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# Sustainable Design of Buildings using Semantic BIM and Semantic Web Services

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**Abstract**

In response to the growing concerns about climate change and the environment, sustainable design of buildings is increasingly demanded by building owners and users. However, fast evaluation of various design options and identification of the optimized design requires application of design analysis tools such as energy modeling, daylight simulations, and natural ventilation analysis software. Energy analysis requires access to distributed sources of information such as building element material properties provided by designers, mechanical equipment information provided by equipment manufacturers, weather data provided by weather reporting agencies, and energy cost data from energy providers. Gathering energy related information from different sources and inputting the information to an energy analysis application is a time consuming process. This causes delays and increases the time for comparing different design alternatives. This paper discusses how Semantic Web technology can facilitate information collection from several sources for energy analysis. Semantic Web enables sharing, accessing, and combining information over the Internet in a machine process-able format. This would free building designers to concentrate on building design optimization rather than spending time on data preparation and manual entry into energy analysis applications.


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*Keywords:* Semantic BIM, Semantic Web Services, Sustainable Design, Energy Analysis.

## 1. Introduction


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The use of fossil fuels to produce the energy consumed in buildings has exerted a tremendous strain on the environment. Today, buildings are responsible for more than 40 percent of global energy used, and as much as one third of global greenhouse gas emissions, both in developed and developing countries (http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf). The large amount of energy used in buildings makes improvements in energy efficiency of buildings an important step for lowering carbon emission. Among the most important ways to improve building energy efficiency are [1] :

- Optimizing building's envelop, glazing and mechanical systems
- Proper building orientation and massing
- Optimized lighting and shading
- Use of passive solar and natural ventilation

In response to the growing concerns about climate change and the environment, sustainable design of buildings is increasingly demanded by building owners and users. However, fast evaluation of various design options and identification of the optimized design requires application of design analysis tools such as energy modeling, daylight simulations, and natural ventilation analysis software that require access to dispersed sources of data. The data obtained from various sources are often incompatible in terms of format. As a result, considerable time is necessary to assemble the data into a format that can be used by energy analysis programs.

This paper is based on the premise that disparate sources of data necessary for building energy analysis must be created using Semantic Web standards [2-4] and made available to energy analysis software as semantic web services [5] . Building energy analysis requires access to the building's geometry, material properties, mechanical equipment specifications, and climate information for the building location. This data must be available for automatic discovery and retrieval by building energy analysis applications. Semantic Web and Semantic Web Service technologies provide the information architecture for making large volumes of geographically dispersed data available to powerful computing resources, thus allowing the widespread automation of data access and analysis.

The objective of this paper is to present the architecture of a building energy analysis knowledge system that automates discovery and retrieval of energy related information. This would free building designers to concentrate on building design optimization rather than spending time on data preparation and manual entry into energy analysis applications.

## 2. Semantic technology and semantically defined building information

Semantic Web provides a network of connected data over the Internet that is machine process-able [6]. Semantic Web allows sharing information on the web [7] and drawing conclusions on data that are generated in other sources [8]. The graph data structure of Semantic Web enables applications used during design, construction, and service life of a building project to easily combine and connect geographically dispersed information related to the building [9,10].

In Semantic Web, ontologies are used to define the concepts and the relationships among the concepts in a domain [11]. A knowledge base is an information repository created based on an ontology for collecting, editing, and sharing information [12]. Computer applications that use semantically defined information must first import the ontologies that define the data and become aware of the organization of data. Semantic Web provides distributed knowledge based systems that can be easily integrated (http://www.obitko.com/tutorials/ontologies-semantic-web/ontologies.html).

Web service technology allows computer applications to communicate information over the Internet [13]. However, web services have a number of limitations: (1) they provide syntactic interoperability which requires data be transferred in a specific format, (2) interfaces of a web service must not change, otherwise, applications communicating with the service break, and (3) the content of a message exchanged with a web service cannot be interpreted by computers; this prevents any workflow automation. To add semantics to the content of a web service message, the content must be formally and explicitly conceptualized using ontologies.

To extend the capabilities of web services in the direction of dynamic interoperability, Semantic Web and web service technologies are combined to create Semantic Web Services. Semantic Web Service technology uses ontologies to semantically define web services [14]. This can automate service discovery, composition, and execution [15].