameters involved in the creation of the real object.

Parameters are always a predefined list of properties that the user has to select from, or abide by their rules for the manipulation or creation of a new object. This information makes up architectural knowledge. The object will not be useful without the knowledge used to build it. But the problem is that the object is as good as the knowledge behind it.

How objects are used

Objects should have a specific structure of their related information that relates to the different stage of the building design lifecycle. Every bit of information is relevant in one stage or another in the design process. It is up to the designer to decide when to reveal each bit of information according to how much decision he is willing to make in the design phase he is working on.

Starting in the preliminary design phase, objects would be generic and only describe the function and some of the general geometry specific to that object. It would only be used to define spaces, enclosures and openings while developing architectural plans. In subsequent stages, more detailed specifications could be decided and specified.

For example, a door object would be used in the preliminary design to define a space entering point. No specifications are needed. The finish, color and the sound and fire rating might not be considered at this stage. The price and the vendor are not of importance too. In the design development, the same door object would be specified in better detail. Specific dimensions, material, and glazing are decision that might be made during this stage.

In the working drawings and bid document preparation phase, prices, as well as full specifications are needed. Vendors and availability might be included too.

Finally at the construction site, the installation instructions are required to install the door.

On another level, the analysis and the detailing of structural members can have a similar life cycle.

A structure member would be modeled as a generic object in the preliminary design of a building. With time, such a member would get more articulated and dimensioned. The structure analysis of that member would be conducted on a more specialized platform such as Tekla XSteel. The fabrication documents would be created and passed to the fabricator in the construction phase of the project.

Knowledge and the Semantic Web

In many architectural practices, architectural elements such as windows and doors are usually selected from vendors' catalogs, and the architectural profession relies on vendors and manufacturers' catalogs for specifications. For example, it is very rare that a door is custom designed. Architects depend on a pre-designed unit selected from catalogs, which include the knowledge needed for the creation of the object inside the CAD system.

The catalog contains the knowledge needed to correctly describe, specify, price, and install the element.

Making use of the ubiquity of the internet, many manufactures of architectural products have their catalog online. The sources over the web constitute the knowledge base about the elements being designed for use in a certain situation.

However, these catalogs are currently not formatted in a standard format that can allow a standard method of accessing the data within. This deficiency makes the available data static, and dependant on the designer to locate and make use of it as desired.

With the emergence of the semantic web, this relationship is destined to mature. With the advantages of using Extensible Markup Language (XML) as a data structuring standard, extracting the information of the vendors' web sites will likely be much easier and automatic. If CAD objects could extract the needed information from a web page catalog that is written in XML, and change its parameters accordingly, then all the knowledge at the manufacturer side would be transferred to the object, provided by that that object is coded to handle that kind of information. This will be accomplished if the main players in the industry agree on making it happen.

XML describes a document's structure and meaning. It does not describe the formatting of the elements. The document contains tags that describe its contents and not its appearance. On the contrary, HTML includes generic formatting, structural, and semantic tags that mainly describe how to represent the document in a web browser.

Instead of generic tags, XML uses meaningful tags, a technique that has many advantages such as enabling the data to be read by humans and making it easier for nonhuman or automated robots to locate specific data in a document.

The BIM-based CAD and the new technologies such as XML together with the internet will eventually change the way business is conducted. There might be a big change in the current models due to the emergence of other tools that will force a different way of information delivery.

Future Models

With the new BIM based CAD packages available on market today, one can conclude that this is going to be the trend of the future, and that better capabilities would be eventually implemented to best describe the building model and to best fit the needs of the designer without sacrificing creativity and practicality (Ibrahim and Krawczyk 2003).

General drafting CAD packages will eventually shrink to very small part of the market, for general use and smaller projects.

With that concept in mind, the objectifying of building components would get more detailed and will include more building elements.

To handle these functionalities, the future of the building information modeling system might converge toward one of two models. The CAD packages can either become super complex systems in a way that can handle all the needed sub systems for designing and editing all the related aspects of the model, or the systems will become more flexible and constitute different specialized systems that can communicate together using the architectural model as a base of reference.

The International Alliance for Interoperability (IAI) model for the interoperability has emerged out of the second view; foreseeing the cooperation between different software packages where every package is capable of adequately pursuing a single task as more likely to happen.

The Industry Foundation Classes (IFC) initiative was meant to be the solution for that concept. Although the concept behind it is valid, it has lost a lot of momentum through the years, and some main players in the creation of the alliance are backing up on the support of IFC standard (Tolman 1999).

1. *The integrated model:*

An integrated model (Figure 1) expects that all the systems and required information to be integrated in one big CAD system that can answer all the questions and have all the information in one database. BIM as a concept supports to some extent this point of view, but it stops short of providing the whole related items in buildings.

Architectural BIM systems deal only with architectural elements, making it difficult to coordinate such information as structural members' sizes after being analyzed and sized.

Information about other objects such as windows and doors can be to some extent downloaded from vendors' web sites, although the current implementation does not keep this information linked to that source. This deficiency might prevent from getting the latest price for an up to date cost estimate.

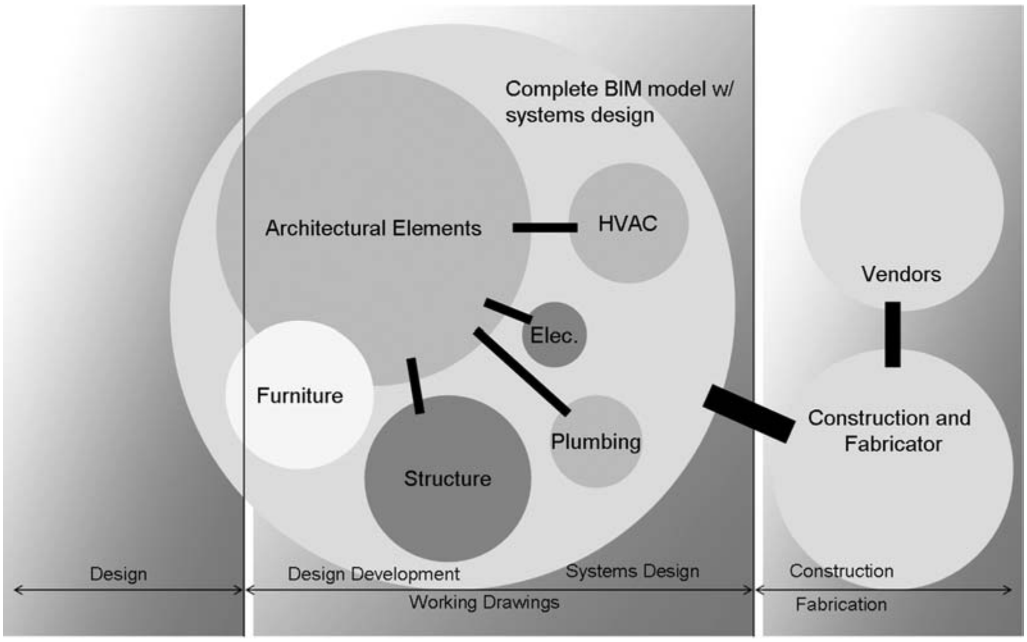

Figure 1. The Integrated Model

A package that would depend on such a concept should have many modules integrated into it such as:

1. Structural analysis module that is capable of sizing structural members and would update the architectural presentation of the structural members in the building model, for example, resizing the walls dimensions that are attached to columns after a change in columns dimensions in both the model and the drawings. In a futuristic system, beams and columns objects would change their sizes automatically according to the change of spans or number of floors based on enough design criteria that were given to them by the engineers.
2. Mechanical systems module that can analyze, present and represent the mechanical systems of the building.
3. Cost estimate module for cost analysis.
4. Code checking, energy consumption, thermal behavior analysis, and wind analysis by Computational Fluid Dynamics.
5. Such a system might eventually be able to make some design decision based on situations, such as suggesting a certain color for a door that matches the color scheme selected for walls in one part of a design.

This system should be capable of sharing information among different designers, architects, engineers, estimators and specification writers providing custom interface suitable for each function.

For all required functionalities, such a system is harder to realize. It will require more resources to run and maintain. The knowledge provided by vendors and manufacturers should be included in the database and should be updated regularly to keep it up-to-date. If everything would be stored locally in the systems, its database would have to be as big as how much information it contains. Not only file sizes should become bigger but the application itself and the hardware running it would become increasingly bigger as well.

Although such a system will keep the control over the building information in the hands of the architect, provided by that he is the owner of the system, it will require that all the specialists be working with the same system.

2. *The Distributed Model:*

On the other hand, this model (Figure 2) expects that the architect building model would be a referential model. A model that can access and point to the information from where it is stored and make use of it but not imbed it in the CAD model, allowing other systems to access the same information and to make use of it in their own way. Many specialized systems can communicate through one model. Every system does what it specialized in and passes the information to the next. This model can reach up to the construction site where the information ends its journey. The medium for sharing the information could become the Internet.

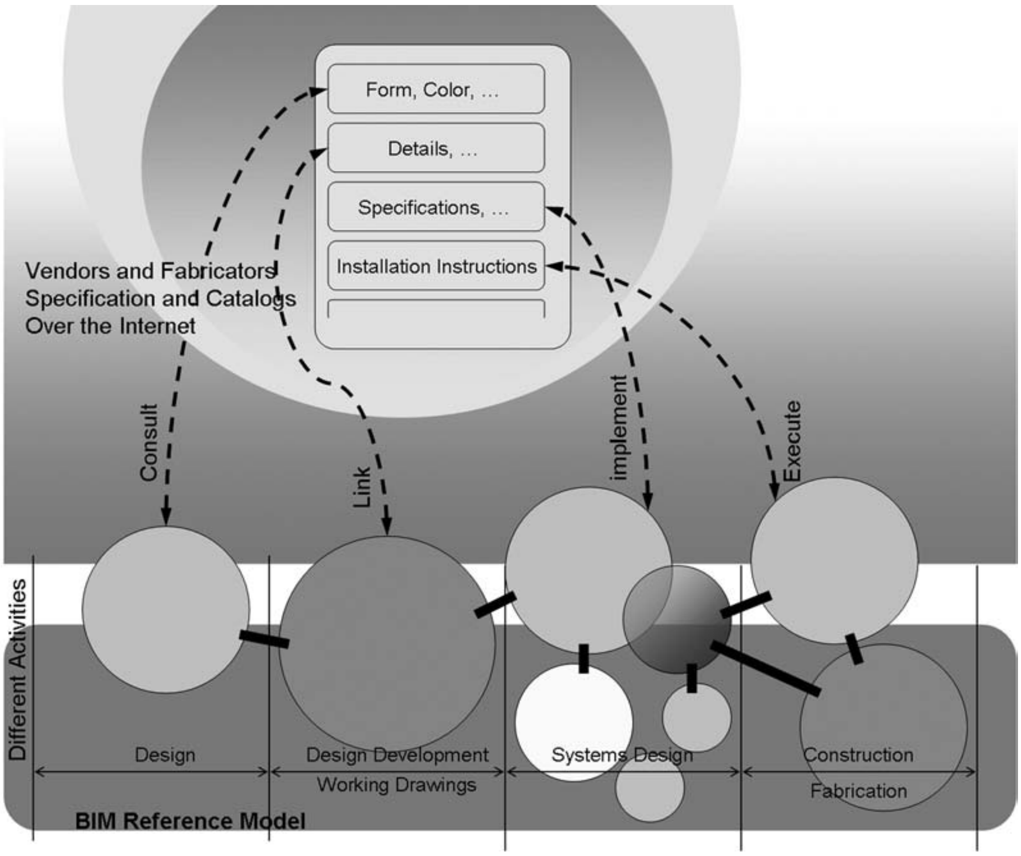

Figure 2. The Distributed Model.

This system can be realized by letting the objects in the designer CAD building model refer to the position of the information about itself on the web site of its vendor or fabricator. The designer, in the early design process, would make a decision about which element and component to implement in his building design. The information retrieved from the web page is enough for this stage, where the visual aspect of the element is of more importance to the designer than the technical information.

In the design development phase, the same designer or another, will be able to retrieve more information about the same object as needed, these new information might involve the price for cost estimate, and other specifications such as fire rating.

In the working drawing phase, more technical information could be viewed as well as the price for cost estimate purposes, while in the construction phase, special installation instruction can be retrieved. Each bit of information is used by an application that is suitable for handling it. All using the reference to it from the original model of the designer who made the decision of selecting the object and linking it to the knowledge needed to represent it from a web page.

With this approach, if all the data is stored in a standard format such as XML format on the vendor web site, the interoperability question will be answered. As the need to convert the data between incompatible systems will be eliminated.

In his dissertation, Hyeonsoo Park (Park 2001) demonstrated the feasibility of a procurement system that depends on the Internet as a catalog depository of building components. The system suggests that the information about the element should be stored on the web site of the vendor or manufacturer, libraries of CAD objects, which represent manufacturers' products, are located in the distributed locations of multiple databases and made available to designers remotely over the web. It is expected that manufacturers using such a system be responsible for making their product available using XML, thus standardizing the method by which their information is retrieved by the designer.

The major benefit from such a system is that the information about the element involved in the building design is retrieved from the provider of the element, which guarantees the comprehension and consistency of the information through out the whole design and construction process. Such a system will keep the model as thin as possible, as the information is linked and not imbedded as well as insure that the latest information is being incorporated.

What has currently been realized by Autodesk's i-drop and Geometric Description Language (GDL) technologies enables the designer to choose from commercial part catalogs that can be used in design, these components mostly are geometry presentation, some are parametric, but mostly they are not smart CAD objects that can describe information further levels than geometry.

Conclusion

With current BIM CAD objects, the connectivity over the web could enhance the content of the drawing and guarantee coordination of information. Vendors could structure the information about their products in a way that makes the retrieval of relevant information to specific design tasks more direct.

Architects do not need to acquire all the needed knowledge as a structural engineer to model the structural systems in a BIM based CAD system, nor all the technical knowledge to detail components that do not affect the final look of the building, on the contrary, architects tend to use catalogs of vendors to select components and use the offered details if it is suitable for the job.

The BIM CAD systems would either become super containers for information about building elements, or a referential model that points to the information when needed.

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