Future of simulations

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Abstract

This paper discusses the current building physics simulations and compares them with development in other technical fields. In particular, the paper an effective way in which input information can be reused. An effective way to link building physics simulations from various domains.

1 Introduction

In the following introduction the current situation in the domain of building energy simulations will be sketched.

1.1 Development of simulation tools

Simulations exist since the 60's [6]. The first generation of simulations consisted of individual calculations in an analytical way. Simulations were steady state. Although this did enhance the understanding of the research field and give an indication of performance, the link with the real world was weak. In the mid 70's a second generation of simulation tools using time steps was introduced. This made the simulations more dynamic. It was a big step forward. As research progresses and matures, the simulaton tools mature as well. By the end of the last century it is normal to combine multiple processes and variables. Simulations are now based on space, dimension and time [5].

1.2 Present situation

Currently there are many building physics simulation tools. Most of these tools are made by domain experts. A 'heat and moisture' simulation is written by a 'heat and moisture' professor and 'acoustical' calculations are done by a program modelling the 'acoustics'. The people who designed, implemented, and worked with these tools, have extensive knowledge about them.

However for an outsider it is difficult to make adjustments in it.

Furthermore, if different properties of one building need to be calculated, detailed knowledge of all the different programs need to be combined. Also the input for the different programs need to be prepared. The different input methods and formats are often specific to that program, making it impossible to easily reuse information. Thus, information written for one program will need to be rewritten for another.

From this point of view not a lot has changed since 1986, when J.A. Clarke wrote; "The existing systems suffer from inflexible software structure and the lack of a common approach. Software structure is inelegant and requires detailed knowledge of the data structure to upgrade algorithms." Clarke state that authors of building physic simulation software are often energy specialist, but coding amateurs [5].

Though most simulation programs are fragmented, there are programs in the market who combine various fields of technology together. One of these is Building Information Model server (BiMserver) [3]. One program, one global input, for different calculations. A program where input is done by the architect. If the architect makes a change, all simulations in BIM will use the new input, and easily can be checked weather with this input there will be any new problems. However for BIM all employees need to leave their old software and start all over in BIM.

1.3 Current pitfalls

The technological possibilities grow with increase of computing power. Although this is a great advantage in terms of calculation time, it also has it's pitfalls. Herke Stuit, vibration simulation developer at Movares engineering consultancy in Utrecht, explains: "Since the existing of model simulations there has never been enough computer capacity. People want more and more accuracy, more elements, and smaller steps. The problem now is the reliability of the results." An increase in time steps (a higher resolution in time) does not always improve the accuracy, sometimes decreasing is better [8]. No matter how complex the simulation models, it is still hard to provide the correct input. For most simulations there are a lot of unknown variables and uncertainties. At Movares, therefore, they use experiments to check the chosen input.

Also Anna Catharina Verkaik, PhD, researching flows in small tubes at Eindhoven University of Technology, notes a similar problem. No matter how the computers' capacities will grow, people will provide more input, or complex the models and programs will become... "Bullshit in is bullshit

out"!
How do you keep track of your reliability? Verkaik wants to see a link of simulation and experiment. "Don't forget, a system is a strong as the weakest link."

2 A Possible Future

The situation as described above, is not specific for the domain of Building Energy Simulations. The problem has occurred in many different domains before. From those domains a lot of ideas can be borrowed.

2.1 Thinking in systems

To bring the simulation tools for Building Energy Simulations to a next level a different approach seems to be advisable. Working for TNO Defence, Security and Safety, Patrick Hanckmann, describes some of the techniques he believes to have given simulations in this field a boost: "In the domain of defence and security the simulations have been a necessity, as many mission related tasks can never be or would be too expensive to be performed in real life. Most of the simulation tools in use are based upon standards. These standards can be at various levels, from communication between tools, to settings and geometric information." As an example Hanckmann mentions the HLA communication standard, and the CityGML standard for describing buildings and environments.

This different approach could be based on the following principles:

1. modular and loosely coupled tools,
2. use of open standards,
3. separation of simulation framework and algorithms,
4. use of intelligence in tools.

Also see figure 1. The following sections will describe these principles in more detail.

2.2 Modular and loosely coupled tools

When the different tools are build separate from each other, thus loosely coupled, than a user can choose which tools to use for a simulation run. Not always is it necessary to simulate all effects on a building. The advantage here is two-folded. The simulation will be less resource hungry, and the user does not need to provide all input information.

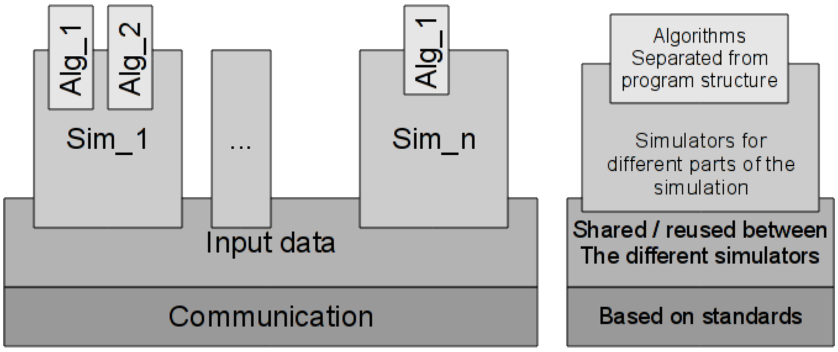

Figure 1: Graphical overview of the proposed approach.

2.3 Use of open standards

The use of open standards will improve the situation on a variety of levels. Firstly where different simulations require different ways for providing the same information. When the simulation tools use the same standard input methods, the input only needs to be provided once. This saves time, and prevents errors. The good news here is that standards are already in use. For example:

- CAD is the standard norm for Architects, to describe their building in detail. Size, material, thickness, all information is in the drawing.
- The City Geography Markup Language (CityGML) is a concept for the modelling and exchange of 3D city and landscape models. It is a common information model for the representation of 3D urban objects [1].

Ideally the CAD drawing and other standardized inputs will be uploaded in a combined physics simulation and be able to look at a diverse range of physical aspects. In this way building physicals can become more time and cost efficient, and be in included early in the building design and prevent discomfort, extra costs, or damage later[4].

Besides standards on the input side of the simulation tools, there also needs to be a standard for communicating between different simulators. This way, researchers and commercial companies can create their own simulation tools and use them in conjunction. Of course, there can be more points where standardisation can be useful.

2.4 Separation of simulation framework and algorithms

As mentioned before, domain experts in building energy calculations are very often not professional programmers. This results in tools with high quality models and algorithms, but low quality software implementation. Often researchers want to test multiple algorithms and versions of algorithms to improve them or compare them. These algorithms (or models) are what the research is actually about. Therefore, the simulation tool should be flexible enough to "load" new algorithms without a need to exactly know how the software internally works.

When less effort needs to be put in the software around the algorithm or model, then there is more time to test and improve them. This could potentially result in higher quality research.

2.5 Use of intelligence in tools

An often heard question in "Building Energy Users News" [2] is what input the simulation uses. Therefore it would be ideal if the simulation can advice coefficients. This will need intelligent systems. Still, no matter how intelligent the system will be, it should be clear which values are being used, and how to changes them.

3 How can we get there

Changing the landscape in world of simulation is not an easy task. Changing in software are relatively slow [7]. In the long run, using standards in the simulation tools will benefit the developer and the user. Tool can be developed more time and cost efficient. However in the short term, being compliant with a standard asks for investment in time and energy. It will be difficult to get all developers and researchers to adopt the standards. We basically need a "Napoleon" in the world of simulations, who can make every field to switch to standardized norms.

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