A WEB-BASED APPROACH TO TRANSFERRING ARCHITECTURAL INFORMATION TO THE CONSTRUCTION SITE BASED ON THE BIM OBJECT CONCEPT.

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Abstract: The current means of transferring architectural data to the construction site depends mainly on the drawing either manually or electronically drafted both in physical or digital formats. The printed or manually drafted drawing is being replaced with the digital version that can be accessed with a PDA. There are many benefits of the digital form over the physical form. However the full potential of this medium has not yet been fully exploited. The new CAD paradigm, BIM (Building Information Modeling), suggests that all the building information can be represented as a digital database that constitutes the information about the building elements as three-dimensional geometry, as well as, properties and specifications in the form of objects. This paper describes the process to convey the information about the CAD objects to the construction site through the web by extracting the properties of the objects into an XML file which can be queried for the needed data.

1. Introduction:

It is understandable that the A/E/C industry still uses the current familiar and well developed representational system of the building information following the legacy of the drawing. Hence, the current BIM-based CAD packages designed for architects are capable of producing professional two-dimensional drawings from a three-dimensional data model almost automatically; this is a great enhancement to the current drafting paradigm, and a real change in the way data is represented, created and modified but not to how it is presented.

With the emergence of BIM-based CAD, comes the concept of CAD objects, which are different from the drawing entities that are used to represent lines and arcs in conventional CAD system.

1.1. CAD OBJECTS

Objects are digital representation of the real world building elements such as walls, columns, doors, windows and slabs. With the object come both the geometrical information that describes its shape and dimensions, as well as, its specifications and behavior.

An object from a computer science point of view is an independent procedure that contains both the instructions and data to perform some task, and the programming code necessary to handle various messages that it may receive.

While most of the current drafting CAD packages are object-oriented programs; the objects they provide are only graphical objects or "drawing entities". Although such objects may have all the concepts of programming objects, they are used mainly to draw a representation of well-understood drawings of highly symbolic information about the building. It is upon the architect to interpret the meanings of what is drawn, in the exact same way as with physical drawings.

With the BIM generation of CAD systems, embedded information can describe the geometry, as well as, materials, specifications, code requirements, assembly procedure, price, manufacturer, vendor and any other related data associated with how the object is actually used. A door as a smart object also understands its relationship to a wall and reacts accordingly.

1.2. TRADITIONAL RELATIONSHIPS:

For communicating the building information, the A/E/C industry still depends on sets of drawings that might reach thousands in numbers where every drawing attempts to present part of the information about the building; a set of drawings for each floor, showing architectural walls, doors, windows, stairs and columns, another set for the electrical wiring, and a third for mechanical and plumbing along with tables, schedules and lists of specifications and sizes. With this arrangement, there is a great amount of information that is combined on the same drawing and in the same time there is other information that does not exist in that specific drawing, creating the need to carry detail and specifications books along with the drawings set. The vast amount of drawings also creates a management problem for the architect, since all these drawings have to be coordinated and revised, and for the contractor, as all of them have to be reviewed to guarantee the correct execution of the building.

With such a system there is no way to isolate individual building elements to view as needed, everything has to be viewed in the context of the floor plan with reference numbers to the details book for a specific details, for example, a cross section of an expansion joint might not be available on the plans of a building but in a details books with a reference number on the

plan. The relationship between the viewer and the needed information is not defined in such a system; it is the viewer's responsibility to find the relevant needed data.

This arrangement does not consider the nature of the part which receives the data whether an engineer, a contractor or a construction worker; it is not user specific. The same level of information and detail is laid down on the printed paper or in the two-dimensional CAD file on a portable computer. It does not take into consideration the different level of detail needed in each construction phase. An incremental display system capable of showing different levels of details as needed would be more versatile in such a situation. At the construction site it would be useful to the worker in charge of installing doors to see the information related to his job together in an integrated view that does not contain other information about other building elements unless asked for.

The architectural information in a construction document does not only contain graphical information but related textual information as well. Moving between these two types of data representation should be seamless through the same interface, which is not feasible in a paper based system.

1.3. THE DIGITAL MODEL

The movement back and forth from a drawing to another document can be eliminated in the digital format by having hyperlinks to related materials. Hyperlinks will not only connect the information together but also will connect external information resources to an element in the drawing.

The digital model should not be just having the same DWG, DWF or PDF file on a PDA at the construction site, but it should be a browser of building elements where the user can navigate his/her way through the items in an efficient manner. Initially, this will not replace the drawing, but it would replace the need to look for information in different documents. Ultimately, this approach could completely replace paper drawings.

More and more information can be added to the digital model that can be used directly in the construction process, for example, positioning a façade cladding piece if the three-dimensional coordinates needed to place it were easily transferable to an automated crane.

With such a system, there is the potential of retrieving more information about the parts from the web as well; therefore, facilitating the process of providing the latest updates without the annoyance of versioning the paper drawings.

2. From the construction site up

The current CAD tools are designed to follow the legacy of drafting and drawing production. Although the latest BIM is a major advancement over

the older drafting CAD, it follows the same legacy of how drawings are prepared. Instead of looking at what can the new medium best do, these packages look at the problem from the point of view of the architect at the office whose job is to produce drawings for bidding, not the entire picture of the whole process of constructing a building with the architect as one member of it. Accordingly, the final product of these systems is drawings, either printed or in digital formats like PDF or DWF. Although the drawing legacy has been around for centuries, this does not mean that it can not be replaced with a different model that makes better use of the current technologies and better fits current needs.

The construction process of the building should be considered in the system that creates and prepares the data for it. It might be better to look at the process from where it ends; the construction site.

By looking at what the construction site needs and how the data is produced in the BIM model, the concept of the drawing as we know needs to be made more dynamic.

For example, the building data as objects in a BIM CAD system can be browsed directly instead of printing it as plans, section and elevations. Or the information that is needed for fabricating some elements can be digitally transferred directly to the fabricator such as steel sections, without being printed on paper.

With the existence of the internet, linking to resources in a web site becomes very useful and the information does not have to be in its entirety in the drawing, but only linked to through the web. Such a concept has been partially realized by the GDL and i-drop technologies by Graphisoft and Autodesk respectively for a similar function, but it was completely geared toward the drawing creation.

3. The transfer system

This research project describes a mechanism to transfer the building data from the architect CAD package to the construction site directly by means of the web. The concept depends on using the notion of objects to navigate through the building components.

[0]Using web server technologies such as CGI and PERL as a programming language, and drawing data files that is written in XML, a system can be created to automatically convert object-based CAD files into XML which can be accessed through the web.

3.1. THE BENEFITS:

1. A user specific data presentation, the data can be organized into categories that defines the needed portion of it to the user.

2. Can guarantee the hierarchy of rights to see the data. Every user has different authorization for different parts of the data.
3. Situation oriented data, for example, a contractor might not need the geometry information about an item for procurement, but will definitely need the price and vendor information.
4. Linked data display, as it is displayed in a browser, the links can lead directly to other useful resources such as a specification sheet in DOC format or installation procedures as PDF or HTML.

3.2. THE GOALS:

It is imperative to define the goals of such a project as its functionality can be achieved through a variety of technologies with different degrees of sophistication and cost. The goals for this project were set taking into consideration the research aspect of the problem and not a commercial solution, as well as, the ability to demonstrate the concept not to execute it in a professional quality. Consequently, the goals of this research project are:

1. A cost effective approach to browse the building elements information using standardized technologies as much as possible.
2. An easy to use system where advanced skills are not needed to operate, which makes it suitable for everyone at a construction site regardless of their skill level with computers.
3. To show both textual and graphical information about the object being displayed.
4. To show related information as hyper links that is accessible through the same interface.

3.3. THE SYSTEM COMPONENTS:

Three platforms are needed:

1. For the BIM CAD system, we experimented with Autodesk Architectural Desktop 3.3. While it is not a real BIM solution, it utilizes the concept of objects for many architectural elements, as well as, its ease of customization and the possibility to write code that can run and perform functions on its data. Within the environment of AutoCAD, Visual Basic for Applications (VBA) is used as the programming language for the routines needed to extract the data.
2. A regular web browser that is capable of correctly rendering forms and running applets; we used MS Internet Explorer 6 because it is widely available and can be obtained at no cost.
3. PERL as the programming language that will run on the server side to answer the form requests. The choice of PERL was based on the wide availability of it on most servers and its relative simplicity, as well as, its native support for text processing which makes it well

suited for processing XML. As PERL is free, there is no charge for developing application based on it.

3.4. XML

XML or Extensible Markup Language is a meta-markup language, in which it is possible to develop your own tags. These tags must be organized according to certain general principles, but they are flexible in their meaning. XML is a text based standard for data structuring. It is a set of rules for forming semantic tags that break a document into parts and identify the different parts of the document.

For the data files, the choice was the XML format for the following reasons:

XML is verbose by design. Since it is a text format and uses tags to delimit the data, XML files are nearly always larger than comparable binary formats. That was a conscious decision by the designers of XML. The advantages of a text format are evident; it allows anyone to look at the data without the program that produced it. Text formats also allow developers to easily debug applications and the disadvantages can usually be compensated at a different level as disk space is less expensive than it used to be. In addition, communication protocols such as HTTP the protocol for moving hypertext files across the Internet, can compress data on the fly, saving bandwidth as effectively as a binary format.

XML is license-free, platform-independent and well-supported, so by choosing XML as the basis for a project, it gives access to a large community of tools and engineers experienced in the technology. Opting for XML is like choosing SQL (Structured Query Language) for databases: programs and procedures still have to be built to manipulate it, but there are many available tools and people who can help. And since XML is license-free, software can be built around it cost free.

Another reason for using XML is that it makes it easier to share the information with other applications. One of the goals of this research is the possibility of communicating with other systems and sharing the information more effectively, as a result XML will be the best candidate for the intended functionality.

Autodesk's DesignXML was not considered because it is directly related to the AutoCAD DWG file format; it was developed to replace the DXF format on the web. It is meant to communicate the type of information that AutoCAD as a program needs. Although it describes the objects in an adequate manner, the overhead data that is relevant only to AutoCAD makes it unpractical to use.

It is better to set up a set of needed tags for the required function instead of utilizing a standard that was developed for a different function.

3.5. HOW THE SYSTEM FUNCTIONS:

As shown in Figure 1, the process begins by preparing the documents in the content creation program; the BIM CAD system:

1. After the designer finishes working on the file and gets prepared for printing the drawings, the designer will run a VBA macro inside the system which will go through every object of the drawing and extract the needed information about it and encode an XML file.

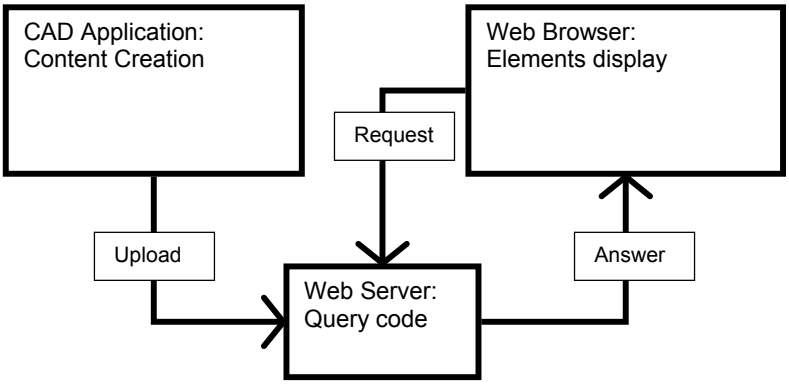

Figure 1. The relationship between the three parts of the browsing system

2. That file will be send to the server via FTP where it will reside until needed by a viewer from the construction site.
3. When a viewer needs to browse the information, using the web browser, he/she logs to the system start web page where a welcome statement and instruction on how to use the systems is displayed.
4. By clicking START the viewer is running the PERL programs over the server side which will dynamically creates HTML code and send it back to the browser.
5. The viewer then will have to define the project, the floor and then the element category he/she wants to see. The program looks for the specified file and passes the path to the next HTML screen.
6. By clicking the wanted item (Figure 2), the program will query the XML file for matching criteria and return a list of all the properties of the object together with a diagram showing the object graphically.
7. This process can be done as many times as needed until the required piece of data is reached.

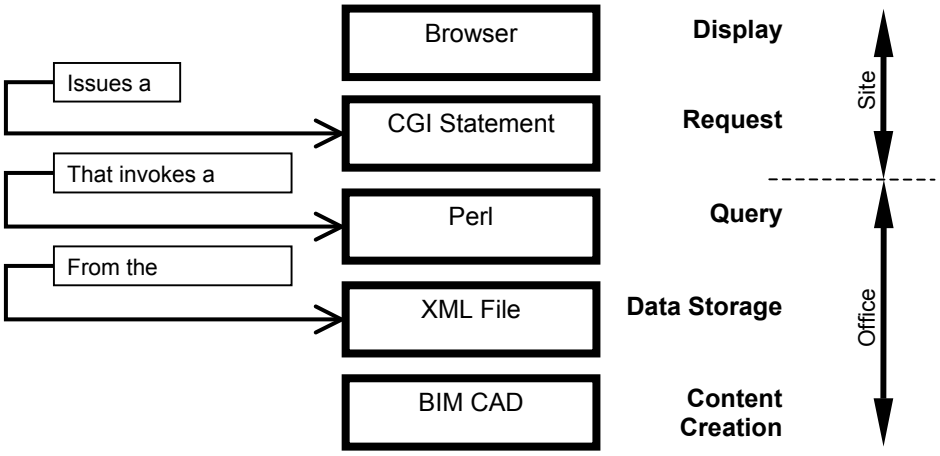

Figure 2 .The process of retrieving the information from the XML file through the web

The data files and hence the program querying them is structured by element type. Every file is a separate floor of the building, browsing the data will require the user to specify the floor first then select the items needed to display.

The system will display a list of all available items specified, then the user will have to select the desired item to see its properties and draw its geometry.

For example, a construction worker who installs a window can locate the position of the window from a drawing, and by browsing the building elements on the browser, the worker can find all the needed information about that window, from position, dimensions, details, to the installation instruction posted on the web page of the vendor.

Conclusion:

There are some concerns that should be addressed in the conclusion of this paper:

Autodesk Architectural Desktop 3 is not a real BIM CAD package, although it utilizes some AEC objects. ADT is better classified as a representational CAD, unlike Autodesk's Revit or Graphisoft's ArchiCAD which are real building modelers. For that reason, ADT does not include all building elements as objects.

Some building elements are harder to define than others. The elements that can be objectified can easily be separated into units. Other elements can be objectified in detail but can not be quantified as units such as brick walls.

The redrawing of the geometry of the object on the HTML page requires the implementation of a viewer. As the DWF viewer is only two-

dimensional and requires pre-preparation, we were looking for viewers that can reproduce the three-dimensional quality of the model on a web page.

We can conclude that the proposed XML-based system is capable of demonstrating the possibility of transferring the object information to a distant viewer, which validates the concept of the research.

It is feasible to depend less on the paper drawing and details and specifications books in favor of the digital solution which, if correctly implemented, could better serve the industry information delivery system.

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