Optioneering in Collaborative Design Practice
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ABSTRACT

The discourse about computational support of collaborative architectural design has in recent years mainly focused on the topic of Building Information Modeling (BIM). In this paper, the method of ‘optioneering’ is presented that, in contrast to current BIM capabilities, assists designers and consultants to resolve design problems through integrated analyses across disciplines in the early stages of design. Although the method of ‘optioneering’ has only recently been adapted in building practice, it has been preceded by manifold efforts by researchers in the field of design and computation over the past two decades. At the end of this paper the computational framework ‘DesignLink’ will be discussed. ‘DesignLink’ supports ‘optioneering’ in the design stages before BIM becomes effective and it is currently being developed and used to support performance optimisation of building projects in practice.
1. Introduction

A seamless design and evaluation environment has been envisioned by researchers since the early days of computational design but the integrated design system has been elusive for the last 30 years. [1]

This paper explores how computational technology can support the process of optioneering in design practice. First a definition of the method of optioneering is provided to introduce the terminology in the context of architecture, engineering and construction. Thereafter, and in considerations of lessons learned from research on computational design-collaboration systems, a new framework is presented that is currently being tested in architectural practice. This framework, titled DesignLink, helps designers to analyse building performance by combining rule-based geometry-modeling and multi-criteria design optimisation to support decision-making processes on complex building projects. The outcomes illustrated in this paper are based on a three year research program (Delivering Digital Architecture in Australia - DDAA) that was set up as collaboration between researchers at RMIT University in Melbourne and design practitioners at the global engineering firm Arup.

2. Optioneering

The first step for successful collaboration using ICT in architectural design is to analyse the processes through which designers and consultants exchange information and build up knowledge individually and in teams. Architects and engineers face wicked problems in everyday practice and they apply different world-views to the way they operate. There is no single optimal solution for a design problem, but there is an array of possible design options that can be explored to find a suitable solution. The evaluation of options depends on design priorities from a plurality of disciplines participating in a design project.

The conception of this paper was preceded by an industry survey about decision making processes in multidisciplinary design teams. Responses from the survey highlight that experience is a key factor for designers and consultants to comprehend the dependencies in group-decision-making. At the same time, the survey reveals that only a few practitioners truly understand over-arching design issues, as they act predominantly from within their professional silos. While project timelines get shorter and the information content increases, a profound understanding of dependencies required for design decision making is not shared by all. The method of optioneering can give less experienced designers and consultants a better framework for decision making and it allows experts to make better informed decisions in a shorter matter of time whilst considering a wide array of alternatives. Advances in Information and Communication Technology (ICT) allow design teams to exchange information in an ever
more integrated and rapid fashion. Computational environments in support of the optioneering method need to take into considerations the cultural and procedural differences intrinsic to different professions involved in AEC to provide a platform for shared understanding and sense-making.

2.1. Defining the method of optioneering

_It is often necessary to make decisions between equally good alternatives as well as needing to satisfy various competing objectives. If none of the alternatives satisfies all the objectives and specifications, the decision maker has to select the best way forward based upon compromise and selection._ [2]

The term optioneering is a hybrid between option + engineering. It implies the creation of options that are arrived at though informed decision making, based on a level of scientific rigor similar to that applied to engineering processes.

The term optioneering is being used in everyday building practice to describe an approach where designers create multiple variations of a design proposal and evaluate those in regard to diverse performance criteria that were set out at the beginning of the design process. As much as optioneering makes part of everyday jargon in practice, it has yet to be defined properly in the English language[1].

Encyclo, a UK based online encyclopedia defines the optioneering as: _a term increasingly used in industry when management needs to be confident of a course of action; particularly where regulatory or funding bodies seek a demonstration of due process_ [3]

This mention of the industry does not indicate which industry is being addressed in the encyclopedia. In industries other than AEC the term is used to describe a strategy in business-oriented decision-making.

_When the consequences of the decision are serious, optioneering is a process that enables clear and structured decisions to be reached._ [2]

_Total Interactive Solutions_ lists four elements that are necessary to facilitate optioneering processes:

1. identifying the options and the criteria for the option evaluation
2. providing impartial scoring for the options and applying weighting criteria
3. viewing and analysing the results; sensitivity and robustness analyses
4. Ensuing stakeholder participation to achieve buy-in to the decision

In strict technical terms, the process of optioneering can be counted as a method supporting _Multi Criteria Decision Analysis (MCDA)_ as described by

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[2] MCDA provides a rich collection of techniques and procedures for structuring decision problems, and designing, evaluating and prioritizing alternative decisions. [4]
Malczewski [4], multi-criteria decision environments allow for the evaluation of complex problems where decisions need to be taken based on a high degree of uncertainty. According to Linkov et al., MCDA analysis serves to evaluate and choose among alternatives based on multiple criteria using systematic analysis to overcome the limitations of unstructured individual or group decisions. [5]

Optioneering processes are intrinsically tied to human decision making. Although the search for possible solutions through optioneering benefits from automated optimisation processes in the evaluation of multi-criteria objectives, the ultimate goal is to provide users with the choice of an array of possible design options.

After considering the general definition of optioneering the question arises: How does the process of optioneering in multi-criteria decision environments relate to the collaborative design process? The current discourse about collaborative design revolves predominantly around interoperability assisted by Building Information Modeling (BIM). While the usefulness of BIM for the management and coordination of design data across disciplines is not disputed in this paper, it is argued that BIM needs to be complemented with processes and tools that foster early design discovery, linked to integrated analyses across disciplines.

A case for optioneering in collaborative design can be found in Laiserin’s distinction between two approaches to architectural design: form-making and form finding. [7]

While Laiserin defines form-making loosely as a process of inspiration and refinement (form precedes analysis of programmatic influences and design constraints) he characterises form-finding as a process of discovery and editing where form emerges from analysis. Laiserin argues that pre-rationalised form corresponds to form-finding [7].

The concept of form-finding is crucial to a new mode of interaction between designers and consultants and it can therefore be seen as precondition to optioneering processes. In current architectural practice, building performance (e.g. related to cost, sustainability, or operational issues) becomes an increasingly important factor in the process of designing. The idea behind form-finding postulates a collaborative and social effort where designers and consultants engage in a discourse at the outset of a project to define, weight and trade-off building performance criteria on a holistic level, without necessarily aiming for a clearly defined goal.

Investigations in design practice that have informed the conception of this paper revealed that optioneering has the potential to facilitate lateral thinking between design professions that would otherwise rely on coordination by the architect. In doing so, a network of connections can be established across disciplines based on the specific requirements of design.

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3 An array of automated performance-optimisation procedures for multidisciplinary design optimisation (MDO) are listed and described by Flager et al. [6] (2008, 1–19)
The configuration of the network can vary depending on the required evaluation between a number of participants at a given point in the collaborative effort. The network described in Figure 1 is an example showing a group of collaborating professions who are laterally interconnected.

3. Methods for knowledge-sharing in support of optioneering

The previously mentioned survey that informed the conception of this paper analysed the preconditions for design teams to engage in optioneering routines using parametric design and engineering optimisation techniques [8]. Outcomes from this industry-wide survey undertaken in at Arup and their collaborating partners⁴ suggest that the comparison of building performance information allows professionals to appropriate better their way of interacting with their team partners. Results that can be obtained from optioneering processes only add to the sense-making process among professionals if the base-criteria are understood by all participating team-members.

The three-year investigation in building practice at Arup revealed that optioneering partners first need to define the criteria-space of their multi-objective design evaluation at the outset of design collaboration. The

⁴ The survey included interviews with practitioners in London, Amsterdam, Singapore, Sydney and Melbourne.
definition of the criteria space requires a dialogue where team members discuss the main performance drivers behind the array of possible solutions they aim at during the optioneering process. Aspects of design priorities from individual disciplines have different impact on the overall outcome of the optioneering process. Some performance-aspects are major drivers in the generation of a project and they need to be addressed as early as possible, other aspects have little impact on the overall outcome and they are considered later in the design development process. While it is possible to establish a matrix that lists some common performance criteria for each building type, experience in practice shows that design criteria are often subject to major variations from project to project.

Designers questioned about their ability to provide expert input in collaborative design teams stated that it is pivotal for them to understand how to provide qualitative support based on project specific performance specifications as well as expertise from previous projects. Each discipline operates on the basis of distinct performance targets with different concerns and different units to describe quantitative values related to their field.

Responses from the industry survey at Arup highlight that the involvement of the whole design team at the outset of a project is currently not common practice. In particular interviewees with mechanical engineering (MEP) and environmentally sustainable design (ESD) background criticize that they get involved on projects at a stage when many of the basic design drivers have already been set down by others.

Research in practice at Arup and their collaborating partners indicates that a useful method to make the design-team understand and develop the main drivers for a given project is to conduct charrettes at the start of a project. In contrast to traditional methods, charrettes in an optioneering context are not only used to discuss design ideas and to decide on first principals. Instead, they are used to quickly develop a large array of design options in a structured and informed manner by associating design proposals with their underlying performance data. Priorities and design-drives that are agreed on during the optioneering charrettes can be captured in a qualitative manner, brought into context through integrated analysis and results can be visualised using graphic notations that are easily understood by the whole design team.

The concept behind optioneering is not new. It becomes more effective through new ways of interaction between professionals from distinct disciplines who collaborate using streamlined computational interfaces and thereby delegate faster turnover of results. Designers and consultants can now consider how building performance might influence the overall building geometry, the structural system and façade options.

Taking the selection of the facade glazing-type as an example, professionals could interpret specific topics such as the importance of the cladding type and the skin heat flow (which is related to the thermal transmittance of the façade) to extract information about their importance.
across different domains. Results from the industry-survey presented in Figure 2 illustrate that while the selection of the cladding type is of high relevance for all professions, the thermal properties of the façade are only relevant to a few (architect, ESD, Façades and MEP).

The system of mapping priorities illustrates one possibility to demonstrate design drivers to the whole team in form of graphically explicit spider-diagrams. A spider diagram colour-coded according to disciplinary affiliation (as seen in Figure 3) could then serve guidelines for common priorities that should be addressed by the team.

Figure 4 illustrates the traditional design approach of how parties interact from issuing the design brief until reaching an outcome. The generation of design options and the interpretation and analysis by consultants occur in separate steps. Decision making is at times done in isolation based on just a few basic design options.
Figure 5 shows a collaborative approach through optioneering where the generation of design options is closely linked throughout the team at an early design stage and multiple solutions are proposed and considered by the design team.

If set up in the right way, optioneering could also enable design teams to compare current jobs with previously undertaken projects and even capture some of the expert knowledge applied within. This knowledge is often not tapped into beyond team-specific or project-specific situations.

4. A computational tool in support of optioneering across disciplines

What support can be provided by computational tools and interfaces to practitioners who engage in optioneering routines?

One major obstacle for concurrent work methods between architects and engineers is that traditionally any major change to a design project results in cumbersome alterations for architects and, in particular, for the consultants downstream [9]. Direct involvement of consultants in the early stage design process (as opposed to the checking and evaluation of prescribed design targets) beyond basic advice about configurations is difficult to achieve.

In architecture and engineering domains ICT has revolutionised the way professionals analyse, evaluate and present outcomes from their field.
through possibilities of computational visualisation, design analysis and simulation [10–12]. Tools for simulation and analysis provide new possibilities for designers and consultants to predict building performance, and to interact in design collaboration with new media [13]. Collaborators profit from computational support through the exchange of 3D geometry models, the increase in speed for drafting [14], design analysis [15], and from the possibilities of sharing information via networked communication systems [16,17].

Most computational tools in the building sector serve individual disciplines, only few tools are available in practice that specifically address transdisciplinary design issues across professional domains. Some software providers want to make end users such as architects and engineers believe that all aspects of design from early stages to detailed design, construction and operation can be solved using their specific BIM tool (Autodesk 2009, Bentley 2009) [18,19]. Based on the responses from more than 240 architects about their design methods and tools in the early design stages, Parthenios [20] identified that only a diminishing percentage of architects opt for using BIM tools to inform their design thinking during early conceptual design. His study confirms that BIM becomes most powerful in later design stages where coordinated assembly of building components, error checking through clash detection and the extraction of detailed quantities of building components are of primary interest to project teams.

4.1. Previous efforts for developing computational collaboration frameworks in architecture.

The development of computational support for optioneering across disciplines as presented in this paper has been preceded by a number of efforts in academic research. Computational platforms for integrated analysis across disciplines had mainly been developed since the 1990’s. Driven mostly from within the academic context in the US and Europe, researchers such as Augenbroe and Winkelmann [21] Kalay [22] Papamichael [23], Chen, Frame and Maver [24] as well as Mahdavi, Suter and Ries [25] have investigated computational frameworks for collaboration.5

Systems such as P3, BDA, VSE, and SEMPER were driven by researchers who aimed to support architects and engineers in addressing architectural design in a holistic, socially responsive, and environmentally responsible way. Although none of the systems listed above have been advanced by software companies to market them for commercial design practice, their development has nevertheless contributed greatly to current efforts in the field. My observation of tools currently used in practice suggests that the research described above lead to tools that worked properly in a highly controlled academic context, but failed to deliver in the chaotic environment of common architecture practice.

5 A comprehensive listing of tools for design collaboration can be found at Iral (2007): The quest for integrated design systems: A brief survey of past and current efforts.
Whereas the tools listed above were ahead of their time on a conceptual level, they lacked the right technological support to become effective at the time of their development.

Comments of those who participated in the development of the tools and frameworks, identified either an imbalance in compensation for extra efforts undertaken for appropriating information and the failure of a single model approach [26]; or they reported on rigid procedural models and the use of object libraries that hinder intuitive design during the early stages; other tools failed in their attempt to recreate the design studio in a virtual version to evaluate results of single optimisation processes. Comments regarding the SEMPER framework explained that it was not set up to interact with commercial software used in practice at the time.

Research for the systems and frameworks described above has not been in vain but it has influenced strongly the development of current approaches in the industry. Those aspects of research undertaken in the 80s and 90s that focused on interoperability and design data coordination of clearly definable building components are now featured prominently in BIM applications. Those elements that relate more to the integration and evaluation of performance analysis across teams have informed the framework that is presented here in more detail.

5. Designlink – a proposal for a collaborative design-framework

“Practitioners need to be able to use tools they trust and are familiar with” [6]

The review of previous efforts in the generation of collaborative decision support systems revealed one feature that all systems have in common: the aim to support social aspects of design collaboration across disciplines. Although researchers accomplished many of the goals they set out to achieve in developing a computational framework for early design collaboration, none of the systems has been adopted in design practice. Below I have listed seven reasons that are most apparent to me in regard to the lack of acceptance in professional practice:

1. lack of interaction with software used in practice
2. extra effort necessary for appropriating information,
3. failure of a single model approach,
4. object libraries that hinder intuitive design,
5. inflexible model setup,
6. failure to recreate processes as they occur in the design studio, and
7. limited analysis results due to single optimisation runs

5.1. DesignLink basics

I participated in the development of a collaborative design framework DesignLink over a period of three years together with a colleague with
engineering IT background and a colleague with Computer Science background. Each of the following paragraphs illustrates how DesignLink attempts to overcome one of the seven challenges mentioned before.

DesignLink was conceived to automate intelligent linkages between design-data from design and analysis tools currently in use in architecture and engineering practice. DesignLink does not conduct building performance analysis itself, but its interface allows users connect data from and to third party tools. The framework thereby enables users to engage in optioneering processes while applying an array of proprietary software they are familiar with. Given this functionality, DesignLink provides design and consulting professionals with a combination of external representations of design data in a custom user-interface.

DesignLink is based on an open, documented and extensible data structure with a low threshold for users to add and appropriate information according to their needs. Whilst the core of the application framework was established and tested by the DDAA development team, DesignLink has now been open-sourced to attract contribution on the broadest level possible. A software developer’s kit (SDK) allows more advanced users to extend the core of the framework and to customise plugins that link the framework to whatever proprietary software they use. Experience at Arup has shown that some designers script interfaces between tools they wish to connect. These interfaces often only link two tools and a separate interface needs to be generated for each additional one. By setting up one core framework through DesignLink, this problem was overcome. A single data schema is sufficient for connecting a tool to a whole range of tools as long as they already plug into DesignLink.

Feedback from practitioners at Arup and their collaborating partners suggests that one single design model cannot facilitate a sensible integration of all possible design data. The types of performance analyses that inform the conception of medium to large scale building projects are multi-facetted and they often require specific appropriation of geometrical data. Rather than relying on a single model approach, the DesignLink application framework is set up to connect information from multiple software applications with the capability of accessing, interpreting, and hosting both geometrical and non-geometrical project data. The DesignLink extensible information schema supports a superset of all the information needed by any tool acting as part of the framework so that all the relevant information can be made available to users at every step during the design process. The information schema is capable of containing the geometric data, performance analysis requirements and analysis results for a particular design instance. In those cases where automation and optimisation is considered, the schema coordinates and compares multiple instances of

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6 The development of DesignLink was undertaken as part of the ‘Delivering Digital Architecture in Australia’ (DDAA) project supported by the Australian Research Council (ARC), RMIT University, Melbourne and Arup.
these same data sets. When automation capabilities of the framework are used, automation management information is stored in the schema, not just the information being manipulated by the process.

In order to allow users to engage intuitively with geometrical data stemming from proprietary design and analysis tools, DesignLink is not limited to handle geometrical elements from predefined object libraries. Instead, project specific design information is exchanged via Extensible Markup Language (XML). The use of XML is central to the flexibility within the information structure of the framework: the DesignLink schema.

The overall DesignLink schema is broken down into a number of sections which target particular roles supported by the framework. As shown in Figure 7, the main sections are Automation, Decision support and Project details and Design. The Decision Support section contains data used and captured by the Decision Support module, such as any analysis results.
extracted for use by the Rule Engine. The Automation section is primarily used by the DesignLink controller application to store data required to construct the rules used by the Rules Engine and data pertaining to any automated processing. The Project Details section contains information about the project, such as the source files that were used.

DesignLink is a tool that supports social interaction between design partners in day to day practice as it happens in a design studio. According to Nonaka, sense-making processes and knowledge sharing between collaborating team members occur through the use of metaphors, analogies and coexperience [27]. During the early design stages designers observe and interpret multiple design criteria that are derived through iterative processes that depend on changes to the shape, program and performance of a project (just to name a few). DesignLink’s Rule Engine allows the design team to define and manage trade-offs between a great array of design performance aspects in a short matter of time. Designers and consultants thereby bring analysis results from their respective fields (e.g. based on structural, environmental, programmatic or cost performance) in relation with geometrical characteristics of the project. The DesignLink Rule Engine then assists them to set up ‘what if - then’ scenarios to mediate between parameters in the geometric design template and performance analysis/optimisation.

5.2. DesignLink user interface

Previous investigations [28] illustrate that computational tools require careful integration with conventional (non computational) work methods to ensure computers are used to support the design process instead of being limited to a production tool. DesignLink enables professionals from various backgrounds to visualise, juxtapose, and compare design information relevant to their fields. It has a strong visual component with a user-interface that can be understood by multiple professions in order to foster discussions and informed decision making.

Those aspects of DesignLink that rely on computational calculations for complex tasks of Multi-criteria Decision Analysis (MCDA) are running in the background while the user interface allows practitioners from distinct disciplines to engage with each other’s information in an intuitive way. The main purpose of the DesignLink visual interface is thus to provide design and consulting professionals with a combination of external representations of design data. The performance data is portrayed as graphical and numerical information from charts, numeric summary-variables, pictorials and explanatory text.
The *DesignLink* user interface is designed as an environment that can be adjusted according to specific needs. *DesignLink* is being developed to serve as a communication interface between multiple professions as much as it can generate useful information for individual professionals. Users therefore have options to select either a *general* view of the project containing information relevant to all involved, or to choose among a various possibilities to display information specific to distinct professions.

Next to these options, users can also chose a *comparative mode* where they focus on comparing different disciplinary inputs. The concept behind the *DesignLink* user-interface is to reserve the main window as display for the numeric and graphic performance-data and to maintain a smaller area on the right of the screen for basic project information such as images, text and mini-dash boards. This concept is illustrated in Figures 9 and 10.

### 6. Conclusion

Optioneering is a useful method to provide professionals with support for creating metaphors and analogies using integrated analyses across disciplines in early stage design. *DesignLink* has been developed in consideration of previous research efforts in the AEC domain to assists in optioneering processes through the generation of computational interfaces. It thereby uses extensible information schemas to communicate between various software applications and to allow for trade studies among them. Links
between rule-based geometry representations of diverse disciplines and performance analysis offer promising possibilities and they facilitate quick comparison and trade studies between design options. A shared user interface further strengthens design collaboration by visualising building performance attributes that can easily be compared in one computational environment.

If we assume that computing power will reach a level where consultants can provide building performance feedback on the fly during design meetings, will design partners be able to interact with the quantity of information available to them? Limits of bounded rationality, the point where the capacity of the human mind to register information is saturated, may at the same time lead to limits in optioneering capabilities. This is not necessarily a negative sign. On the contrary, design teams could well profile themselves through their capacity to select carefully amongst those performance aspects for optioneering that best represent their particular interest and design signature.

More research is needed to understand how optioneering processes such as described in this paper can be integrated better with current efforts in BIM. This paper is written on the assumption that BIM methods currently only insufficiently support transdisciplinary design and integrated analyses in
the early design stages. The optioneering method has been presented as one alternative path for early design collaboration where the project is still constantly changing and project teams quickly want to explore multiple design options. Work is currently undertaken by those advancing DesignLink to find intelligent transitions between optioneering output and processes in support of BIM.

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References

2. URL: http://www.tis-ltd.co.uk/feasibility.html [15-02-2009].
3. URL: http://www.encyclo.co.uk/define/optioneering [15-02-2009].


