Virtual Building—An Object-Oriented Database Approach Toward Data-Driven Building Simulations

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INTRODUCTION

This paper introduces a *data-driven* approach for performance simulations is introduced using an object-oriented database, called "Virtual Building" (VB). A hierarchical class structure is presented to better store building construction, material and environmental data. The data includes descriptive/static information about the building geometry, material composition of assemblies, material properties, HVAC system/components and their characteristics (i.e., the design); parameters describing the operating and environmental conditions of the building (i.e., the state variables), either simulated or measured; and data reflecting the energy and indoor environmental performance of the building. Methods to connect VB with simulation environment are introduced. Two Examples using data-driven approach for performance simulations are demonstrated.

Implementation

This study is to model building in certain hierarchy to better represent building construction, material, and environment information. Building elements are divided into certain class, and certain classes will make up a higher level class. Each class has properties to represent its relevant components information. In storing building information, objects are generated in terms of their class and object data are stored in terms of class properties. The Object-Oriented Design (OOD) Building structure is shown in Figure 1.

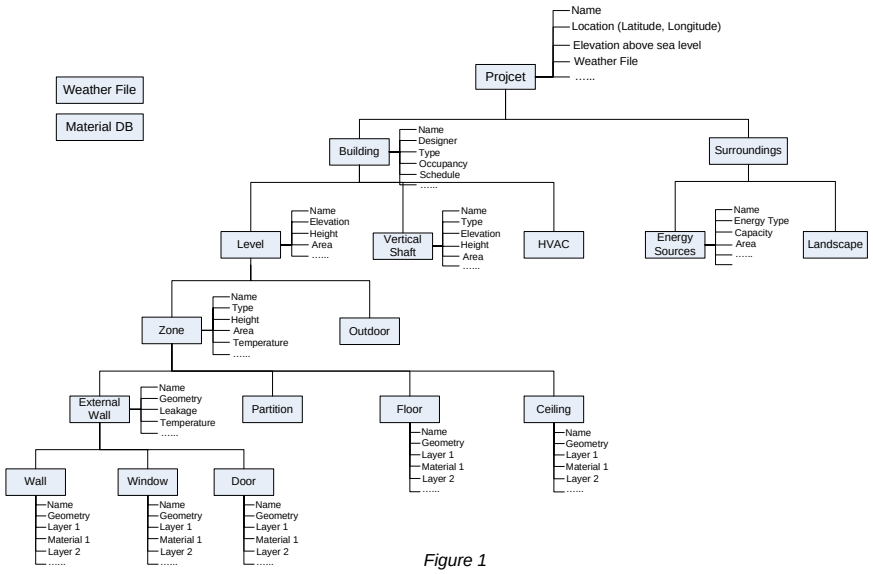

Figure 1

The hierarchical VB structure also enables inheritance of properties of a higher level class (a parent class) by a lower level class (a child class). For example, the weather info that is associated with the whole building's location (a property of the "Building" class) can be inherited by the "wall" class in simulation of its hygrothermal performance. This is an important feature since it also enables the information entered in the early design stage (typically "building" level information) to be used in the later design stage at which more detailed simulations are conducted.

Another advantage of using Object-Oriented Database (OODB) is to facilitate building information transfer to simulation environment. It is known that in modeling a whole building performance (environment, or energy simulation), data describing building geometry, construction materials and indoor/outdoor environmental condition are needed. The connection of OODB with simulation program will make data more transparent to simulator. We call the combination of database with simulation program "Data-driven" method (Figure 2). Data are fed from CAD files which describe building construction information and sensors monitoring results which contain weather condition, building indoor condition etc. These data are stored in Virtual Building and driven from Virtual Building to simulation programs when certain simulation require. One example is to use Virtual building to run building energy simulation (EnergyPlus). During modeling phase, data are stored in VB. To simulate building environment building information is pre-loaded into VB and by programming, VB can modify building data input file (.idf file) to achieve various building simulation needs. Figure 2 also shows the data driven path, the source of data and how it is used for. Metrological sensors can be used to monitor weather information and data are stored into VB in structure. Then VB modifies the input .idf file according to user's setting. Under some specific "Design Date" weather conditions, simulation is conducted (Figure 3) . Finally simulation results are compared with on site monitoring results which are also stored in VB. The advantages of VB is to dynamically conduct simulation based on monitoring conditions (i.e., a data-driven aspect) and have both simulation and measurement data operate in the same general conditions (weather). This provides a good baseline to compare simulation results with measurement data, optimize building performance and control parameters, predict building performance to minimize energy use or prevent contaminant transportation.

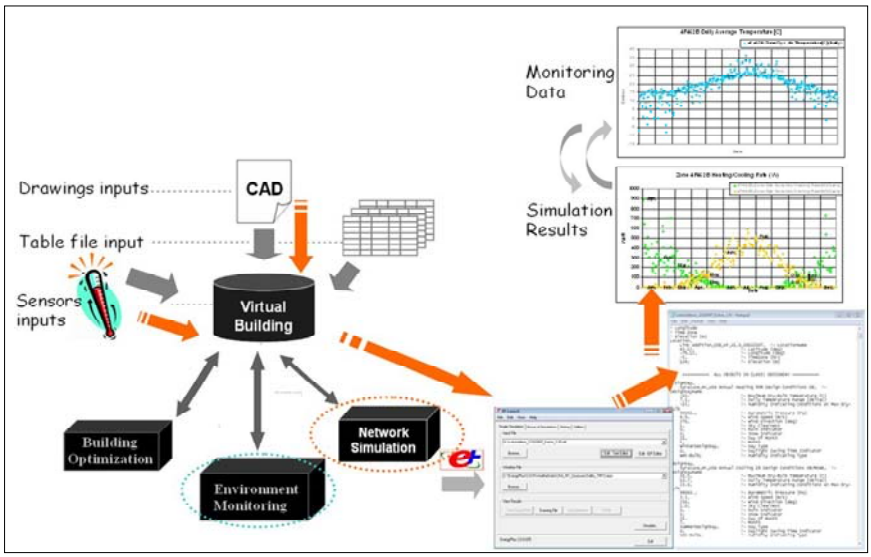

Figure 2

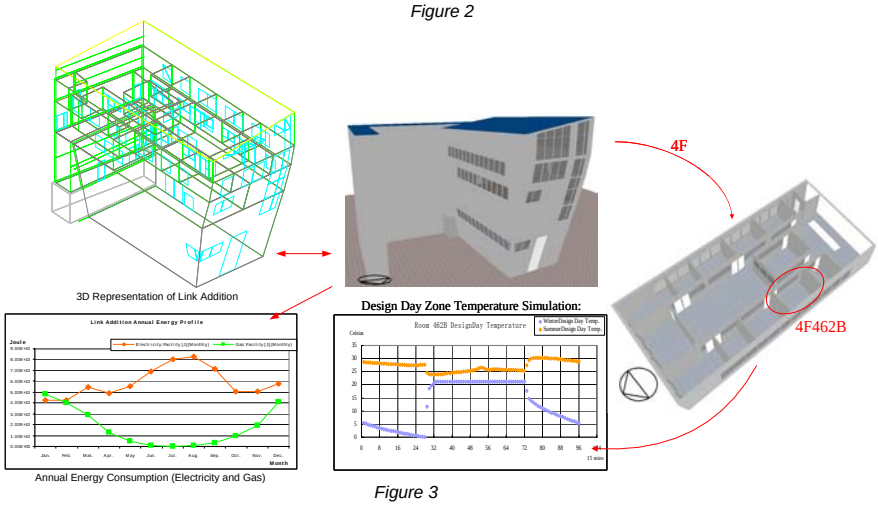

Figure 3