EnerXML – A Schema for Representing Energy Simulation Data

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ABSTRACT

The eXtensible Markup Language (XML) has recently become the W3C Standard for communicating data over the Internet. The e-commerce industry and several new software applications have embraced this technology taking advantage of the potential for re-usable and interoperable data. In order to take advantage of XML, each industry is coming up with standard tag terminologies such that the data can be self describing and understandable, independent of the application creating or using it. Adopting XML for energy simulation data representation would enable different simulation programs to work with a single data format and allow other applications to make use of this data or even produce part of this data. EnerXML schema is a proposal to standardize tag terminologies for energy simulation data such that applications interested in interoperability can provide an Application Program Interface (API) conforming to this schema. This paper presents an overview of interoperability issues, introduces the XML concept and describes the proposed framework for EnerXML schema.

INTRODUCTION

Energy performance simulation software requires extensive input data and modeling expertise. Several recent user-interfaces and data exchange techniques address some of this difficulty in using energy simulation tools (power DOE, visual DOE, EnergyPlus/BS-Pro). However, users – both beginners and advanced – are still faced with the fundamental problem of data gathering from several different sources which represent the data in different format and to varying degree of detail. For example, the building geometry information may be represented in an object-oriented building model such as an Industry Foundation Class building model (IAI 1997) or simply as a graphic primitive format such as a DXF file containing points, lines and arcs. Further, the material properties information is often obtained from catalogs and handbooks; however, if this data can be obtained directly from a manufacturer's web site at run-time, this can simplify data entry and provide up to date information for simulation. The growth of Internet applications and services provided by manufacturers and other service organizations provide a number of new opportunities that can benefit the future efforts in energy simulation software development. As more and more web-based applications are deployed, users may soon expect to submit simulation data as a collection of web addresses and may expect to receive an electronic mail containing the simulation results. This is conceivable and even practical with the rapidly evolving technologies and standards for web-based data communication.

INTEROPERABILITY INITIATIVES FOR ENERGY SIMULATION

Simulating the energy performance of building requires detailed information of the design and operating conditions of a building. The amount of data required and the accuracy of results vary depending on the assumptions and the nature of analysis techniques used. Over the past three decades, energy simulation software tools focused primarily on modeling and calculation for improving the accuracy of predicted performance.

Decisions on building geometry, orientation, space planning, envelope and occupancy made at the early design stages have a significant impact on the energy performance of buildings. At this stage, the information available is inadequate for modeling the building for detailed simulation. Because of time constraints and lack of appropriate tools, energy evaluation is often delayed until the detailed design phase when it is too late to consider any changes to the basic design decisions. During the past five years, the personal computing environment has provided great opportunity for simulation tools to be used in early design stages making it practical for developing user-friendly graphical interfaces and performing a complete annual simulation within few seconds.

Interoperable software solutions for the AEC industry are becoming a necessity to improve productivity and eliminate any error during data communication between the team members. Several attempts have been made to demonstrate the integration between CAD systems and energy analysis/simulation software such as AEDOT (Brambley et.al. 1988), COMBINE (Augenbroe 1994), and Softdesk Energy (Chassin and Gowri 1998). The challenge in integrating CAD and energy simulation has three important components: (i) user-interaction, (ii) data exchange and (iii) calculation methods. Graphical user-interfaces and detailed calculation techniques are available widely. The data exchange mechanism is where we have the most difficulty because of no common building models and lack of standards. Most current CAD systems are based on vector representations, which need to be collected and represented as primitive building components such as walls, windows and doors. This aggregation is fundamental to modeling the building whether used by a CAD system, energy simulation tools, estimating or project management software. The Industry Alliance for Interoperability (IAI) is addressing this issue and has published the latest Industry Foundation Classes (IFC 2.x) that can form the basis for representing a building model useful to all team members. The current data exchange mechanism used is STEP Part 21 files that adhere to the IFC building model. Toolboxes and interface techniques are being developed to assist software developers to work with this building model. The most recent effort in interoperable energy simulation is the IFC to IDF translator (Hitchcock, 2001) for the Energy Plus simulation software. The IFC to IDF translator provides a mechanism to transfer the building geometry, zone definition and other information from a CAD system to Energy Plus. Such translators are expected to be embedded in the CAD systems or other application software user interfaces for seamless integration with energy simulation tools.

The current IFC model representation in STEP Part 21 files require enormous programming overhead for the software application providing support for using the IFC model. However, if the software were to work with the native IFC building model, this overhead will be trivial. Due to the evolutionary and complex nature of the IFC model, it would be hard to foresee any native model implementations within application software. For the near term, interoper-ability using IFCs will be largely file-based data exchange between applications.

One of the most recent and more promising approaches is to represent data in an alternative format using an XML schema.

XML OVERVIEW

XML is a subset of SGML (Standard Generalized Mark-up Language). SGML was created 30 years ago in an effort to define a mark-up language for representing textual information. XML is often referred to as containing 80% of the functionality of SGML with only 20% of its complexity (St. Laurent, 1999).

XML is a meta mark-up language that provides a universal method for describing structured data. XML compliments HTML (HyperText Markup Language) in presenting data that can be easily understood and used by other simulation software applications. HTML uses a set of standard, pre-defined tags to render documents for viewing or displaying them in Internet browsers. XML allows users to create tags that can be used to mark-up data and Internet browsers use a style sheet to present the XML data for display. Different style sheet forms are used depending on the client – e.g. the same data may be displayed on a PDA (Personal Digital Assistant), web phone or a computer screen in different formats as required by the device. At the present time, XML data is often rendered using XSL (eXtensible Stylesheet Language) that can produce HTML code for display. Web browsers such as Internet Explorer 5.x support XSL style sheets for displaying XML data as HTML.

Though the current focus of XML community is in web-based services, XML concept reveals a more fundamental change required in application development from the interoperability perspective. XML adds a new, intermediate level of abstraction between the data source and the user-interface. Thus, if the data source happens to be an application, the user-interface need not be dependent on the data format specific to that application. This approach will enable a user-interface with the knowledge of a particular schema to work with all application software that can communicate data conforming to that schema. For example, if a standard schema exists for representing energy simulation data, then a user-interface can be developed to work with any number of simulation engines such as DOE-2, Blast, Energy-Plus or any other simulation engine as long as these tools have program interfaces supporting that standard schema for data input and output.

In an effort to coordinate XML schema development, the IAI has joined forces with the aecXML to develop the standard for electronic communication using an XML schema framework for architectural, engineering and construction industry applications (aecXML, 2000). There are also implementation efforts underway to represent the IFC model in XML for data exchange. The BLIS team has published

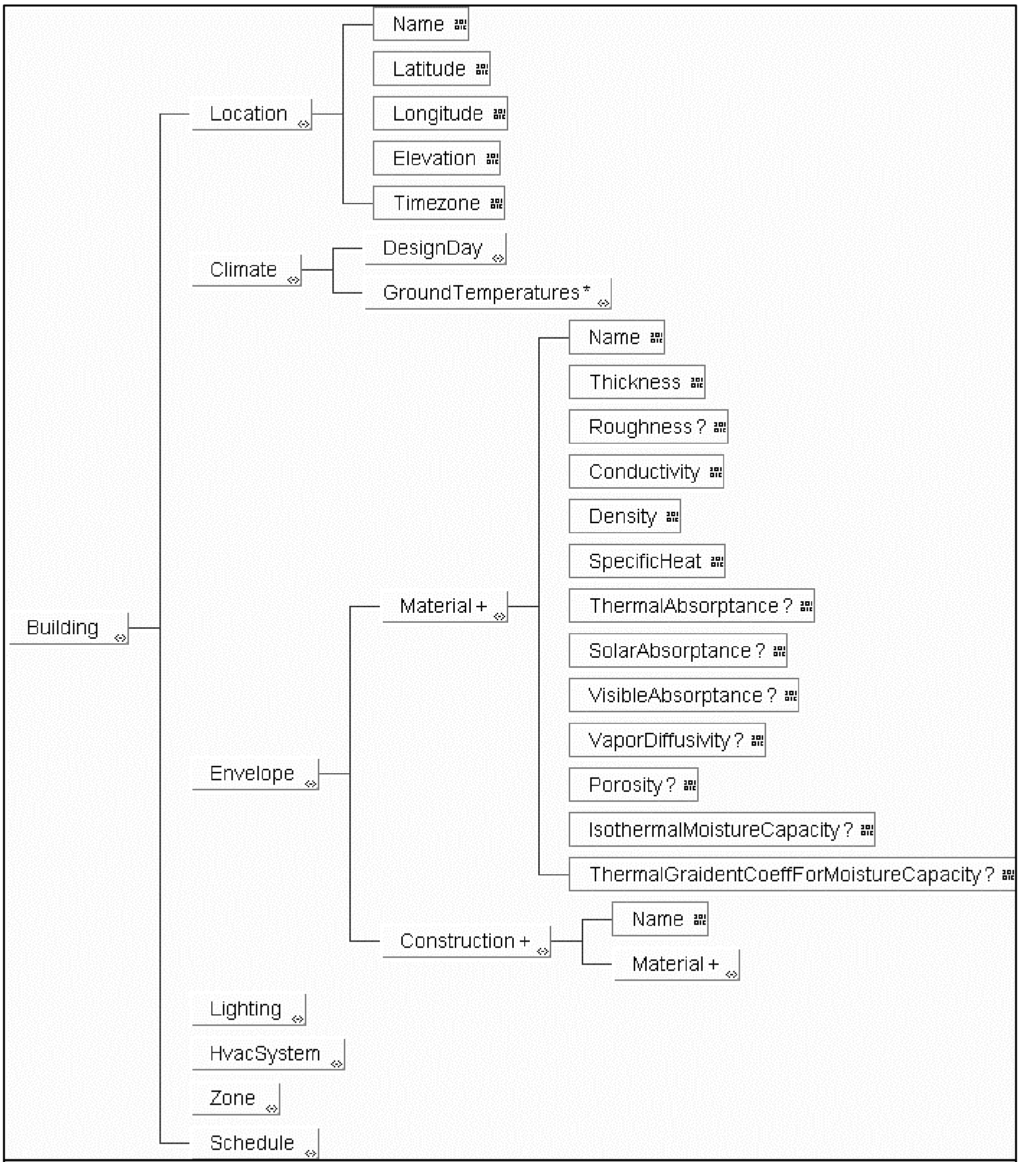

Figure 1: Top Level EnerXML Schema Layout

```
<?xml version = "1.0"?>
<!DOCTYPE Building SYSTEM "file://explore/EnerXML.dtd">
<Building>
 ...
    <Envelope>
      <Material>
            <Name>Stucco</Name>
            <Thickness Unit = "ft">0.03125</Thickness>
            <Conductivity Unit = "Btu.ft/h.ft2.F">0.41667</Conductivity>
            <Density Unit = "lb/ft3">166</Density>
            <SpecificHeat Unit = "Btu/lb.F">0.2</SpecificHeat>
      </Material>
    </Envelope>
 ...
```

an XML schema that can be used for exchanging data in IFC V2.0.(BLIS, 2000). The success of using XML for data exchange and electronic communication depends on industry standard on tag terminologies and wide application support for standardized schema.

EnerXML SCHEMA

The EnerXML schema was proposed to standardize and develop a common data model for representing energy simulation data in XML such that all energy simulation software can speak the same language. One of the motivations for this initiative was the recent development in IAI/IFC object model and the aecXML working group on the development of schemas for the AEC industry. The original emphasis was in generalizing and simplifying the data model for wider distribution, easy access, web enabling the data for other applications and keeping it in public domain for maintenance and updating.

The following seven major domain areas were identified for generating tag terminologies:

1. Location
2. Climate
3. Envelope
4. Lighting
5. HVAC System
6. Zone
7. Schedule

Figure 1 shows the top-level hierarchy of schemas required for supporting energy simulation software with the Location, Climate and Envelope schemas expanded to the second level as an example. Figure 2 shows an example XML data snippet from the first draft schema developed to support material properties. XML tag names and attributes are consistent with commonly used industry standards such as the ones from ASHRAE, ASTM and IAI. The top most level is common to the several segments of input required by most of the commonly used simulation programs. The second level represents the data attributes needed to describe each of the input segments. Many of these attributes currently exist in the IFC model and the HVAC domain extensions. However the use of IFC model would not be practical because the voluminous amount of data and overhead associated with representing the geometry information. EnerXML can be viewed as a subset of the IFC model, but more specific to address the needs of the simulation software. It is possible to develop interfaces between the IFC model and the EnerXML such that automatic geometry extraction from an Application Program interface is made transparent to the end-user.

The initial concept for EnerXML schema received an overwhelming support from more than a dozen industry users when it was first announced in the BLDG-SIM mail exploder in April 2000. But, due to lack of funding and private sector efforts such as gbXML (GeoPraxis, 2000), the scope of EnerXML was narrowed to support the external data requirement in the Code compliance software developed and supported by the Pacific Northwest National Laboratory (Gowri etal 1999).

Several on-line construction specification and product catalog services have been contacted to provide material properties information using this schema. This material properties information would be directly used in the COMcheck/MECcheck user-interface and added to the assembly type menu of the various components. Figure 3 shows the software architecture of how the EnerXML schema based product data is currently being tested in the COMcheck and MECcheck software. It is possible

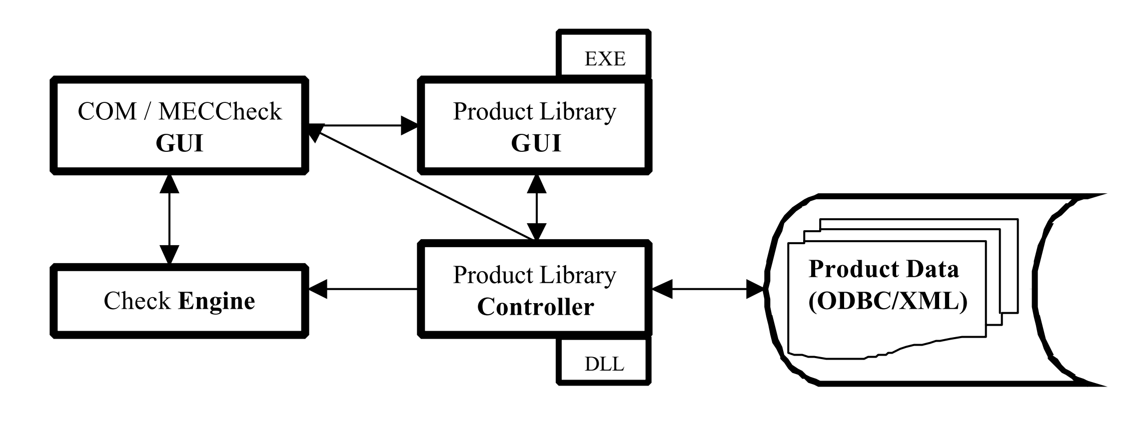

Figure 3: Software Architecture Integrating XML-based Product Data

that the product data can be provided in an ODBC compliant database as well. An XML parser is being implemented as part of the Controller that determines the database format and appropriately parses the data. A prototype implementation is currently available to demonstrate the potential benefits of XML based data exchange using this architecture.

An application program interface is currently available to read XML data of IFC drawing data files and check compliance using either simple trade-off or performance simulation method using DOE-2. Both COMcheck and MECcheck software can work with the IFC-based data models either in the IFC format or in XML format. An example scenario of exporting an XML drawing file from a CAD system and checking compliance using COMcheck-EZ for ASHRAE 90.1-1989 requirements has been showcased as part of the BLIS implementation activities during the past year.

There exist a great number of possibilities for XML-based data exchange for energy simulation software. Re-usable, universal and self-describing data representations are the immediate advantages of developing an industry standard XML schema.

CONCLUSIONS

EnerXML is a proposal aimed at developing an XML Document Type Definition standard for supporting the needs of energy simulation programs. The EnerXML schema development is coordinated with the IAI/IFC building model and the aecXML initiative, and follows the aecXML schema tag definitions. The outcome of EnerXML schema development will provide the building energy simulation software developers to work with one standard format for describing data and develop web-enabled simulation programs. With XML support growing with the new web-browsers, EnerXML will become a critical piece for enabling web-based data exchange of simulation data. The energy simulation software development and user community should come together quickly to define and adopt an XML schema that can support the various parts of the simulation processes and work with the other interoperability initiatives in the AEC industry.

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