A Plan for Intuitive Virtual Reality Retrieval and Annotation of COBie

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Abstract- Construction Operations Building Information Exchange (COBie) is a rapidly evolving standard to capture information electronically during design and construction, to provide it to facility managers. COBie eliminates the current inefficient process of transferring massive amounts of paper documents (such as manuals, warranties and usage guides) to facility operators. COBIE eliminates the need for post-hoc as-built data capture and helps to reduce operational costs. This information is essential to support the operations, maintenance, and the management of the facilities assets by the owner and/or facility manager. Following Construction Closeout the COBie document then forms a live data set for continued use by facility managers to find, access, and update relevant maintenance documents. One method for accumulating COBie data is to annotate Building Information Modeling (BIM) documents which encompass both the architecture of a structure and the properties of each sub-system such as doors, heating and cooling units, and fixed electronics such as projectors. BIM documents are an attractive target for accumulating COBie data but BIM software such as AutoDesk Revit™ is complex and beyond the expertise of most construction and facility managers. This barrier to wider use of COBie can be overcome by proving intuitive interfaces for non-expert users to search, access, modify and add data to the underlying BIM dataset. One highly intuitive interface would be to allow facilities managers to "walk" through their building as Virtual Reality avatars. Selection of the correct COBie object to view or modify would then be enormously simplified as the virtual representation in the virtual BIM building found in the same location as the real object in the real building. This paper discusses the plan developed in collaboration with The United States Army Corp of Engineers (USACE) -Engineering Research and Development Center (ERDC) – Computer Aided Drafting/Building Information Modeling (CAD-BIM) (ERDC CAD-BIM) researchers and an early prototype of a virtual environment in which COBie annotated buildings can be imported, traversed by users in a natural and intuitive way and annotated with ongoing changes to COBie objects.

Keywords: Virtual Reality, BIM, Web-Based, COBie, Management

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Introduction

Beginning in the summer of 2009 an interdisciplinary team of students and faculty from The University of Southern Mississippi (USM) Schools of Construction and Computing began meeting with research staff from the USACE ERDC-CAD/BIM Technology Center for Facilities, Infrastructure, and Environment to explore possible collaboration and ways that USM could contribute to the CAD/BIM Center's mission as shown below:

> **CAD/BIM Center Mission:** Coordinate the use of computer-aided design (CAD) and building information modeling (BIM) activities for facilities, infrastructure, and environment within DoD. This coordination include setting standards, promoting system integration, supporting centralized acquisition, and providing assistance for the installation, training, operation, and maintenance of CAD and BIM systems. The CAD/BIM Center also directs specific applications development, promotes communications, development and standards, furnishes technical advice, interfaces with professional organizations and industry, evaluates technological developments, and recommends necessary CAD and BIM policy to ensure that maximum benefits are received from these technologies.

One area for contribution by the USM team was the exploration of novel approaches and technologies particularly in new and expanding areas of effort. One area of great current interest to USACE is Construction Operations Building Information Exchange [COBie] which is an extension of Building Information Modeling [BIM] to encompass the needs of the facility management.

Currently exchange of information between construction managers and building managers is a physical exchange of paper documents. These documents contain the necessary information to support the operations, maintenance, and the management of the facilities assets by the owner and/or property manager. This is an inefficient process that involves not only the cumbersome exchange of mass quantities of paper (and the subsequent problems of moving and storing this paper), but also because the information on this paper is collected at the conclusion of a job, requiring that the previously created information must be updated/recreated to adhere to the variations to design plans that normally occur during construction and commission. [1]

COBie solves the issue of moving and storing physical copies of paper by condensing this information into as a spreadsheet. One problem remains a barrier to wider adoption of beneficial COBie technology ~ how to accumulate COBie data in an effective manner and how to access this data easily once a building is completed. BIM documents are an attractive target for accumulating COBie data because BIM software is intended to coordination data related to building design, simulation, and construction. A graphic showing the lifecycle of COBie data as part of a BIM document is shown in Figure 1.

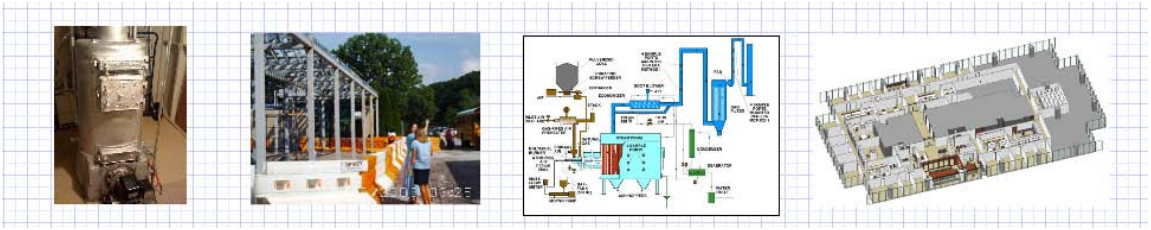

Figure 1. Lifecycle of COBie data which is attached to an object in a BIM document during construction and is then be retrieved and updated during the useful life of the completed building.

A BIM's 3-D graphics of buildings and systems are generated by data that can be easily changed as the project develops. Most BIM software links intelligent objects together, so when a change is made to one object, parametric changes are made to any other objects that are linked. For example, if an engineer changes the height of a door, the corresponding frame and door knob automatically change.[2] However, BIM software which includes both the features of an advanced CADD drawing software and a data repository requires a high level of training to use comfortably. BIM software such as ArchiCAD [3], shown in figure 3, is currently used most frequently by architects who have a great depth of experience with various types of similar CADD software.

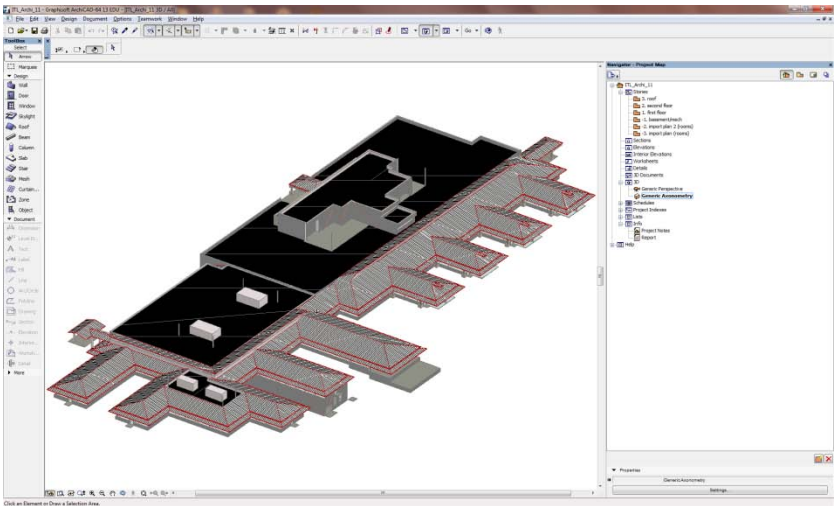

Figure 2. USACE ERDC Information Technology Laboratory (ITL) in ArchiCAD (with permission from the ERDC CAD/BIM Center).

Working with the ERDC CAD/BIM center the interdisciplinary USM team of faculty and students from both Construction and Computer Science have develop a plan and working prototype for a more intuitive COBie data entry and retrieval interface using the "Building Blocks" Collaborative Virtual Reality platform. This paper describes the early development of Building Blocks, its use for COBie data entry and retrieval and current and future progress of the project.

Building Blocks

The Building Blocks platform is intended as a general platform for the development of BIM-related collaborative applications for Architecture, Engineering and Construction (AEC). Most of the technical details of the implementation of Building Blocks developed at the University of Southern Mississippi are beyond the scope of this article but an overview of the rendering technology and client-server architecture is important to the plan for intuitive COBie retrieval. Building Blocks uses the O3D [4] scene graph engine which is a WebGL [5] implementation developed by Google. O3D features hardware supported rendering in a web page as shown in Figure 3.

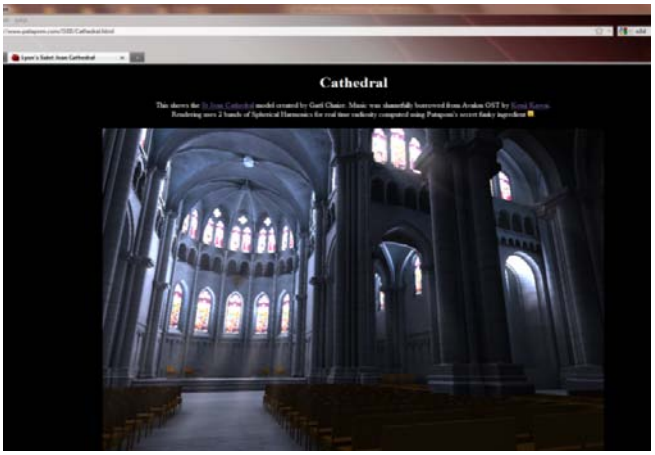

Figure 3. A Sample of O3D rendering on a web page showing high quality graphics and graphics card support for advanced shadowing and shading [5].

Rendering through a web page is convenient for development as both the user interface and the graphics engine are programmable in Javascript and hosted web pages with O3D content are easy to distribute to end users who will not need to install new software. Figure 4 shows an early version of the Building Blocks environment running on a maximized web page with both 3D rendering and controls developed in Javascript.

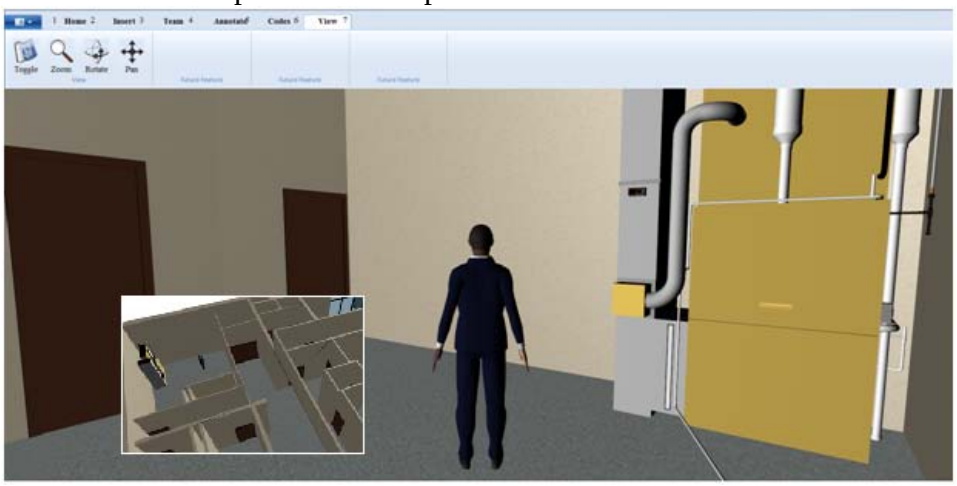

Figure 4. The Building Blocks environment showing a mixture of ribbon controls and 3D rendering coded in Javascript (models used with permission from the ERDC CAD/BIM Center).

Building Blocks is a collaborative environment accessible through Internet with a web browser in which multiple users can interact and see each others' actions in the Virtual World. This functionality is provided by a modularized server which currently provides replication, shared inventory and various load and save functions for models and entire scenes. Each client running on their own browser window sends automatically messages to the server about changes of positions or actions such as adding an annotation to an object so that users can collaborate and share a single virtual space as shown in Figure 5.

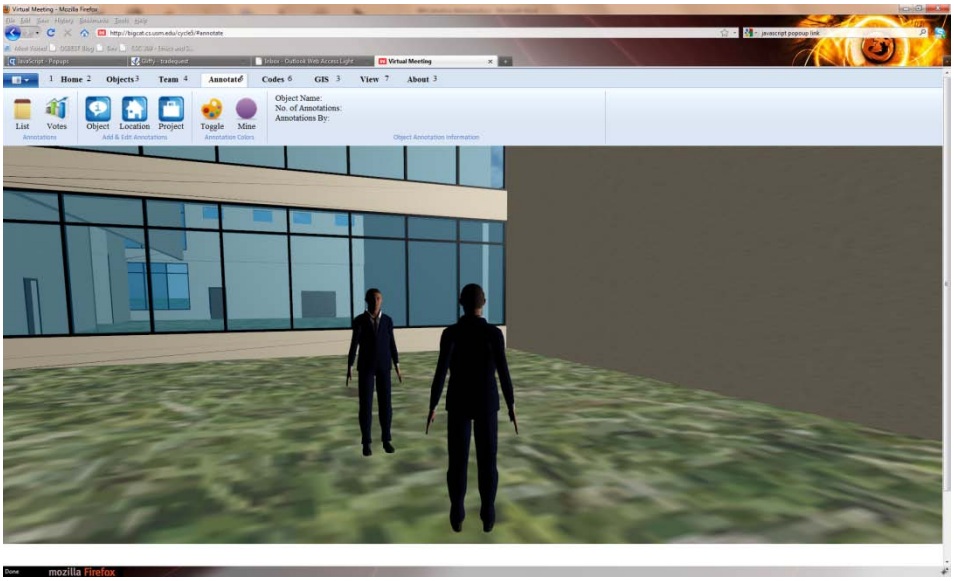

Figure 5. The Building Blocks environment showing multiple users interacting which is provided by the replications server.

Intuitive BIM Retrieval

The idea of intuitive BIM retrieval is to use the Building Blocks platform for provide an avenue for Architects and Construction Managers to add COBie annotations and links to a BIM model and for Facilities Manager to be able to retrieve this information in a Virtual Reality representation of the actual building. In order to develop this capacity the USM team first developed an exporter for Revit [6] one of the most widely used BIM software packages. The Revit-O3D exporter translates the 3d objects in the BIM model to JSON [7] an executable text format which is easily rendered by the Building Blocks client. BIM components such as columns, air-conditioning units, elevators, etc as well as materials such as concrete, carpet, etc are translated to O3D materials so that various building elements and materials are well represented. The exporter also translates the local Revit database format to MySQL[8] and writes out all BIM and embedded COBie information to the Building Block Server. Figure 6 shows a diagram of the Revit/O3D exporter.

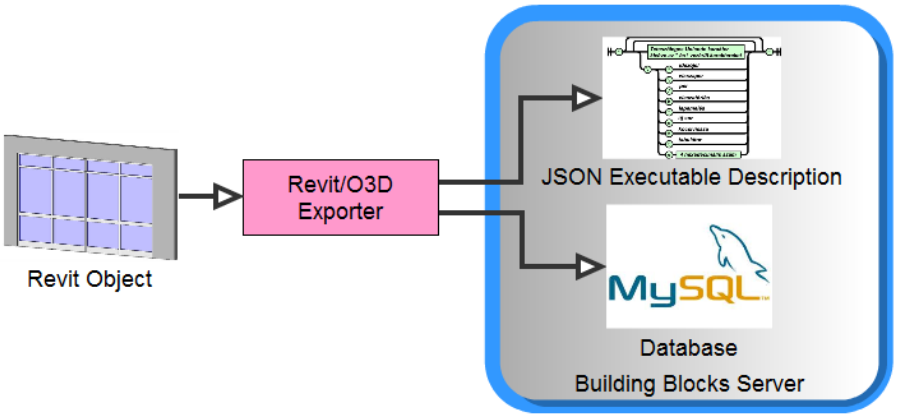

Figure 6. Diagram of Revit/O3D exporter showing object 3D characteristics being translated to JSON and other object properties being stored in the server database.

Object indexes from Revit are preserved during the export process so that each item in the virtual environment has a unique embedded ID number. This number is retrieved when a user clicks on an item and used to query the server database. Selection of items in the 3D virtual environment from a 2-diemnsional view is achieved by the O3D "picking" library which calculates a ray from the users current position, view and mouse click to determine which object the user intends to select. BIM and COBie information such: maintenance requirements, part replacement specifications, finish information, etc are attached to the elements of the building which after the user click on them are retrieved and displayed in the environment as a popup. This process is shown in Figure 7.

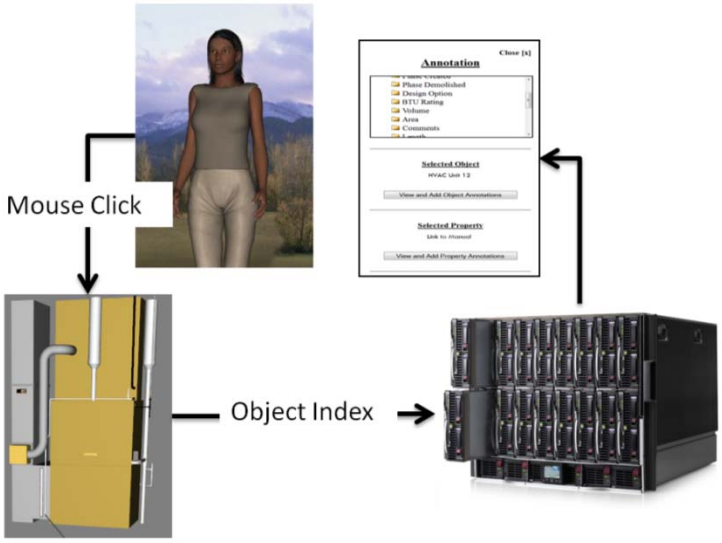

Figure 7. Retrieval of BIM and COBie properties using embedded object IDs.

Changes to COBie information can then be returned to the BIM model repository using an import (or round trip) tool currently under development.

From this basic architecture the focus is now extending the usability of the concept with the following functionality:

1) In-world search by name, category, locations, users, date of entry etc...
2) Clickable listing of all annotations which brings the user to the proper Virtual Reality location
3) Filterable floating indicators to show embedded information

Also, the use of Virtual Reality for COBie retrieval opens up many new possibilities for visualization of buildings during the facilities maintenance phase such as the experimental "ghost view" shown in figure 8 which allows users to quickly scan for information by looking (and walking) through walls.

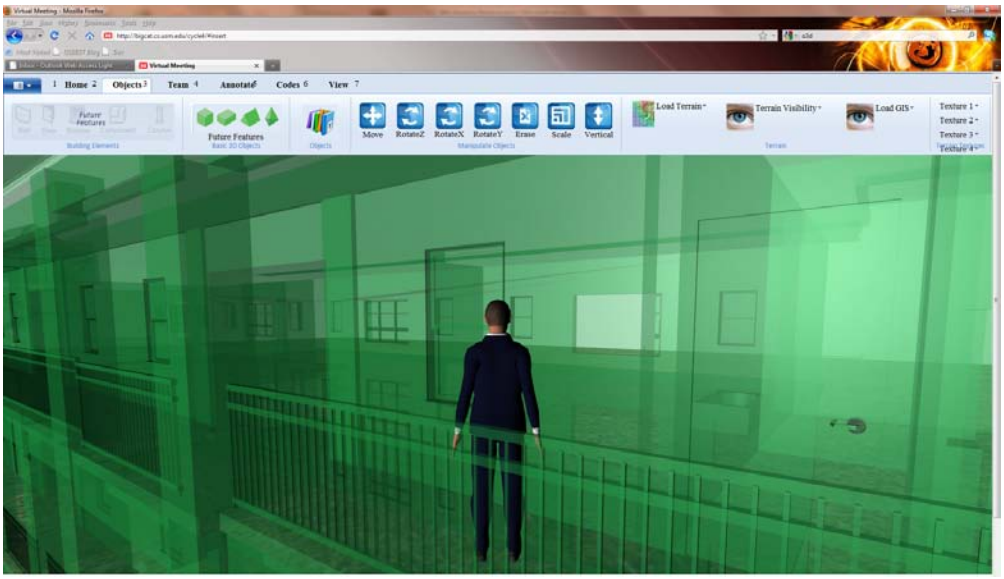

Figure 7. Experimental "ghost view" which could be used with floating indicators to quickly scan for embedded COBie information.

Summary

Construction Operations Building Information Exchange (COBie) is a rapidly evolving and could be the missing link to extend the benefits of BIM to the complete project life cycle from conception to decommissioning by providing value information to all stakeholders without requiring extensive specialized training in BIM. The stakeholders can access the Building Block developed as part of this project using a web browser and take advantage of the BIM benefits with simply navigating in a virtual reality environment and selecting building elements to obtain additional information. Although, it is very early to be able to determine the full impact of this new technology, both the University of Southern Mississippi and The United States Army Corp of Engineers (USACE) -Engineering Research and Development Center (ERDC) – Computer Aided Drafting/Building Information Modeling (CAD-BIM) (ERDC CAD-BIM) are very encourage with the preliminary results of the prototypes.

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