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KOMUNIKACIJA IN PRETOK INFORMACIJ V KONTEKSTU ARHITEKURNEGA NAČRTOVANJA

COMMUNICATION PROCESS AND INFORMATION FLOW IN THE ARCHITECTURAL PLANNING CONTEXT

DOI: https://dx.doi.org/10.15292/IU-CG.2018.06.066-073 ▌UDK: 728.1:658.5 ▌1.01 Izvirni znanstveni članek / Scientific Article ▌SUBMITTED: August 2018 / REVISED: September 2018 / PUBLISHED: November 2018

IZVLEČEK

V pogojih vse večjega kopičenja podatkov v vsakdanjem življenju postajajo orodja za obdelavo podatkov vedno bolj zmogljiva, da omogočajo podporo kompleksnemu načrtovanju stavb. Proces arhitekturnega načrtovanja ponuja vrsto novih instrumentov za oblikovanje, načrtovanje in načrtovalsko odločanje. V idealnih pogojih dostop do informacij služi zagotavljanju in dokumentiranju kakovosti stavbe, v najslabšem primeru pa povečano število podatkov zahteva predvsem čas pri zbiranju in procesiranju, brez koristi za stavbo in njene uporabnike. Procesni modeli lahko ponazorijo vpliv informacij na oblikovanje in načrtovanje in tako podpirajo arhitekta in načrtovalca pri vodenju procesa. Članek predstavlja pregled zgodovinskih in sodobnih modelov za vizualizacijo procesa arhitekturnega načrtovanja in vpeljuje načine, kako opisati današnjo situacijo, z vključevanjem različnih deležnikov, dogodkov in instrumentov. Renesančne modele primerjamo z modeli, ki so se uporabljali v drugi polovici 20. stoletja. Predstavimo tudi sodobne modele, predvsem v smislu njihove vrednosti v luči vse bolj računalniško podprte gradnje.

KLJUČNE BESEDE

proces načrtovanja, struktura in faze, akterji, pogoji, orodja, udejanjanje, postopek načrtovanja

ABSTRACT

Against the background of growing data in everyday life, data processing tools become more powerful to deal with the increasing complexity in building design. The architectural planning process is offered a variety of new instruments to design, plan and communicate planning decisions. Ideally the access to information serves to secure and document the quality of the building and in the worst case, the increased data absorbs time by collection and processing without any benefit for the building and its user. Process models can illustrate the impact of information on the design- and planning process so that architect and planner can steer the process. This paper provides historic and contemporary models to visualize the architectural planning process and introduces means to describe today's situation consisting of stakeholders, events and instruments. It explains conceptions during Renaissance in contrast to models used in the second half of the 20th century. Contemporary models are discussed regarding their value against the background of increasing computation in the building process.

KEY-WORDS

Design process, Structure and Stages, Actors, Conditions, Tools, Manifestations, Planning proces

1. INTRODUCTION

1.1 Complexity in the architectural planning process and communication models

The architectural planning processes deal with an increasing amount of information or its digital form data (Windsperger et al., 2010). One reason is the rising complexity of projects and extended functionality of software programs which are used to develop, steer and communicate the planning decision. Against the background of growing data quantity in everyday life, information augments continuously. As the variety of knowledge sources and tools generating very specific categories of information is increasingly available, planners are capable of making their decisions based on information which was not accessible before the frequent use of the internet in the 90ies and the introduction of Web 2.0 in the beginning of this century. The architectural planning process experienced a growing impact of computation which offered great potential. The introduction of computer aided design contributed essentially to reduce the time to draw and encouraged more complex design approaches. The communication among the planners and clients became easier. Plans as mean for communication could be produced with less effort. In the beginning the technical connection between semantic and geometric information was introduced by the concept of building information models. This supports the implementation of quantifiable aspects in different stages of the planning process. In the design and planning phase aspects like costs can be a basis for optimization and be later on updated and monitored. The production of a building, including the activities of the stakeholders becomes more transparent in all stages, the design and planning, the construction and the building use. Furthermore, it shows potential to also include the time after the use phase as a source for secondary resources.

The new level of transparency especially in the planning process stimulated the demand for meta methods which range from organisational structure for the process documentation to specific definition of terms and regulations in order to come to an agreement for specific milestones. From disciplines outside architecture methods and software solutions have been introduced to visualize and monitor the planning process.

The increased computation is also accommodated by changes which constitute potential risks. One challenge is the recognizing relevant data; while it is currently possible to judge whether compliance with mandatory regulation is achieved, it becomes considerably more difficult to distinguish relevant from irrelevant information. A planner could easily get lost in the data-scapes and loose working time by processing information that is not (at that time or not at all) useful for his work. Additionally, quantifiable information are significantly better represented compared to qualitative capabilities. The translation of building qualities into a numeric and therefor tangible capabilities exposes the risk of reducing a variety of values in architecture.

Models to visualize and reflect the architectural planning process have been introduced already in the times of Renaissance. Later on, the dynamic and elements of the planning process have been investigated by design theorists. Especially in the last six decades, architect and planners increasingly discussed models of communication in architectural design. In the context of this research information flow models are looked at in regard to their suitability to show successful and failing process while *successful* in this context can have different designations.

1.2 Aim and method

The aim of this paper is to provide an overview of information flow models which include historic conceptions of the building process, as well as contemporary approaches from other disciplines. This review paper provides an understanding of different model characters and explains their potential to different applications.

The paper is based on literature review, including books on architecture theory, scientific journals ranging from 1970 until 2018. Furthermore, the results of three student courses on information in the architectural design context are included. The assignment included the development of a model to visualize an architectural planning process. The *grammar* the students created is introduced here as well as the findings based on the students application.

The paper is structured in four parts (chapters), of which the first part (2nd Ch.) introduces different communication models. It starts with an historic communication model of in the context architectural planning process and proceeds with Mid-century approaches not strictly limited to the planning process of buildings. The second part (3rd Ch.) reflects on the model's potential for different application in the architectural planning process. Based on this, students developed models in three subsequent courses models to show the information flow. The models are introduced in the third part (4th Ch.). The paper closes with a discussion on the different approaches against the background of today's complexity in the building process (5th Ch.).

The aim of this paper is to identify models that are suitable to show successful and failing processes and indicate whether more information lead to an increased quality for the building or the building process. Models to visualize and discuss the architectural planning process have been mainly produced and applied by architecture theorist and IT specialist. The paper explores the application of communication and information flow models for architect designing and planning a building and for consultants hired to optimize the architectural planning process.

2. DEVELOPMENT OF COMMUNICATION MODELS

In Renaissance, design solutions were thought to be the results of exclusively intuitive, sudden inspirations, originating from the creative genius of one person, the architect. Leon Battista Alberti describes this position as the one who holds the complete intellectual control of the design, develops and defins it within a multitude of drawings (Alberti, 1485/1988). The architect expresses the so-called lineaments (*lineamenta*) which incorporates both, the virtual idea in a designer's mind and its representation on paper.

Thus, the lineaments are the designer's intellectual products preceding and directing the physical execution of a design. From the present point of view, Alberti's description of designing may be described with a model of communication that shows a linear flow of information conditioned by a clear hierarchy (Carpo, 2011). In this model, one actor takes all decisions and defines the solutions that are communicated by means of the drawings to the building site where they have to be executed as faithfully as possible.

Manifestations of a changing conception were produced in the 1960ies, for example in Europe by the Team Ten group which formed within the context of the CIAM (Congrès Internationaux d'Architecture Moderne, Engl: International Congress on Modern Architecture) Congresses and started a critical revision of the modernist era. They underlined the need and the potential of collaboration of different disciplines for the adequate solution of urban and architectural problems and lived that conviction through the intense theoretical discussions within their international group of architects (Smithson, 1974).

The drawing of an "ideogram of a net of human relations" (Fig. 01) shows the conceptual communication model of the Team Ten. Information is exchanged in a net character. Another visualization of communication involving different parties is Charles Eames' "Design Diagram" (Fig. 02) elaborated for an exhibition in 1969. The diagrams show the multiplicity of concerns and interests involved in the design process, it underlines the importance of different actors like the client and external specialists, and shows an overlapping field in the centre as the place where the design decisions should take place (Demetrios, 2001).

The role of the architect in the planning process was recognized as a centralized information manager depicted in the Design Diagram in Figure 2, who communicates various information to different stakeholders. Most information (in the past and present) is exchanged between the architect and the client or other engineers and the architect aiming in meeting the client's expectations and ensure a high quality of the building. The planning process follows a certain structure (starting with a design idea, to construction planning, realisation and use phase) but the communication among the stakeholder is project-specific.

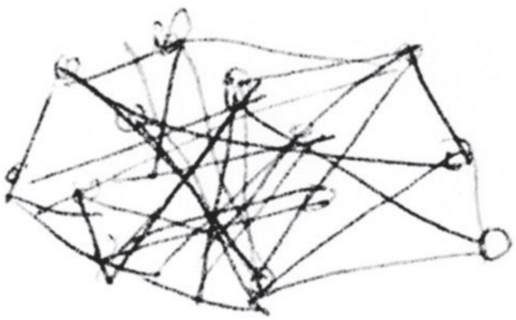
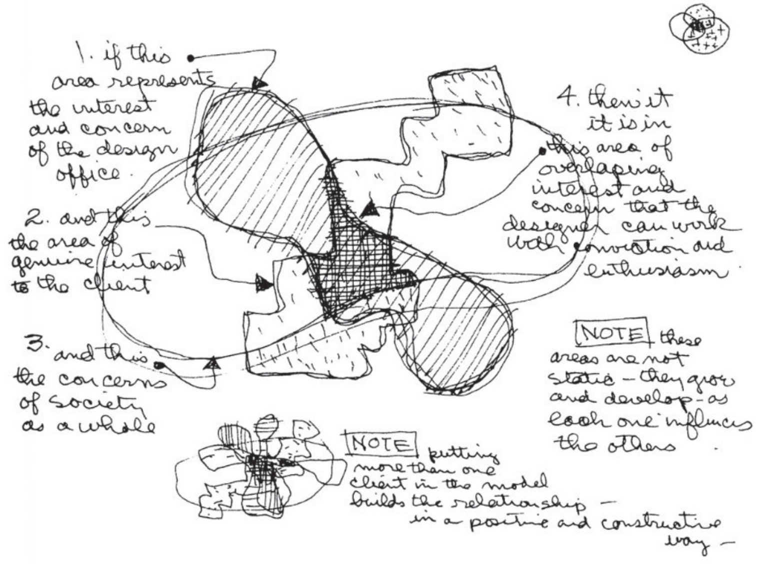


Figure 1: Sketch by Alison and Peter Smithson: Ideogram of a net of human relations.

Figure 2: Charles Eames' "Design Diagram", 1969.



3. APPROACHES FOR CONTEMPORARY COMMUNICATION MODELS

3.1 Data Flow Diagram

In the second half of the 20th century poor information transportation was identified as one origin for design failures and motivated the development for process models to find and tackle them. Improving the management of a project by modelling its framework became a new method to provide an overview of the whole process. This generic approach is based on a comprehensive understanding of the information flow within a process (Browning, 2001). In 1970 the *Data Flow Diagrams* (DFD) was designed by Constantine, a US software engineer, to visualize information flow in data systems with the focus on processes and information flow (Stevens, Myers, & Constantine, 1974). Baldwin and Austin (A. Baldwin, Austin, Hassan, & Thorpe, 1999) used this approach to transfer it to the building sector. With this method the transformation and coordination of information flow in a system could be displayed and information exchange between activities can be mapped. According to Baldwin, data flow diagrams are organized in a hierarchical manner with the main task or process at the top level, called *context diagram*. This diagram is divided into further subtasks or processes until the identification of tasks which generate specific information conditions at the bottom of a diagram. These tasks known as *functional tasks* represent the design outputs or deliverables like drawings, calculations or sketches. Figure 3 shows a structure of a generic data flow model for conceptual and schematic design with 6 stages. This schematic diagram provides a comprehensive graphic of the overall process and provides a model which monitors information requirements for each design task.

Figure 3: Structure of a generic data flow model for conceptual and schematic design (Baldwin, 2010).

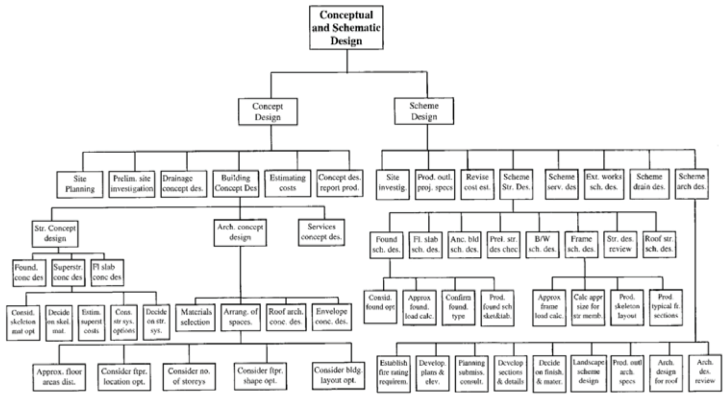
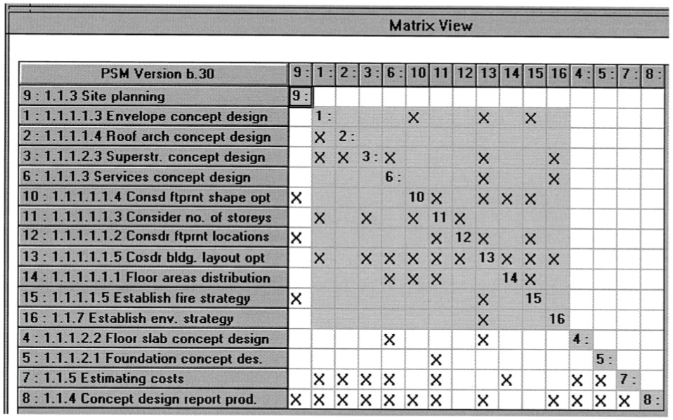


Figure 4: Baldwin, 1998: An example of an DSM with an identified iterative loop.



3.2 Design Structure Matrix

Don Steward introduced the *Design Structure Matrix* (DSM) in 1981, a model that analyses dependencies between tasks and information (Steward, 1981). Research on information flow was and still is conducted by several international institutes like the MIT, Loughborough University, University of California at Berkley and (Hardin & McCool, 2015). Against the background of the digitalisation in the building sector and especially with the introduction of information linked geometries, building information model, the use of models based on DSM can be increasingly observed. Several information modelling techniques have been developed by the software industry since the need of a comprehensive understanding of information flow between stakeholders' relays to the production of computer-based information systems.

During the design phase changes in the design occur as loops in the information flow which are known as iterative design tasks. The DFDs does not identify these iterations. Applying the DSM can be a useful for that. This model is used to determine communication failures and information flow gaps in a design process by displaying the relationships between components of a system. Due to the iterative nature of a design process information are being moved back-and-forth between stakeholders or disciplines. Especially in a multi-disciplinary process like building projects information like calculations, structural loadings, facility specifications are being exchanged between architects, civil and structural engineers or building services engineers (Liau & Wang, 2000). By identifying dependencies between design tasks and reordered them a planning process can be improved. Therefore, the DSM identifies loops by portioning sequences of design tasks caused by changes in the planning process. These changes can relate to the clients change of requirement or desire, a delivery of false information, unavailable resources, weather conditions or others. As shown in Figure 4 the DSM organizes tasks in rows and columns. Dependencies that exist between two design tasks are marked in the matrix. If a task provides input to another task, than a mark exists under the diagonal line. If a mark exists above the diagonal line, than a tasks provides information to a previous tasks which indicates that the information is not existing at that design stage and an assumption has to be made. After completing the task its information needs to be checked which causes a loop in the design process as shown as a grey shaded area in the diagram (Fig. 4).

Using the DSM to analyse the planning process can identify misleading or missing information, which relay to changes in the planning process and raise the potential for design failures or delays in the schedule. It provides a simple and compact visualisation of the planning tasks and their relationships to each other based on their dependencies. This model is used in disciplines like the automobile industry to manage the product development. Today DSM is often applied in combination with other visualization models like flow charts. (For example in (A. N. Baldwin, Austin, Poon, Shen, & Wong, 2007) a process flow chart, an information dependency table, a horizontally organized project program chart and a DSM are combined to what the authors call *Analytical Design Planning Technique*).

3.3 Visualisation of process models

Process models are used in different disciplines like business management, psychology, ergonomics and computer science among others. They represent different perspectives of processes; while business management models seek for optimization of company organisations or production flows, psychology and ergonomics focus on displaying interdependencies aiming in a better understanding. In the building sector both approaches can be recognized. The following distinction can be helpful to specify the context of the process looked at. Ergonomics differentiates types of process in *Business processes* (which aims in the production of goods and services for a certain market), *Work process* (describing the process within one company with regard to a person) and *Workflow process* (a formalized process which is structured by time and procedural aspects). Looking at the building process could be considered as Workflow process with different stakeholders (Mütze-Niewöhner, 2017).

Over time, different visualisation languages developed. In the 1960ies Petri nets were developed in the computer science context to show different parallel processes (Petri, 1962). It showed to suitable to discuss theoretical analyses and simulation but lacked clarity to be included in practical application. In 1977 and in 1983 as revised form, the standard DIN 66001 *Information processing; symbols and their application* was published which was originally developed to illustrate computer science program sequences (Deutsches Institut für & Normenausschuss, 1983). (Scheer, 2001) describes the *Event-driven process chain*, which was introduced in the 1990ies as one model to be used for the analysis of processes at departmental level and for computer-aided optimization processes. It includes a graphical language which provides forms for certain parts of the process description.

4. INFORMED BUILDING DESIGN MODELS

In the building sector, established models to visualize the planning process can be found only in very simple form. (This is especially true for small and medium size projects. Nevertheless, it is expected to change with the increased application of BIM). One example is the construction schedules which describe the time of completion of a task in written form and includes a horizontal bar chart. These diagrams grew with the complexity of the building and the planning process. The information which can be derived from this type of visualisation is very limited. It names tasks, the responsible stakeholder and the defines when the task is due. The information which can be derived is limited to whether an assignment is fulfilled according to a certain time frame. The quality of the produced subsection or the reasons for delayed /early completion are not documented.

The technical means in regard to software products for visualization offer a great potential for the design and the management process but is also brings along new types of challenges or even risks. With ongoing bigger amounts of information the issues of organizing, evaluating and communicating them becomes increasingly important. While it is still possible to differentiate between information that is mandatory or not, it becomes considerably more difficult to distinguish relevant from irrelevant information. A planner could possibly get lost in the data-scapes surrounding the working process. The method how to handle the complexity of data and how they build criteria for their selection is closely connected to the models of communication used in planning processes. Within these models it can be observed how the flow of information is developing. This was the starting point for the student courses *Informed Building Design* which was conducted in the format of a research module. In three subsequent courses (in the summer semesters 2016, 2017 and 2018) the topic of information in the architectural planning phase was investigated. Each course assignment included the development of a process model and its visualisation with three different foci; The first dealt with the establishment of a visual expression, called *grammar*, the second focused on expressing the process and the third dealt with mistakes in the planning process.

4.1 The grammar

In order to visualize an exemplary flow of information during a planning process the components of the grammar are combined with a graphical code. The components *actors*, *conditions*, *tools, products* and *coordination* have each a symbol (circle, square, rhomb, rectangle) and a colour. Further, the thickness of the symbols' boundary line indicates the decisional hierarchy among them. Thus, it is possible recognize which actor produces which quantity of information but also whose information is on a higher position within the hierarchy. The diagrammatic visualization of the communication model and the flow of information is therefore capable of a distinction between the quantity and the decisional weight of information (Fig. 5).

Stakeholders can be a physical persons, an office or an institutions. The architect and the client are included in every model. Architects collaborate with specialized planners from different areas of expertise and, especially in larger projects, with different professional figures linked to project management. The client can be private or public, represented by single individuals or groups and be interested directly (a private person commissioning the own house) or indirectly (an investment group) interested in the results of the planning process. Furthermore, if not the same person, the users of a building can become actors, too. Public institutions, like building authorities and the land-registry office, account as actor. In greater projects, especially in public buildings or when participation of the population is included, citizens may be part the planning process. In later design stages, the executing building firms become active participants of the planning process.

A planning process is exposed to a series of conditions which are contained in formulation of the design task—the brief. The brief contains various binding specifications, like the functionality, the indications on quantities, and the specific requests of a client. Normative standards and contractual specifications build another group of design conditions. Finally, the factors time and costs are fundamental conditions of planning.

The different actors of a planning process use a multitude of tools which can be highly specific and can become very influential in generating and processing information. A first subdivision of tools differentiates into analogue and digital drawing tools, analogue and digital modelling tools, text and calculation software, photographic cameras, and the tools of Building Information Modelling.

As a product of working with different tools, manifestations are produced. These represent the processing of information and become then units of information on their part. Typical products created during planning processes are sketches, drawings, models/mockups, photos, tender documents, plans, textual documents, cost calculations, schedules, and Industry Foundation Classes.

Figure 5 shows different components of the model: on the left the different stakeholders, in the middle the topic, on the right the tools, on the far right the output format an on the bottom the point of coordination where decisions (yes or no) are taken.

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NATEČAJ
COMPETITION
PREDSTAVITEV
PRESENTATION
DIPLOMA
MASTER THESIS

Figure 5: Different components of the model.

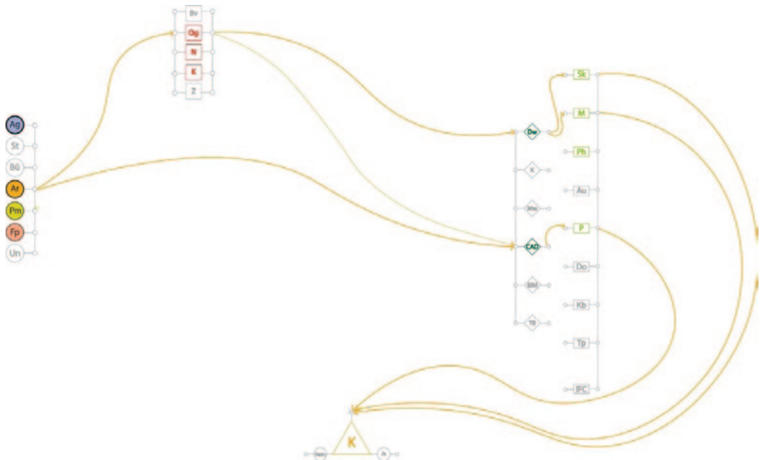
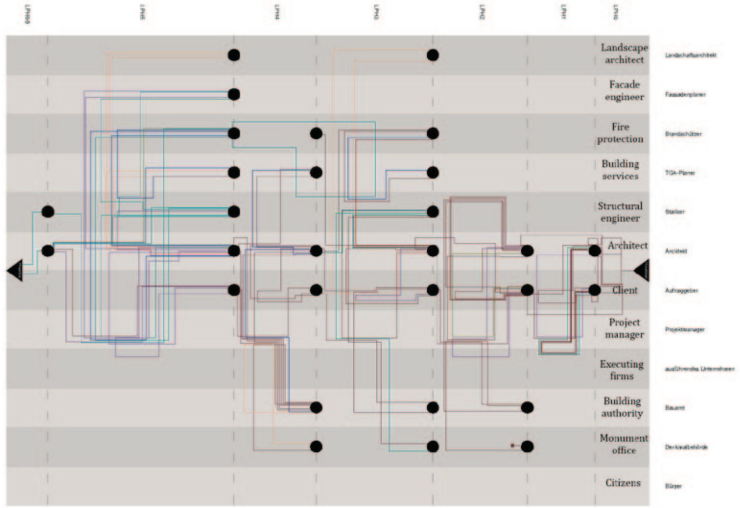


Figure 6: The process model of the second course.



4.2 The process model

Based on the grammar presented, the subsequent model focused on visualising the planning process while the grammar was adapted. It included the group of *actors, framework conditions*, *topics*, the *information flow*, the *type of information* and the *media* that carries the information (Fig. 6).

The actors follows the logic introduced in the previous chapter. The framework conditions include the qualities of the building project defined by the client (German: Bauvorhaben, Bv), the properties of the site (G.: Ortsgegebenheiten, O), standards for building construction (G: Normen, N), costs (G.: Kosten K) and time (G: Zeit Z).

The topics describe the information the media refers to. It is subdivided in I) design, II) building services, III) finance, IV) building construction, V) interior construction and VI) environmental aspects.

The information flow shows three icons. One for incoming information, one for outgoing information and information that is not passed on. The triangle represents a stakeholder.

The type of information is differentiated in qualitative and quantitative.

The media four categories are given: 2D drawings (CAD), digital 3D Modell (IFC), visualisation (V) and text (T).

In Figure 6 the actors are represented on the y-axis in the form of swim lanes, thus it is recognizable which actors are involved to which extend according to work phases. Furthermore, the information flow can be tracked. The process is structured by the nine phases defined by the professional associations of architects and engineers, the German Fee Structure for Architects and Engineers, HOAI. It specifies legal responsibilities as well as fees and is used as a common underlying structure for the protocol. The different topics are represented by the different colours. The topic that dominates a phase is best visible.

Figure 6 shows the process model of the second course. On the x-axis the phases according to the German Fee Structure for Architects and Engineers are shown, the y-axis reflects the actors. The differently coloured lines show different topics.

4.3 Planning mistakes

In third course a specific planning task was provided which should be visualized in the model. Based on the experiences before the model presented here included the following categories: *actors*, *topics*, *media*, *type of information*, *milestone*, *weighting* and *information transfer*. While the first four are adopted from the previous models, three new categories are introduced.

The milestone contains a variety of assignments at the end of planning stage. It is displayed with an octagon shape.

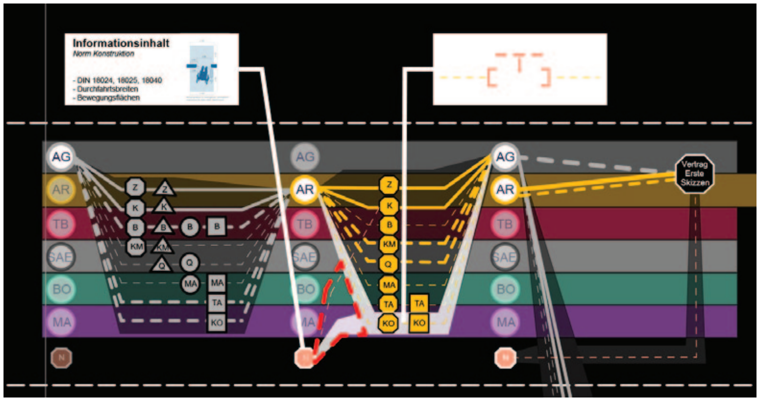
The weighting is differentiated in soft and hard. It is indicated by a thin (soft) and thick (hard) line.

The icon for information transfer refers to the translation of information into built subjects. It is shaped like a arrow.

The diagram shows the time in months on the x-axis and the different planning phases according to HOAI on the y-axis. The ideal sequence presents itself as an diagonal line meeting all milestones to complete the construction in the planned time. Deviations from this diagonal can function as recognition for problems or flaws in the process flow.

In the hypothetical problem case, the client discovers a planning error after completion and reports it to the architect. Here, the door to the bathroom

Figure 7: The problem of lost information.



is not barrier-free and the wheelchair user cannot use the bathroom as it is too narrow. The source of the error in the process documentation can quickly be traced back to performance phase 1, in which the necessary standards and guidelines were not called up by the architect with regard to the construction. This error is characterised in the further process by a rebound in performance phase 1 and thus deviates clearly from the diagonal of the ideal case. The integration of the standards would have constituted a *hard* factor and, in an interactive system, would lead to the process stopping at this point until the target had been met. In the further processing of the correction of defects, the process then goes through LPH 3 and 5 as before and ends with delayed completion after 20 weeks instead of the projected 14th weeks.

Figure 7 shows the problem of lost information which resulted in missing one milestone.

4.4 Reflection on the proposed models

The three approaches used different categories to define the grammar. Actors and media are included in all of them. The framework conditions occur also in all three; while in the first two, the category is named as such, in the third the subjects of the framework is not differentiated by divided in soft and hard. Tools is only used in the first one, topics are part of the second and third as well as the information transfer.

The variety of categories were discussed among the participants of the courses with the conclusion that ideally different foci should be supported by customized visualisation. A model which reflects the planning process should ideally include a broad variety of information but select the parts that are necessary for a certain time span, for a specific actor or to fulfil a milestone. Different visualisation levels and box-in-box scheme were part of the discussion.

Process visualisation models in architecture are impacted from other disciplines with is also reflected in the motivation to apply the models. While quantifiable data can be used to optimize a process or a product, qualitative data needs a representation as well in order to be integrated as relevant criteria.

The models do not only serve to evaluate and optimize, furthermore they can be used to reflect on the process or to function as a type of process--supporting instrument which helps to organize the growing amount of information in the form of data.

5. DISCUSSION

In recent years, architect and planners discussed models of communication in architectural design not only as mean to reflect and visualize processes but also as idea of communication as an integral part of designing. This is connected to a substantial shift in both, the intellectual conception and the practical organization of architectural design. Considering the discussed models, implies the definition that designing as a process that features decisional sequences, involves different actors and is characterized by ongoing interactions.

Before electronical data was introduced to architecture, models for communication processes were used to visualize the relation of different stakeholders to one another and the information flow within a process. The modelling of processes and schematic visualisation helped to understand and clarify how the use of new tools and the varying influential field around the process are changing the decisional sequences of planning and thus, the profession of the planner. Later matrixes were introduced to reflect the interdependencies between different actors. Based on this method, software products were developed which lead to increased capabilities in processing data.

Nowadays, two principal factors are influencing the possible models of communication active within these decisional processes: the increasing complexity of design tasks and the rising influence of economic and ecologic forces. In order to cope with the changing situation, an ongoing development of collaborative and communicative tools is taking place and in this moment. The most relevant and influential one of them is Building Information Modelling that translates the Charles Eames' idea of a field of maximum overlapping of concerns into a digital model.

One target of the new digital tools is to minimize errors in the sense of "wrong decisions". For this scope, they collect and compare as much information about the planned object as possible in order to detect contradictions and incongruences. This function is particularly important from the stage of execution planning on but in order to control costs and time efficiently it is supposed to be integrated in possibly early design stages. Another target of digital tools and their capacity of collecting and processing information goes beyond the avoidance of "wrong decisions": it is to take "intelligent decisions" helping to optimize the design from early decisional stages on. This optimization is made in correspondence to parameters or criteria whose definition can be once again already the result of some kind of data elaboration and evaluation.

Therefore, an ongoing trend of information-based decision-making can be observed. The sharing, communication and negotiation of information, or data, thus become key-factors in design processes. Along this development, a series of relevant questions are arising: how is the complexity of available information handled, how can contradictory information be negotiated and how are suitable criteria to differentiate between relevant and irrelevant information developed? Which influence do the different tools have in this context? Moreover, how will the models of communication within these data-scapes look like?

Against the background of new conditions, architects and planners need an basic understanding of the complex parameters and conscious perspective on them to steer and guide the architectural planning process. The deeper understanding permits to propose new models of communication and to develop adequate criteria for the structuring of design processes that augment the quality of their results.

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