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Dynamic extension of Building Information Model for "smart" buildings

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Abstract

Building Information Modeling (BIM) is a powerful technology that is used to support decision-making about a building during its life-cycle. This research explores application of BIM technology to "smart" buildings. "Smart" buildings differ from usual buildings. The biggest differences occur in the design and the operational stages. The article shows that traditional BIM solutions, due to its static nature, don't cover all needs of "smart" buildings technology. Dynamic extension of Building Information Model is proposed to cover gaps of traditional BIM in the design and operational stages of "smart" buildings life-cycle.

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Keywords: Dynamic Building Information Model; Designing smart buildings; Smart home; Smart building

1. Introduction

One of the global problems of this century is an enormous increase in the world demand for energy and depletion of available energy sources. Over the past fifty years computer performance has increased by millions times. The conjunction of these two factors makes "smart" technologies, which are proposed for saving resources and increasing people's living comfort, topical and possible. The vital element of "smart" technologies are "smart" buildings.

For today's buildings we have a lot of codes and standards as well as proved tools for design, construction, operation and demolition. One of the powerful and promising tools is Building Information Modeling [1].

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However, due to their static nature traditional BIM can't be used as a reliable basis for creation of CAD systems for designing and operating of "smart" buildings. Firstly, traditional BIM are static because they can't show us processes that take place in the building, they only show physical building characteristics. It was shown that for robust design of "smart" buildings we need a measure of a building "intelligence" (Building Intelligence Quotient, BIQ) [2,3] and a model that allows us to simulate environmental changes and inhabitants activities within a building for calculating BIQ. Secondly, traditional BIM are static as all model updates are done manually by engineering stuff. It is very inconvenient in the operational stage and, as a result, building model might be outdated and incorrect that makes it is unusable for efficient facility management. To support decision making during operational stage of a building life-cycle a model that shows actual parameters and processes instead of design values is needed.

2. Use cases of the dynamic extension of BIM

There are some potential stakeholders of a dynamic building information model: developers of "smart" building solutions; designers who choose between some existing "smart" building solutions; facility managers; developers of building codes and standards.

A dynamic building model might be useful for developers of "smart" building solutions. Developers should test and verify their products somehow. Obviously, that it is impossible to validate all cases in a real building with real inhabitants. So, developers of "smart" building solutions need to build a model that will allow simulation of processes that take place in a building for testing and debugging their algorithms. Besides testing functional requirements (i.e. % of correct decisions made by the building's artificial intelligence) the dynamic model can also be used as a test environment for non-functional (performance) requirements. Performance is a critical point for building "intelligence". There is a lag between the firing of a sensor and the response, that consists of algorithms complexity + network latency + hardware delays. This lag should not be so long to inconvenience the inhabitant. If by any reason it isn't possible then an additional effort should be put towards inhabitants comfort. For example, due some hardware limitations in the Adaptive Home [4] there was a lag about 700 ms from once motion in a room has been detected to turn on a light. To resolve this issue an additional component was introduced. "Anticipator- predicts impending zone occupancy and to issue a lighting command shortly before the zone becomes occupied." [4]

Designers want to know how to choose the best "smart" building solution for a particular building? The interesting question is, what the best means? To say that something is better than another we need a formal, ideally in a quantitative expression, definition of the "best". As a measure of a building "intelligence" we can use Building Intelligence Quotient [2,3]. As a dynamic building model allows to simulate environmental changes and inhabitants activities it can be used for calculating BIQ.

Facility managers want reliable near real-time management and monitoring features in the operational stage. We must admit that sometimes our assumptions in the design stage are not accurate and a building functions slightly different than it was intended. As a building is equipped with sensors and meters which are triggered by environmental changes and people's activities, sensory information can be used to adjust the building model in a near real-time automatically. So, it is always possible to see what is going on with a building right now. A facility manager can use up-to-date information for planning some activities more efficiently, for example, emergency evacuation. The special modules can automatically perform analysis for detecting equipment failures using accumulated data, for example, if the temperature in a particular building zone is below normal for a long time despite the fact that heater always works on its higher power, it would probably be worth sending a notification to a repair team indicating the reason and particular equipment to check.

Codes and standards developers also can get valuable information from a dynamic building model. A model reflects a real state and behaviour of a building over time and gives an ability to explain changes of states of a building as a system depending on various factors. Thus a building model can become a bridge between the standards that were used for building design and its real performance. It will give an abilities: to judge about efficiency of standards without special inspections and examinations, to understand gaps between standards and reality and, finally, fix standards to achieve better buildings' performance. All required information might be extracted automatically and sent for centralised processing to concerned institutions. Statistics about a big amount of buildings gives us an opportunity for using data mining in building engineering and judge about different technologies' efficiency.