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Developing 6D BIM Energy Informatics for GDL LEED IFC Model Elements

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Abstract

The Geometric Description Language (GDL) is a computer-programming language that allows for the creation of GDL based object libraries used in Building Information Modeling (BIM). GDL objects are parametric objects and they contain all the information required to describe architectural building elements such as 3D geometric model, 2D CAD symbols and texts. The information in GDL objects is organized in a structural tree hierarchy, based on the Industry Foundation Class (IFC) schema. Using GDL objects allow the creation of many additional building information and parameters that can be embedded into model elements present in designs.

Described in this paper are two methods for the creation of custom GDL objects; (1) utilizing GDL script and (2) modeling the 3D object using 3D modeling software, e.g. 3ds Max. Also, describe by the author are the creation of LEED (Leadership in Energy and Environmental Design) related model element parameters using the IFC, GDL, and LEED model element parameter writing GDL script. The author has developed a prototype BIM model that contains GDL objects embedded with LEED related information and actual cost of architectural design and construction products. Currently under development is a Virtual Reality LEED related IFC compliant software applications so that sustainable built environment information, utilizing one IFC model, can be interoperable with BimServer and Virtual Environments that can produce cost and energy simulations from the parametric data within the object-oriented parametric BIM model.

Keywords
GDL, BIM, IFC, IFCXML, LEED

1. Introduction
The importance of a BIM model element is it allows for the input of critical information needed during the whole facility life cycle. Information is what BIM is about [5]. Information is embedded into a model element by entering information into the model element parameters (Figure 2).

A BIM software tool that is fully interoperable, IFC compliant, must support the IFC and/or IFCXML file format and schema. IFC allows the interpretation of model element data via the International Alliance for Interoperability (IAI) now known as BuildingSMART. IFC LEED parameters added to the GDL model elements are the focus of this paper, but at this time there is no direct LEED schema for the Industry Foundation Classes (IFC) to support the interoperability of the LEED model element information (Figure 2). The author has developed other methods for sharing the IFC LEED information for BIM via custom software application by utilization of virtual environments created using game engines, e.g. Torque 3D, XNA for Xbox 360, and Unity, and the use of advanced databases linked to the BIM.

The author has embedded cost into the model element parameters of the GDL objects for 4D and 5D BIM simulations. The *virtual cost* embedded into the parameters represents the *actual cost* of the product to be erected on the construction project site. The prototypes also demonstrate that the creation of LEED information plus cost embedded into the GDL model element parameters reflects a LEED cost relationship using a Sixth Dimension know

as 6D created by the author and the concept is provided in recent papers by the author [6]. Other 6D papers are prepared for publishing during spring of next year for they are still under review.

In the future more GDL object custom parameters created by users will be IFC interoperable if more sub-set schemas are developed by the International Alliance for Interoperability (IAI), Model Support Group (MSG), and other methodologies are developed. The author is currently researching and experimenting with the creation of new sub-set schemas for the IFC to be proposed to the MSG. The author believes sustainable built environment information should be interoperable via the IFC schema to provide more efficiency and cost benefits for the Architecture, Engineering, Construction, Facility Maintenance and Operation Maintenance (AEC/FM&OM).

2. Background

Leadership in Energy and Environmental Design (LEED)

Internationally people are concern about energy, water, carbon footprint, indoor and outdoor air quality, harvesting of regional material, and disposal of waste. Buildings around the world affect the livelihood of all living species through their consumption of energy, resulting to pollution and ozone depletion [6]. Buildings are also consuming 5 billion gallons of potable water per day [7]. In the USA, buildings consume approximately 37% of the world energy, and 68% of the world electricity [1]. The author use LEED as a standard do to its wide acceptance among the AEC/FM&OM industries.

Geometric Description Language (GDL)

The author has developed a way to make GDL objects interoperable with other BIM software. GDL model element objects are stock model elements native to Archicad. The GDL Reference Guide [4] can be used to learn novice script and model from scratch or edit a stock model element parameters in the GDL editor in Archicad and save it as a custom model element .gsm file format in an embedded library, and export as IFC 2x3 TC1[3] to use in other software. This can eliminate the need to buy BIM model elements from third party proprietors to interoperate with software such as Revit. The custom model element can then be accessed to make copies and transfer the files to a database repository, e.g. a BimServer, for efficient data management and harvesting of each BIM model element via the IFC file format.

GDL contains all the information necessary to completely describe building elements as 2D CAD symbols, 3D models and text specifications for use in drawings, presentations and quantity calculations, e.g. 4D and 5D BIM. GDL is also an intelligent model element object technology that offers a new and efficient way for building component manufacturers to market their products on the via CAM, Internet or CD-ROM, similar to the IFC product models that are shared in the same way. The GDL becomes IFC upon IFC export from the BIM Software Application. The selection of building components during the design phase benefits both the architect, who can design using real-world objects, and the component manufacturers, who can provide product information to support the design process. As the infrastructure for digital communication grows rapidly, higher demands are raised upon intelligent 3D formats and catalogs for describing building components.

Main Features of GDL are:

Optimized for the Internet -
The GDL is a parametric object oriented languages that can create objects that are easy to access and easy to manage on the Internet. GDL-based electronic product libraries require little effort for their maintenance, which means it is easy to keep information on the website up-to-date.

Flexibility and Control -
GDL objects can be used on both the Macintosh and Windows, and are able to export product data in the common CAD file formats including DXF and DWG and the emerging industry standard IFC.

Integration with Building Design -
The selection of building components during the design phase benefits both the designer, who can design using real-life objects, and the component manufacturers, who can successfully market their product at an earlier stage in the

design process. This also leads to the opportunity of this information being reused for COBie, COBie2, SPie, LEED, IFC 2x4, etc.

Product placement -
Manufacturer's data are included in the GDL object information, which means product-specific information is available not only to the designer, but the facilities manager and all other building professionals who need access to such information throughout the building's life cycle.

Cost savings -
GDL is an IFC compliant open standard and easy to learn and use, so the initial development and maintenance costs are low. Additionally, data conversion is automatic, so there is no need to recreate information in different formats such as DXF and DWG, e.g. A GDL library repository on a web server.

3. Methodology

An example of a parametric 3D BIM model element is a GDL object model that allows the input of created data into the model element parameters (Figure 2 & 3). Recent experiments by the author show that this information can be hard coded or developed utilizing a GUI. GDL allows the development of 3D objects via import from external model software. For this project 3ds Max was used as the modeling software of choice for the development of custom 3D models. 3ds Max was chosen by the authors for model creation because of its advance modeling techniques and Graphical User Interface (GUI), e.g. 3ds Max supports the export of curvilinear surfaces (NURBS), not to be supported by IFC until software developers advance the exporters to support the IFC 2x4 schema which applies NURBS and Manufacturer Data. Also, 3ds Max allows mesh modifications, which are strait forward via the GUI.

The newly created GDL model will retain all model information created and texture maps applied during the modeling phase. The author's graduate students have tested the round-tripping of these IFC GDL LEED model elements in different CAD Publishers and the results show now loss of data via the IFC file format. The suggested process is to export a 3ds file from 3ds Max and open it in as GDL script in supporting software. E.g. one can use the 3ds add-on for Archicad that can be found on the Graphisoft web site. The 3ds add-on will allow the user to open the 3ds and save it as a GDL Object. By opening the script of the GDL Object, the user can create new model element parameters and export as IFC 2x3 TC1. Once the new model element parameters have been save, the user can then open the model element settings and embed the appropriate cost, IFC, LEED, etc., information into the model element (Figure 2).

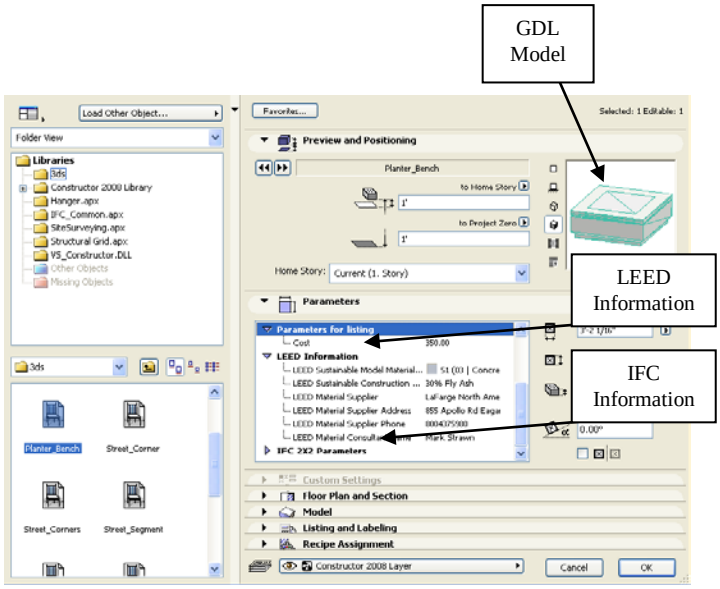

Figure: 2
(Custom GDL model in IFC compliant software application;
A view of a GDL 3D object Converted from 3D modeling software)

After the GDL model element is created it can then be used and added to the BIM (Figure 4). The importance of the GDL object is it can be used on the current project, reused on other projects because it is now in a database or library repository, and edited in the future if needed. Another rule of BIM is to not create anything more than once. In other words, "Do more with less" [8,5]. (Figure 4) shows a prototype IFC BIM with custom GDL model elements that contain cost, LEED, and IFC information that allows the interoperability of LEED cost information in an IFC compliant software application.

4. **Results**

The LEED IFC information was tested for IFC compliance. The Author used an open source IFC viewer and graduate student experiment that showed the LEED cost information relationship that can be used to estimate cost for LEED related construction projects, via the IFC viewer module application from TNO.

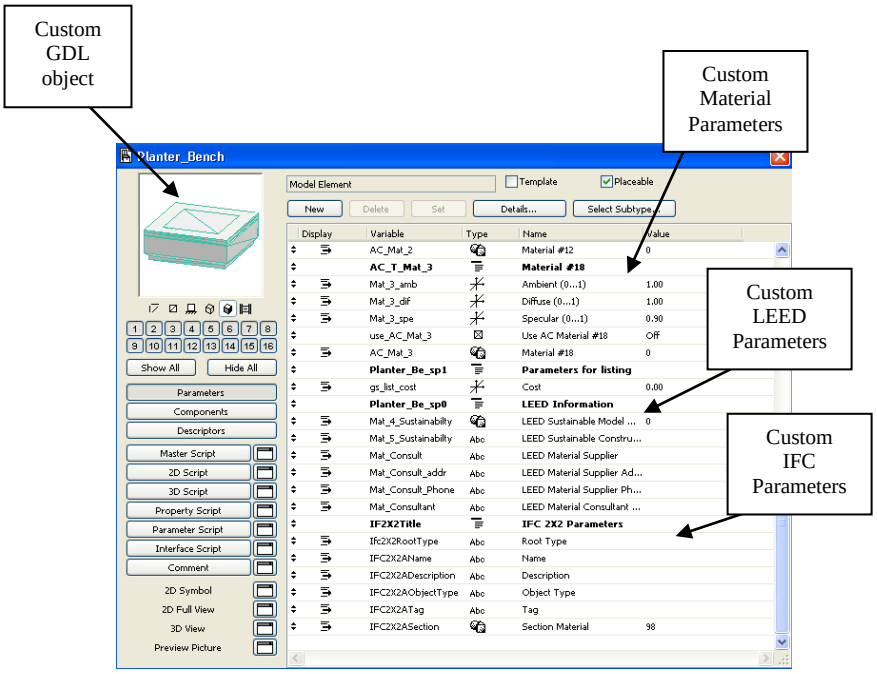

Figure: 3

(GUI Design for GDL Scripted Materials, Cost, IFC, and LEED)

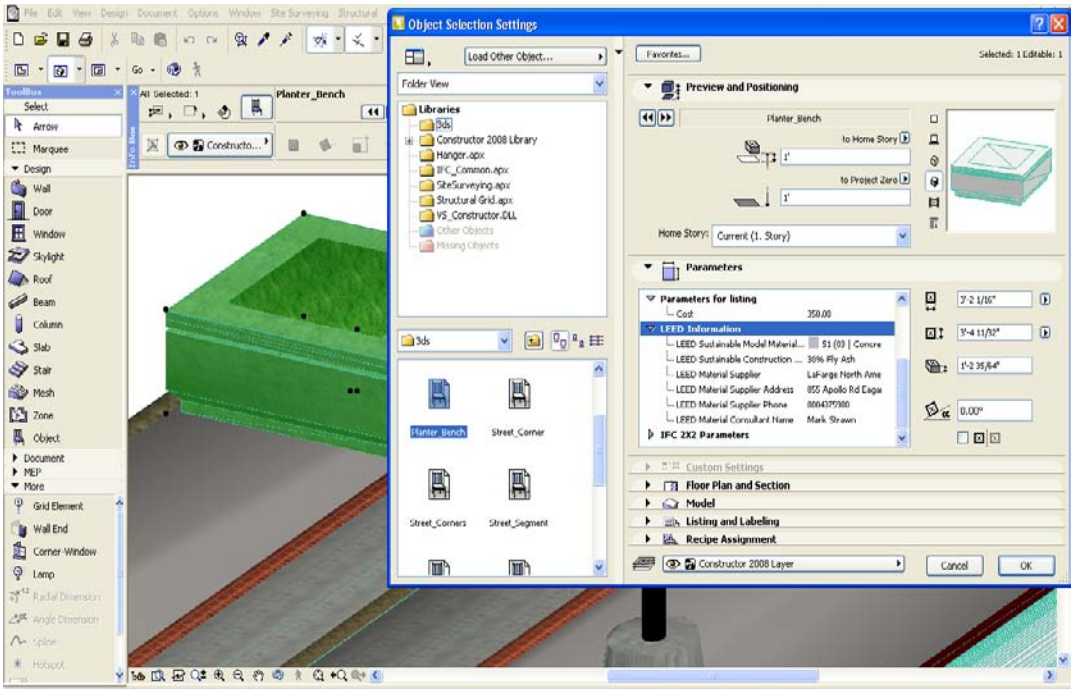

Figure: 4
(3ds Max converted IFC LEED GDL Object implemented into the BIM)

5. Conclusion

The author explains the use of GDL as an important methodology for the future of BIM technologies due to its open standards. With GDL's standardized and easily readable format, applications can be created easily to have interoperability with other common aspects of the BIM process. Therefore there is both a cost and time savings to the development process. The developer has the ability to use either GDL script, a GDL editing application, or both in order to create the GDL object and embed its necessary properties in the model. The information, most specifically the 6D energy information, e.g. LEED, is stored inside the object for easy extraction from a wide range of applications. Overall, the author believes this will lead to more efficient use of BIM in the area of 6D BIM development.

Future Work

Current future work by the author is a Virtual LEED Review System utilizing a Game Engine as the Virtual Environment and a 6D Energy Informatics databases for BIM. Also, using CityGML to create IFC cities for 6D BIM simulations. Other works include the development of BimServers and 6D historical databases based on IDEF ontology's and advanced parallel network topologies.

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