Data Organisation in Construction – As an Aid to the User

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DATA ORGANISATION IN CONSTRUCTION – AS AN AID TO THE USER

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The basic assumption in this paper is, that it will be possible to organise data in construction in a non-hierarchical way, following the lines of facet-based classification. This involves tagging data in a horizontal rather than a vertical order.

We have experienced a long and intense discussion of how to organise data. At a glance the discussion can seem to be merely technical but indeed it involves a broader perspective regarding different understandings of how to perceive, present and organise knowledge. Actors (consultants – contractors) present solutions that are appropriate in relation to their own specific needs, but at the same time they can be difficult to use for other actors.
Empirical examples from the on-going Danish debate will be included. A comprehensive and all-embracing system is promoted ("Digital Construction – a government initiative"). Theoretically the paper builds on "classical thinking" represented by the work of Linnés, and connects to contemporary theory on facet-based classification.
Facet-based classification has not affected the thinking in the construction industry. Presumably this is due both to the mental dominance of hierarchical thinking, and the (earlier) cost of powerful computer hardware. Today it seems obvious to take the facet-based approach into consideration, making it possible to specify ordering of data to the users' practice and frame of reference, rather than fixing the structure of data already when they are saved to the system.

KEYWORDS: Data organization, hierarchical classification, facet classification, user interface, Data filtering

INTRODUCTION

The use of digital data in construction has, at least in Denmark, involved a long and intense discussion of how to organise data. At a glance the discussion can seem to be merely technical but indeed it involves a broader perspective regarding different understandings of how to perceive, present and organise knowledge.

The introduction of Building Information Models (BIM) has fuelled the discussion about contemporary classification models. In Denmark this debate has been accelerated the last years (se for example Jørgensen 2010 and 2008).Those models require a firm and clarified understanding of how to classify and denote data in the models. The way to handle data can be crucial for the ability to serve different partner specific wishes for information as an output.

Problem

At least in Denmark, there seems to be a widespread understanding of BIM as a model gathering and carrying all possible information's, and with the key object representing the physical component. Hence, the classification is primary based on the physical component, and is intended to fill out all parts needs.

This approach is useful for some, but not necessary for all, and in praxis it tends to require that all parts have the same product based point of view. This common point of view will probably be (more) easy to communicate when explaining the idea of BIM but will not benefit the core business of the different partners.

On different levels clients, consultants, contractors and FM organisations present solutions that are appropriate in relation to their perspective of matters, which reflect their specific needs. This perspective can be difficult for the other actors to understand or even accept. This issue reflects the more general point that many scholars (Beghtol 2010) emphasize, namely that all sorts of knowledge handling – including classification is formed by time, cultural context and a specific agenda that the actors hand in mind when they are working in a certain field. This means, that classification systems always have to adapt to cultural and technical changes over time. Crutz and Nicolle (2007) have a similar discussion with an outset in work connected to the semantic and syntactical dimensions in XML programming.

In the field of construction each part understandingly wants a classification to cover their special need, but to develop one classification that is covering all the involved groups' needs, is a major task bound to create problems.

This paper presents a different approach to organising data in construction. The basic assumption is that it will be possible to organise data in construction in a non-hierarchical way, following the lines of facet-based classification.

Facet classification is useful in connection with managed electronic environment such as catalogues and databases. As Broughton and Slavic (2007) puts it "The logic and predictability of the structure of a faceted system, the methodology for the analysis and categorization of concepts, and the existence of reliable rules for synthesis make it an obvious choice for building tools for electronic data management." Building the "tool" involves tagging data in a horizontal rather than a vertical order, with the consequence that the specific ordering of data can be adjusted to the users' practice, needs and frame of reference, rather than be dependent of a fixed data structure.

Although examples of facet-based classification have been used for some years in applications on the Internet, it has not affected the approach of handling information in the construction industry as seen in the matrixes of the initiative of Digital Construction (Bips 2007). Presumably this is due both to the mental dominance of hierarchical thinking, a sector with a tradition for slow response and the cost of powerful computer hardware. The matter of costly hardware is not an issue any longer and today it seems obvious to take the facet-based approach into consideration.

CLASSIFICATION - THE NEED FOR ORDER

Humans try to bring order to their world to understand its relations. A method is to create a shared intellectual understanding, which allows groups of people, sharing the same need of order, to communicate on an operational level. This shared understanding is best when based on an idea that the systems users find logical and natural for their needs. The logicality and the natural use are based on simplicity and clarity.

Classification deals with the process for handling and the systematic approach to data. Classification is traditionally closely connected with the concept of taxonomy, which we will choose to denote as the principle of ordering with validity for a certain field of knowledge. According to Taylor (2006) this definition lies within the broad and quite imprecise understanding that can be found in the literature. Further Taylor states that taxonomy originates from the Greek "Taxis" (order) and another Greek word "nomos" (law). Sometimes the use of taxonomy is almost similar to "Classification". He points to (Taylor, 2006:463) the fact that more recently (with the need of organising documents at the web) taxonomy is often synonymous with "categorized list of terms and include classification schemes, subject heading lists, internet directories and gateways". The taxonomies can be property of organisations which you need a licence to use. Linné's systematics for botany (and other biology) is often mentioned as an example of a (hierarchical) taxonomy. Classification is intimately connected with the embedded understanding of how objects and separated parts are understood as a part of a greater hole. In this way it could be argued that the classification scheme originates in a certain community of knowledge, as discussed by Wenger (Wenger, 1998).

The discussion about classification is constantly actualised by the need for ways of organising information that has to be saved and re-found in different constellations.

Contemporary demands to classification systems – the need for order

Since the days of Aristotle there has been a tendency to classify hierarchically. A hierarchic system draws an understandable image of the order and relationship of the system's objects. The image is well known and looks like the roots of a plant, spreading out the further down we get.

Today we have operational alternatives to the hierarchic structure. The facet structure is such an alternative, in which the object of the system is not placed in a given order, but defined through the descriptions of the object. With this system, different orders can be created, depending of the properties demanded. The object can be placed in an order defined by a specific need.

Through the use of information technology the mass of data has grown considerable and the hierarchic systems that embrace this data are getting ever more complex, so the activities used for handling these systems are correspondingly complex. The problem is known by everyone trying to keep order with the computers pathfinder. The key to understand the application with the facet order goes through the ability to filter data. The problem with the facet order is that it is not hierarchic, and for that reason not the usual way of arranging objects.

Hierarchical classification – the "traditional way"

The hierarchical way of classification takes its beginning in the modern world with the Swedish botanist Carl von Linné's (1707–1778) work 'Systema Naturae', published in 1735. His concept of subspecies has been discussed but nevertheless, Linnaeus is credited with establishing the idea of a hierarchical structure of classification which is based upon observable characteristics (Keita 1993).

The hierarchical point of departure has shown a considerable strength over time in spite of DNA sequencing another new invention in biology, (Kwasnik 1999:26 ff). It is certain that the hierarchical classification was well suited for search in indices, catalogues or bibliographical registers correspondence with a certain area of knowledge. The problem with the hierarchical approach first begins when you wish to assign, re-find, seek or use combinations of data in a way that was not anticipated or prioritised when the classification scheme was founded.

The situation can to some extent be compared with printed non-fiction (e.g. scholarly book). The table of content will usually represent a specifically understanding and structure of the knowledge field that the book deals with. It is easy to use the information and work with the book if we are familiar with this understanding. If on the other hand we wish to juxtapose information from quite different angels, or with the help from concepts (combinations of) other than those originally defined in the book, we would not get much help from the table of content.

A combination of knowledge which crosses the vertical and horizontal divisions of the classification would demand that the concepts represented in the book were transformed to flat structure that we could search in. With the example of the printed (analogous) book in mind, it would be difficult to solve the problem above. If we stay in the book-analogue universe, it is not possible to come up with a realistic solution – we cannot find data in a flat structure without a form of structural support from an organised list, table or similar. In this situation the facet classification offers an interesting alternative.

Facet-based classification

Although examples of facet-based classifications have been used for some years in applications on the Internet (Hearst, 2006), it has not affected the thinking in the construction industry.

Taylor describes facet classification as different from a traditional approach as "(it) does not assign fixed slots to subjects in sequence, but uses clearly defined, mutually exclusive, and collectively exhaustive aspects, properties, or characteristics of a class or specific subject. Such aspects, properties, or characteristics are called facets of a class or a subject…" (Taylor, 2006:394).

As an example on facet classifications, in relation to classifications of food, Brian Vickery writes "The various facets relating to these are different attributes by which they may be classed, and a particular object may be represented by a combination of its attributes." (Vickery, 2008:149), in other words - the properties define the object.

Both Taylor and Vickery connect the breakthrough of facet classification with the upcoming electronic data processing. Today's huge internet-based database systems, used for e-commerce, are based on facet classification. Special studies of interface design used in facet-oriented systems have been produced, to facilitate these systems (Hearst, 2006). Ideally it should not, (for web purpose) be necessary to know a certain subject area and its break-down in sub-discipline in order to retrieve relevant information (Broughton and Clivic 2007).

THE PARTNERS OF THE BUILDING INDUSTRY

Different professions and areas of interests have a natural focus on different objects, and it will be difficult to imagine one classifications system, containing object such as planets and plants, and at the same time being practical useful. For at specific area as the building industry, the natural objects of intersection will be the actual physical object. But do the partners have that much in common, to create a sufficient working space, and to do it in a hierarchical model. These questions require an analysis of those parties' use of data in relation to their responsibility.

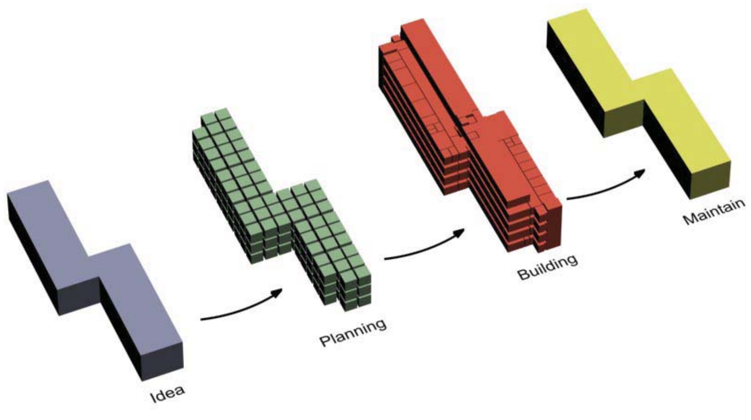
The used terms for the main partners in the construction industry are reflecting a specific task and area of responsibility. Client, Consult, Contractor and Maintenance

These partners can be subdivided e.g. into Architects and Engineers. Depending of a project, some types of consulting partners cover more than one responsibility area. Partners belonging to the chain of supply and the end users are not consisted as hard-core members of the building process.

The parties' classification is closely connected to the phases of building. Idea, Planning, Building and Maintain.

The four phases reflect more than the distribution of responsibility. They also point at the object type each phase is corresponding with, and consequently what level of knowledge and type of data each phase, and part produce and communicate.

Figure 1: The four phases of the building process.



BIM as the partners mean of communication

One of the major problems in the digitization of the building industry has been to solve the problems of data exchange between the partners and throughout the phases. The government initiative Digital Construction has strived to solve this problem, based on the consults world view, and with consideration to the other partners. However, the case concerning the DFK development is, as an evidence of this consideration, inadequate.

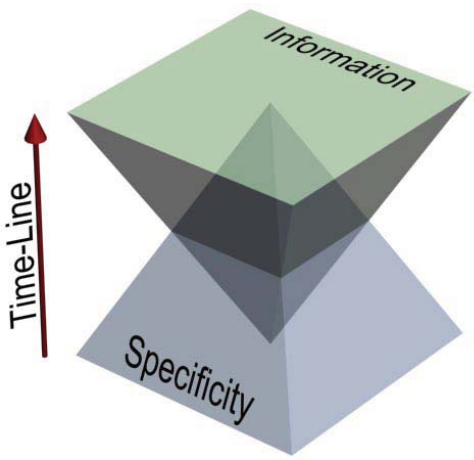
With the introduction of BIM, the consults has establish his own basic point of view, and a quick look on the home site of Digital Construction (www.detdigitalebyggeri.dk) reveal a concentration of digital news, terms and stories of 3D virtual models of physical building, and very little of BIM as a non-physical phenomenon, collections of task descriptions and very little about the actual use of BIM data in maintenance.

Areas of interest, outside the strict visual geometric, and covering other partners, are taken into account in the ten client demands, outlined in the working committee rapport (EBST, 2001). The best example of the range on these demands is to be found in the third demand, where it emerge that: 'The client must insure that the set of drawings must be produced, hence the production drawings can be printed in A3 format or less, and the client must ensure that scale is visually applied on all drawings.' (Retsinfo, 2007). This demand is to be put forward by the client, ensured by the consult, and used by the contractor. The executed demand will enable the contractor to carry around the BIM model, in an analogue version on the site. As reasonable as it may be, this demand doesn't consider other partners use of the high-tech solution. An alternative approach would be a demand, giving the contractors the responsibility to update the as-build BIM.

Project clarification

The partners need information, to make the right decisions and solve the problems arising throughout the process. In the end, all these information's are connected to the building, more or less specific, depending on the positions of the project's timeline. The amount of information, e.g. measured as GB, and level of specificity is two well-known orders in the history of building, and are important parameters for handling documents, ways of communications, contracts etc.

Figure 2: Throughout the building process, the amount of information's rises and the specificity narrows



The partners must resolve all kind of problems at any given time in the process. One partner will have focus on economics, another on materials and a third on functions. Each partner will need to fulfil they requirement through access to sorted information, and the information's must be sorted in relation to their responsibility. Hence, a common understanding of order, allowing all parties to search specific information's, must be established. Therefore, it is necessary to take a closer look on each partner's fundamental tasks and responsibilities, and the types of information needed to satisfy this.

Partner's data

The different tasks can be put by:

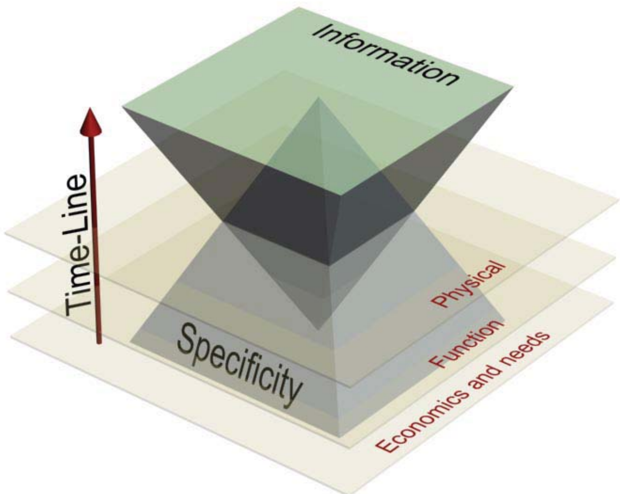
- Client's (idea phase) define a need and procure the economy
- Consult's (planning) convert the specified need to a possible solution
- Constructers convert the solution to a physical condition
- Maintenance keep the building going

The different tasks and the type of data involved, combined with subcontractor's type of data, present an image of the complexity in the idea of a joint system of order.

Basically, the problem is a question of different, but close connected views of the building process. These different views cannot be converted into one unambiguous type of data. Each view is a focused reflection on building information, on a given position on the time line, and each focus will be determined by one partner's specific need and related to his competence of decisions.

In principle, the narrowing of specificity will take a virtual form as illustrated in figure 3. In the early process the client will use a data model with economics and needs as key objects, next phase could have functions as key object, and so on through the phases. The phases inherit the result of the object use, from the previous phase, and not necessary the objects itself. Each phase interconnected with the responsible parts view, competence and business. Previous phase's data specifically used in this phases, must be removed or narrowed down. If not, the vast amount of information will strangle the transparency, and reduce the productivity.

Figure 3: Information focus and use of data types will vary through the process.



The parties' field of focus, the use of data in decisions making and data transfer have particular interests in understanding how to create an operational form of order.

Economic include the cost to the erection of the physical building, the cost of maintenance, expected income, in short the turnover of the building. All partners have an interest in the economic, but have different reasons. First of all, in the construction process the client pays, the others earn. This entail that the clients focus is on the value, created for his money, and e.g. the constructor focus on the money, as the result of his effort. The client's model of economic is a model of insuring the connection between need, function, and solution. This model is built on experience, gained from previous projects, and the primary source of data is extracted from the maintenance companies. For the consults and contractors the model of economic is the framework for the job, and their primary source of data is previous projects. The source and use of data is very different between the parties.

A need can e.g. extend from the local societies need for a school to the clients desires to create a monument. Simultaneous needs, being complementary or contradictory, are usual. The client giving the local society an opera can be complementary, if the society wants it. To build a cheap concert hall on international standard is contradictory. Needs are satisfied through actions. These actions are exercise within a function. A society's need for e.g. education is satisfied with education facilities. On a lower level, the need of water can be satisfied with a pumping system. The client defines the needs, the consult transforms these needs to specific functions, the contractor transforms the function to a real solution, and the maintenance will run it and the user uses it.

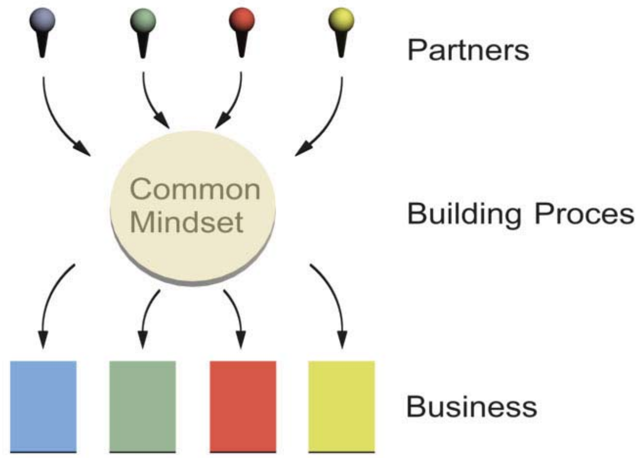
The client's source of knowledge regarding needs would be the end user, the maintenance organizations or the public voice. Different views of economics, needs versus functions, can be the cause for negotiation between the parties, because their tasks and experience vary. The different point of views will cause two different set of data, being difficult to unite in one common precise order.

The physical solution deals with fundamental physical components. In this concept it's the components, or object, we can visually percept. The physical components are the ones the client pays for, the ones the consultant draws, models and uses for calculation and the ones the contractor buys and assembles and the maintenance re-paints and washes. However, the components themselves do not tell anything about the capability of the building. The client and the end users get their needs honoured through those functions emerging from the components combinations.

Point of view

Economics, needs or functions and physical objects can be assigned to different orders, and sub-divided dependent on the situation. If the architect wants to examine a possible change in the functional model, caused by a change in the physical solution, it is necessary to arrange one data type, so it may correspond to another data type. Whatever triggers the activity of rearrangement, it is a question of comparing different types of views, to make it possible to see deviations. Hence, one point of view model must not just be an automatic extract of a primary model, because each point of view model is closely connected to one partners business.

Figure 4: The vision of BIM is to be the 'mother of all information'

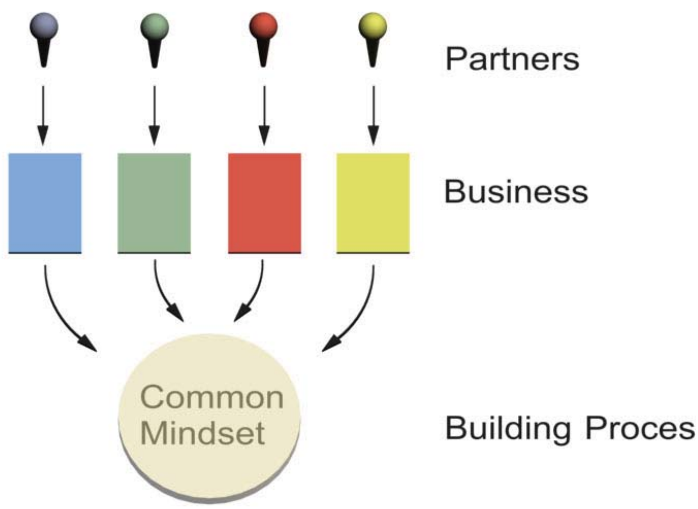


If a BIM model must be able to contain information for all partners, the size will be considerable. This is not a technical problem, which is one of the reasons that gave inspiration to the idea of an all-in-one model. The mind-set is a renaissance idea in a modern digital form.

All information in one model requires one mind-set among all the model users, a nearly impossible situation. One model, representing both needs, functions, economics and the physical, will base its objects on one type of representation, e.g. the physical, and that will create dependency of this specific representation. A building can be represented as needs to be fulfilled, a result of functions or a result of investment, the list can be continued. Each representation will have a specific purpose, and must be sorted accordantly. This kind of order can be obtained by two approaches:

1. The partners agree on a common understanding of order - the original DBK approach
2. Each partner provides own order (as it is seen with the initiative from FM managers in social housing, see Landsbyggefonden 2009)

Figure 5: An alternative BIM vision could be as a collector the necessary information between the partners.



To ensure that the order of each partner will support a flow in the building process, to the benefit of all, a change of fundamental orders is required.

To ensure that each partner support a flow in the building process, to the benefit of all, without losing overview and direct access to own business core data, requires a change in the mind-set of order.

DANISH BUILDING INDUSTRY APPROACH

In construction in general a broader understanding of classification is applied that ranges from classification of building types and real estate to the properties of building materials. Most of these classifications were established in the 1950s and 1960s. Basically we can identify at least three different types of registers, namely:

Administrative registers for registration of properties and buildings - the complex and rather comprehensive Danish building and dwelling register, is an example. *Product registers* can typically be seen as object libraries in different CAD programs organised as building parts. *Registers used as part of business systems,* for example suppliers' product and ordering systems embedded in facility management systems).

Thus the parties of the building industry use all three types of register, but they use different sections. If one part uses administrative data of a building, another part uses data regarding the same buildings physical conditions.

The Digital Construction initiative

The report "Digital Construction – Report from a working group" (Erhvervsministeriet 2001) marked a comprehensive beginning of the digitalising efforts by Danish construction. The report pointed to areas where it would be fruitful to initiate the efforts.

The first area for action was described in the report ("IT-retningslinier for offentlige bygherre' in Danish "IT guidelines for public clients", our translation) aimed at supporting the client with a line of advantages connected with the digitalisation, and in this way motivate the client to be a driver for development.

The second initiative described in the report was 'Udvikling af standarder og IT broer mellem byggeriets brancher' (in our translation "Development of standards and IT bridges between the sub-sectors of construction"). The report states that there is a massive need for a mutual digital foundation for all the parties of construction and that this foundation has to encompass a uniform, object-oriented and systematic approach. The systematic should include documents, building objects, buildings parts and be coordinated with international standards for the different areas. When the outlined initiative was launched in 2003 (Erhvervs- og byggestyrelsen 2003), it was driven by consortia with the consultants as the most important drivers. Taking this into consideration, it was not a surprise that the sketched classification reflected the consultants' views of construction.

The proposed model was not able to fully comply with the consortia's own design guidelines - the development of a particular classification system especially meant for administration and facility management (with special emphasis on social housing), demonstrated this. In the first out of nine reports the authors state (Landsbyggefonden, 2009) that it is regrettable that DBK does not take the perspective of Facility Management into consideration, and this is the motive behind the development of the classification system for FM and administration.

If other parties in the field of construction do not consider DBK to an adequate tool to satisfy their needs, they will fall back on their particular classification systems and DBK will probably fail as mutual platform. Different platforms will hinder one of the primary goals of DBK, namely to harvest the rationalisation profit of a more smooth dataflow in the whole business of construction.

The plan for DDB's deployment (EBST, 2003), was focused on partners variations in the use of ICT. This was done through six focus groups, which largely reflected the parties' business affiliations. The report also discussed the partner's common vision and concept for the industry as a 'product' model (EBST, 2003: page 10) in which product model is clearly a product register and all other data are the product characteristics, or properties. In this case the vision and development of a common classification system does not involve the fact that some parts are working with objects that are probably related to a building but not necessarily related to physical product.

NEW DEMANDS AND NEW POSSIBILITIES – A RETHINKING OF SYSTEMS WITH THE USERS IN MIND

Several examples are giving by Kwasik (1999), on how the overall structure laid down on the field of knowledge, becomes a barrier for the unfolding of the complexity embedded in this field. There can be several reasons for this. Relations and coherence, which are a part of the constitution of the very field of knowledge, can in a growing extent be unsuitable for accommodating new scientific conquest – e.g. cognitions.

Often a simple attempt at caching the "defining criteria" of the classification, neglect the complexity in the field, and in this way in fact becomes a sort of barrier for new development (technological or in other ways) can be accommodated in the classification, and the classification becomes a conservative force for incorporating developments in the professional understanding of the field of knowledge.

It is obvious that the level of complexity in construction is high. This is relevant both for what factors the different parties (client, facility manager etc.) finds relevant and in relation to where on timeline you approaches the process of construction. A classification approach has to deal with this complexity – or be more specific the changes in perspectives due to shift in actor and due to localisation on the timeline – it has to be flexible.

This description of what a kind of challenges the classification system has to deal with makes it possible for us to give short design characteristics of the classification system.

It has to have a flat - vertical oriented structure. The structure does not have to be based on a theoretical argued understanding on how different parties, actors relate to one another, inside a certain structure. Such an attempt would be deemed to fail due to the complexity in the field and a generic classification model would be impossible.

An alternative approach would be to provide the classification system with relative few objects which all are supported by a long line of properties. The objects has, as mentioned above, to correspond with the perspectives belonging to the different parties of construction. From our discussion of the general problems in construction it will be possible to deduce both the object and the properties. In a system with those principles it will be possible for the user, dependent on their special assignment in construction, to choose or rediscover exactly those data they will need at a certain time in the building process. Besides of this vital advance it would, potentially, be possible for the user to add properties, including data to the system. As a main principle, properties have to be located at the same level – in a very flat system of classification.

It is obvious that in a system as the described there will, over time, be acquired a considerable amount of properties with data and not all will be equally relevant for all users. Thus the system needs to have the ability to extract data according to search (mostly by standard-) profiles relevant to that kind of user, although there a possibility for letting the user make his/hers own search profile.

Speaking in the terms of traditional (hierarchical) classification, classification is reshaped by each lookup. Some predefined lookups can be available for use. But it is not an option for the user to create a template for an exact purpose.

A solution as the proposed, has in theory been possible for many years, but is first feasible now due to the very low price on computing power.

Technic matters or/and organization

Data in a BIM model will inherently result in a larger work in terms of data organization, regardless of the type of data organization is involved. When the BIM is intended as a successively built chunk of data, to be refined through the process, the idea is that all parties have access to data in precisely the form that supports their needs. This sounds obvious, and something that all partners have already joined. However, the answer to how data is organized as a practical item is not exclusively a technical choice but also implicate the organizations themselves, i.e. each party's self-organization, working method and location in the process.

Where the partners in the construction industry sees itself as pearls on a string, the introduction of BIM, with all this entails, make it more relevant to consider the partners as consistently present facets of a continuous process. This change in perception of positioning can be a major challenge for each party than the choice of technical solution.

A review of the partners internal organization, will involve a review of data. Where data can be structured in the interests of logic of data itself, the data can also be structured from a logic based on its use, in this case each party's needs with due regard to the other partners. These two logics are not necessarily contradictory, but require that the focus of the discussion concerning data organization, involving data use.

The building industries approach has so far been that if we have only established a collaborative mind-set, the technical solutions could be implemented properly and the industry will achieve a productivity improvement. The question is whether this common mind-set can be found through an adoption, or whether that mind-set first emerges when the technology has resulted in a productivity boost. This could very easy be a "chicken and egg 'dilemma.

Our approach is that the partners must implement data organization, and related technologies with their own business operations in mind, and this is to be done with due considerations to other parties. In the Danish context, the consultants have been engaged to development, and this has led to that this part's own business has been put in front, which is both natural and reasonable from their perspective. Problems arise when they needs is to be the solution for all parts. The idea that 'if everyone does like us', will not necessarily improve the other parties' business areas.

The core in this problem lies in understanding what a due regard to the other parties involved. And a recommendation is that the flat data structure provides better opportunity to support each part. In this structure, the object cannot be only a representation of the physical components. The object must be defined through its properties, so all parties can add properties that exactly support their own business.

CONCLUSION

To classify is not about to put everything in this world into boxes, reflecting the true world, but is to place things and matter into a meaningful structure, and making it operational.

Weather BIM is organizing the construction data in one way or and other, it will be a massive mass of data. The problem is not to generate data, but to pick out relevant data, in other words, to filter data in a proper manner and at a proper point.

To do this we need two things. A way to organize data, making it more searchable and available, than in the hierarchical system, and a filter mechanism as a universal user interface, which on the one hand can create an interface between the users perception and context, and on the other hand function as a dedicated search engine.

The partners of the building industry must revise their own procedures and see the choice of data organization in relation to own organization. This exercise will most likely require changes in the organization, because implementation of technology and the associated software systems cannot be tackled with a technical trick.

To achieve a common mind-set, without ending in the discussing about the chicken and the egg, every part must play with two balls. Where the first ball is a change or revision of own organization the second is the consideration for the other parts and their needs. This is more possible with a flat data structure, because it does not require that everyone agrees upfront. With the flat data structure no single party set the agenda and that each party can optimize their own business and that all parties contribute more specifically to the overall process.

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