The Meaning of BIM

Towards a Bionic Building

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Abstract. *The paper is a position paper, not a report about a research project. It concerns the paradigm-shift that is taking place in the CAAD software and its implications for the business of architecture and more importantly, for the education of future members of the profession. Twenty years ago the use of CAAD software as a replacement for hand drafting was starting. Since then the transformation is complete: hardly a final project in the universities is drawn by hand. Currently, we are witnessing a second paradigm shift and its name is BIM. The meaning of BIM is rooted in two significant differences to current CAAD software and this will have implications for teaching and practicing architecture. The first difference is the way the software structures information in the CAAD file. The standard way to save CAAD information was to organise simple geometric objects according to membership in groups and to sort them according to a layer-metaphor, which primarily controlled the visibility of the geometric elements. Three-dimensional modelling is/was nothing more than the same structure with a more complex geometry. BIM software changes this structure by storing classes of geometries and then to store the specific values of individual geometries according to factors that can be determined by external or internal logical factors. The implication for architects is that we have the chance to be the people in control of the building information model, so long as we invest the time and energy to fully understand what is happening to the building information during the planning process. If we ignore this, the real danger exists that the last control of the building's final configuration will be usurped. As educators we are currently teaching students that will be leaving the schools in 2012 and beyond. By then, the paradigm-shift will be in full motion and so it behoves us to consider which skill sets we want the next generation of architects to possess. This means not just teaching students about how to use particular BIM software or how to program a certain parametric/genetic algorithm in a form-finding process. We need to teach our students to take the leadership in*

building information management and that means understanding and controlling how the building information flows, how the methodologies that are used by the consulting engineers affect our building models, and knowing what kind of logical inconsistencies (internal or external) can threaten the design intention.
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The First BIM

Twenty years ago, many of us decided to draw no longer with a pencil or an ink pen, but to embrace the computer and to draw our drawings with so-called CAD (computer aided drafting) software. Although the first versions of the drawing software were not altogether easy to use, they allowed a degree of precision and control that we did not have in hand-drawn drawings. As well, the software allowed us to structure the information within the drawing, which led to even more control, especially when transferring information to other planners or engineers. In the meantime, the situation is completely reversed: it is very rare that we see a final year project completed by hand or without the support of a computer.

It is clear that whoever wants to build must draw their plans with the computer. This will soon be no longer the case. What will come is not the return of the pencil, but the dominance of modelling. Architects will still draw tomorrow and the day after tomorrow but the tendency is clear: buildings will not be drawn. They will be modelled. Some larger architectural offices (Herzog & de Meuron, UN Studio etc.) have already changed (or at least have decided to change) their design methodologies. The authors expect that in twenty years, we will find it very rare to see a final year project completed by two-dimensional drawing or without the support of computer-based modelling.

The Buzzword for this paradigm shift is called BIM and stands for 'building information modelling'. Building Information Modelling is actually not a new idea. Concepts explaining how to structure building information were published almost twenty years ago (Björk, 1989). What has changed in the meantime is the processing power of personal computers and the way CAD-Software is structured. It must also be clear that what is not meant is the classical three-dimensional modelling found in software such as CATIA, Rhino or 3D-Studio. BIM means adding a semantic layer to the three-dimensional information and to create a single building or data model, which all of the planning partners use collectively.

The roots of BIM can be traced back to the first ideas as to how to use the concept of product models using various media in architectural design (Björk and Penttilä, 1991). The subsequent collaboration of various software corporations with research institutes resulted in the establishment of the Industry Alliance for Interoperability (IAI) in 1995. Over the next years, the IAI worked to establish a standard for describing buildings, which would allow the exchange of building information without the loss of its semantic information. The work is called the Industry Foundation Classes or IFCs, which were first published in 1997. The IFCs serve as a base definition of terms and relationships between building elements and established one of the prerequisites for lossless semantic data exchange between diverse planners during the entire planning process.

The commercial software available to architects has also undergone an evolution if not a revolution. The hitherto methods of structuring buildings in a CAD data file were quite simple in fact. Single drawing elements were combined to form more complex forms (Blocks, Symbols, etc.) and organised in a so-called layer structure that controlled the visibility of the drawing objects. This structure worked for three-dimensional objects as well.

The Current BIM

Newer CAD software that use the IFCs as its basis, structures the data differently. In principle, the objects are no longer simply geometric descriptions organised according to a chosen layer structure. The objects are instead organised according to their relationship(s) to one another or even to externally determined values. Depending on the degree of flexibility in the software, it is possible to establish a building logic based on relationships between building elements and factors affecting their placement and geometry. This parametric aspect of building information enables external as well as internal consequences from determinate dependencies to affect the design. At the moment, fully parametric, scaleable and nested parametric building descriptions are only possible with a few software products. Nonetheless, the trend is clear and the change in the way building description is done in software has changed.

The other aspect is that the original drawing elements that all architects use can be combined with the IFC description to create building elements. This allows objects created in CAD to acquire a semantic relevance to the building. This enables additional non-geometric information to be connected to the building elements. A line that defines a wall is not only defined as a wall-element, but can also be tagged with thermal, physical, acoustic or structural information. This allows planners to use their field-specific view of the building to filter non-relevant information as well as to apply their methods, analysis and simulations to the same core set of information that the architects use. Instead of sending files to consulting engineers, the consultants can apply different methods to the same model. The design suggestions that result from these methods are documented as versions of a distributed yet single model.

The paradigm shift from file exchange to an exchange of analysis and methods allows the planner a higher quality control of the building information from the first steps of the planning process to the building use and facility management. This is not only an improvement of the quality of the building information for the client. Building Information Modelling can help the architect to (re) gain control of the building information and the accompanying responsibility and control of the design itself.

In the end, architects are information-workers. Architects do not manipulate stones, steel or space. Instead, architects manipulate information about stones, steel and space. The role as coordinator of this information (the design), the process of planning as well as the process of building production means that architects must control, coordinate and command over this information. As such, the advent of BIM software is an immense chance for architects. In the last hundred years, architects have given up typical architect's tasks to other planning partners and as such, lessened the role of the architect in the entire building planning process. The use of BIM software can strengthen the role of the architect through the control of information. This will only occur if architects do their homework:

1. Architects must have a command over the building information. This does not mean controlling to the access to the information, but to have an understanding of the information structures and their relationships. Knowing how Product Models in Buildings can be used and understanding how the other planners manipulate this information is essential to establishing authority in a planning process.
2. We must understand the types of information and their relationships so that the design does not become a slave to the flood of data that can arise through a product model. This means that a design idea is only survivable when a deep understanding of the criteria and relationships of design relevant factors is present. A design gesture without this kind of knowledge is not viable and even BIM (or especially BIM) cannot save it.

The challenge is enormous, especially in light of the current status of the building industry. On the other hand, the possibilities that are opened through the use of BIM are so great that it is almost negligent to ignore them, at least from the point of view of the profession.

The Next BIM

Niels Bohr is quoted as saying that predictions are difficult, especially about the future. However, when we look at the current developments, one cannot oversee that the digitalisation of the architectural practice will continue unhindered. The complete digitalisation will probably never be reached, but when information exists in critical legal, geometrical or logistical contexts, the success of the project will depend on consistent and accurate information. It is sure that in this case, the information will exist to some extend as a BIM model.

Students that are starting their architectural studies this semester will enter the marketplace in 2013. Long before this date is reached, we expect the paradigm shift to be almost complete. For students who begin their studies in 2010 or 2012, BIM will be the norm as soon as they work in an office. As such, we as educators must plan now for the class of 2017 and integrate BIM in the curriculum.

BIM will be the core of the digital planning process, but it will not replace everything we do as architects. Parallel to the teaching of BIM, we must also teach other skills and competencies in the context of digital tools for architects. We have to be sure, that future practitioners understand the basics: drawing with the computer, modelling with the computer, writing and layout with the computer, presenting with the computer, and communicating with the computer. And all of these skills should be at a professional level. After all, we are teaching and training professionals.

The digital architectural curriculum does not preclude the use of analogue methods. Rather, analogue methods are fundamental to the execution of the profession and the analogisation of digital information can enrich the design process. What is long overdue is the conception of an integrated curriculum that reflects the principles of BIM. Concepts exist for over a decade as to how to integrate computers in the design curriculum, however these are pre-BIM. The advent of this next generation of software can act as a catalyst for the reform that has been called for over two decades. (Oxman 1986)

Many Faculties of Architecture have a single professor for CAAD or a designated person who is the ‘computer’ person. This ignores the fact that we are all ‘computer’ people now. As such, the use of computers must finally be integrated into the curriculum. This means finding time, people and resources to teach our students the skills they need – these are not necessarily the ones we as older practitioners have.

This is only the beginning of BIM. The use of BIM as the core of the information control and information flow in the planning process has an immense impact on the building production. It is almost impossible to ignore that, independent of the impact of BIM; building sites are less and less a place of building and more and more a place of assembly. The tendency to use prefabricated building components is increasing. This tendency, combined with a semantic and geometrically correct building product model, can only increase.

It is also clear that the proportion of CNC controlled production techniques will also increase. The current trend to use non-repetitive and irregular geometries (independent of how fashionable they are) calls for post-industrial building production processes. Particularly is to note that in these projects, the analogisation (or ‘mechanisation’ See (Russell 2003)) and transfer from digital information to real form takes place many times and at many scales during the planning process. In the end is the building the 1:1 model.

The Virtual BIM

After the fabrication, the digital model will continue to live. The rising demands on facility management (FM) systems will continue unabated. Indeed, the requirement to produce a BIM description of the building alongside the production of the actual building is being seriously considered in some European countries. This version of the BIM-model will become the basis for the FM information. As such, the BIM Model will continue to be updated according to the status of the building itself. The life of the building will be mirrored in the BIM Model – a kind of virtual twin.

A sideshow: the semantic building model is being used to quantify the ecological footprint of buildings. When we know which building elements in which quantity with which production methods are produced, then we can ascertain the grey energy as well as the resource and energy flows needed to produce the building. As such, the building pass being considered by the European Union is made possible by the existence of BIM.

And the consequences of BIM grab even further. Through the progress in the area of ubiquitous computing, buildings will be increasingly networked. This does not mean WLAN access points but rather, that new and newly renovated buildings will be equipped with more and more sensors to monitor all kinds of activities in the buildings. This means that lighting, heating, air conditioning, media delivery etc. can be monitored and indeed controlled. This means that the sensors or services can relay their status in real time to the BIM model. Thus, the virtual model serves as a living document of the building throughout its life cycle. This is a far cry from the predominant use of three-dimensional modelling at present: the production of nice pictures.

And even further along, but not science fiction, the following scenarios are currently playing out:

- Currently, researchers are developing so-called digital-electricity, which allows devices to communicate with one another (and saves energy too!)
- RFID Chips are being implemented in larger Libraries – this allows objects (not just books) to be located within the building
- Key systems for buildings are being connected to central servers allowing the access to rooms to be determined by profiles, roles or time determined criteria

All of these systems can and will be connected to a building model.

The digital model is the first step toward the development and realisation of the analogue prototype. This is the current situation. What is coming, is that both models (analogue and digital) will be intelligent. They will exist parallel with one another and exchange information with one another.

What is missing is the system to handle both the analogue and digital worlds simultaneously – a Bionic Building Concept. This will come, surely as the future will come. As educators (and as planners), we cannot wait for the future – we have to act now. This means taking a few steps in every faculty:

1. Accept the conquest of the computer
2. Deny its right to uspurp every aspect of Architecting
3. Create a curriculum that spans basic architectural computing skills to those that require a degree of software engineering thinking.
4. Prepare the way for Architect-Specialists, who will take care of the BIM models.

The onus is on architects to take hold of this (last?) chance. Architects used to be the master builders. The last two hundred years has seen a decay of this role to the point where the rationale of our role has come into question. BIM provides an opportunity to change this, provided we are willing to accept the responsibility for the building information alongside the responsibility for the building.

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