INTERNATIONAL DESIGN CONFERENCE - DESIGN 2012
Dubrovnik - Croatia, May 21 - 24, 2012.

ASSUMPTIONS FOR DISTRIBUTED CONCURRENT DESIGN AND DECISION MAKING

C. A. Nyström, H. Olsson and V. Asproth

Keywords: distributed concurrent design, concurrent design, decision making, awareness, trust

1. Introduction

There has been a lot of research on different kind of new ways of collaboration, e.g. Virtual teams/virtual collaboration [Gilliam and Oppenheim 2006], [Asproth and Nyström 2012], computer supported collaboration [Carroll et al. 2006], distributed teams [Jansson 2005], interactive spaces [Sundholm 2007]. Despite the amount of articles and research findings, there is not so many findings from research about the *environment* where the collaboration is taking place – regardless of if the collaboration is virtual, distributed or physic or not.

Collaboration exists and is carried out in some kind of environment. In many types of collaboration situations, the target with the collaboration could be some kind of design proceeded with decisions at different levels in an organization. It is desirable that the environment support both design activities as well as the process of decision making.

Concurrent Design (CD) is a method which is characterized by concurrent activities where different stakeholders and decision makers are supported by a well-facilitated collaboration room. Typical tasks that could be managed and solved with this method are complex problems with a high degree of uncertainty and in need of rapid development.

The authors have experiences from the use of an expanded version of Concurrent Design – Concurrent eLearning Design (CCeD) [Strand and Hjeltnes 2009], [Strand and Staupe 2010a], [Strand and Staupe 2010b] during the work with development of a course in data modeling and databases. The outcome was a design document which can be used when the course is planned and implemented. The course is a distance course which will be carried out supported by a Learning Management System (LMS) in fall 2012.

The aim of this paper is to identify and present assumptions and critical factors for succeeding with Distributed Concurrent Design (DCD). A crucial assumption for success in DCD is that the participants in the collaboration have access to necessary information and that the communication works smooth.

The method used is a literature review where we have used a lens consisting of core concepts for distributed collaborative work. The choice of concepts is based on pre-knowledge in the field and practical experience. The purpose of DCD work is to make decisions about a design. Therefore *Decision Making* is an over-arching concept in the lens. *Communication* and *Information sharing* among the participants are essential for the ability to form good decision and is therefore a part of our lens, without us going into the meaning of these concepts in this paper. As the participants are distributed in DCD work the *Technology* used is of importance. How the work is carried out, the *Routines,* can lead to failure or success. Last, but not least, *Trust* among the participants is highly important. The last three concepts also correspond to the elements of concurrent design presented in Figure 1, Tools, Process and People.

The paper is outlined as follows. In section two - theoretical background - we present and discuss some core concepts as Design, Design environments, Concurrent Engineering, Concurrent Design, the importance of awareness and trust, and decision-making. In the third section, assumptions to succeed with DCD are discussed. In the fourth section finally, we present some conclusions and directions for further research.

2. Theoretical background

In this section we present the theoretical background necessary for the understanding of the assumptions for DCD which is discussed in section 4.

2.1 Design in general

Warfield [Warfield 1990] concludes that activities belonging to design are ”intelligence, analysis, synthesis, choice, communication and interpretation”. Intelligence, analysis and synthesis constitutes together ”conceptualization” while communication and interpretation constitutes documentation. This leads to the conclusion that design activities according to Warfield, consists of

- Conceptualization,
- Choice and
- Documentation.

Warfield [Warfield 1990] has also identified the operations which are carried out in a design: Idea generation, clarifying of ideas, structuring of ideas, explain the structure within ideas, and finally, refine and verify ideas.

Design in general, is a creative task. When designing artifacts or whatever characterizes the target design, representative roles among the designers is a good idea to generate ideas and also when activities as choice and evaluation is to be carried out. The roles should be designed and representative according to the target group of the design. According to CCD and DCD, the ideas with roles are similar. If the participants in the different sessions are not representative for the interests they represent, someone of the participants will act as the missing expert(s).

2.2 Design environments

Warfield [Warfield 1990] discusses two types of environment – or rather two “divisions” of environments. These are the Laboratory Environment and the External Environment. The first division is the environment where the different design activities actually take place and the latter is the environment which has fed the design process with motivation and ideas. The Target design is also presented and introduced into the External Environment. The Laboratory Environment was given the name “***Demosophia***” which means “wisdom of the people”. Several disciplines have used this concept as a place supporting the design of social systems in a democratic way. Warfield’s use of “Demosophia” is built on Harold Lasswells vision about physical facilities as “decision seminar rooms and social planetarium” [Warfield 1990], (p. 275). Important facilities that should be present in a Demosophia is physical comfort, spacious and flexible working areas, support for multiple roles among the participants and enough space for displays and continuous data storing supporting recording on video computer support and different kind of communication. Warfield pay attention to the fact that the External Environment as well as the idea with the openness in Demosophia, not suits all cultures. People, who pay attention to power and also want to control a certain situation, do not necessary feel comfortable in such environments as described above.

Phrontisterion is another concept used by e.g. Beer [Beer 1994], (p. 194) which is close to Warfields “Demosophia”. Beer outline a background and argumentation for this “Phrontisterion” based on experiences from WW2 – the war room – but also from other “areas” as the Mission control in the space center of Houston, Texas. The most important functions in this “space”/place is support for complex activities according to capturing, visualization, studies, analysis in real-time, and decisions based on the outcome from these activities. According to Beer, he proposes a “*control center for the corporation which is a continuous activity. This could be the physical embodiment of any System 4. All*

senior formal meetings would be held there; and the rest of the time, all senior executives would treat it as a kind of club room." [Beer 2008], (p. 243).
System 4 is a part of Stafford Beers Viable System Model. The main function of System 4, is to watch what is on in the environment – "outside and then" as Beer calls it. System 4 should be supported by functions for collecting, presenting and analyzing external data. Hence, the system could be compared with a "control centre supported by suitable facilities as electronic whiteboards and other collaboration and communication tools. Furthermore, "filters" which transform the information from the environment to desirable representation which sum-up and aggregate the "data" with historical records. System 4 should be regarded as the main anticipatory system of the organization. [Beer 1981], [Beer 1994], [Nyström 2006]. Phrontisterion was what the Greeks called a "thinking shop".

2.3 Concurrent engineering – concurrent design

Institute for Defense Analysis (IDA) arranged in 1988 several workshops where Concurrent Engineering (CE) was discussed according to success stories, benefits and potentials [Winner et al. 1988]. The background was that IDA had been tasked by the Department of Defense (DoD) to investigate the outcome of the use of CE among industrial settings. The studies (review of published reports and papers, discussions, workshops and study visits) showed that the product quality was improved to lower costs and that the product development time was shortened with the use of CE. The idea was whether DoD could expect the same results if the method was implemented and used by defense contractors. An attendant question was how the defense contractors could be encouraged to use the method.
Participants in the second workshop the same year formulated the definition of concurrent engineering as follow:

> *Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture-, and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.* [Winner et al. 1988], (p. 11).

The main idea was that *"management, engineering, and business approach integrates the design of a product and its manufacturing and support processes"*. It is notable that the concept concurrent design is used in the definition. In our view, CD is a part of CE where the latter includes the whole product life cycle. According to Winner, Pennell, Bertrand and Slusarczuk [Winner et al. 1988], the characteristics of CE are

- Multifunction teams
- Use of CAD, CAE, CAM
- Use of a variety of analytical methods in order to optimize the design of a product and its manufacturing and support processes.

It is not easy to find where the concept CE first was used, but other concepts similar to CE is *simultaneous engineering* and *integrated product development*. Simultaneous engineering (SE) is according to e.g. Ribbens [Ribbens 2000], interchangeable with CE. The concept *integrated product* development (IPD), is more used as an academic discipline though it is found at several universities as courses in engineering programs or cross-disciplinary settings - e.g. KTH (Royal Institute of Technology), Lehigh University (US), University of Strathclyde (UK), University of Malta. Anyhow, the concepts have the roots in product development and *concurrent design* is a more general concept, not necessary directed to physical products.
CD as a concept has been used and developed by the Norwegian researcher Knut I Øxnevad who in 2000 defined and published "the eight Principles of Concurrent Design" which provided radical changes in the way current design approaches had been used. He had also developed the "People, Process, and Tools-Model" as a tool to improve work-processes during his work as a founder and CEO of SIMTANO™, Inc, formerly the Concurrent Design Laboratories (CDL) [Øxnevad 2011b]. The development of the Concurrent Design method, started at National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). Øxnevad, who developed the method, has a background at the Jet Propulsion Laboratory at NASA. [Øxnevad 2011a].

The eight principles are:

1. "Analysis and design activities are performed by a MULTI-DISCIPLINARY design team
2. Design team members work together in CONCURRENT SESSIONS
3. "Customers" and team members participate in the concurrent sessions
4. Analyses and design activities take place in a CONCURRENT, AND NEAR REAL-TIME fashion
5. INTER-LINKED AND HIGH-END COMPUTER TOOLS are utilized in the concurrent sessions by the team members
6. These high-end computer tools are used FROM THE EARLY PARTS OF THE DESIGN
7. COMMON geometrical DATA (CAD) is SHARED electronically BETWEEN the TOOLS.
8. CAD, structural, thermal, and optics data can be IMPORTED and EXPORTED to and from the design team." [Egir and Rosendahl 2007], [Øxnevad 2000]

The "People, Process and Tools-Model" is visualized as a triangle with the three concepts in each corner and the activities: Real-Time Concurrency: analysis, design and simulation in the middle of the triangle – see Figure 1 below.

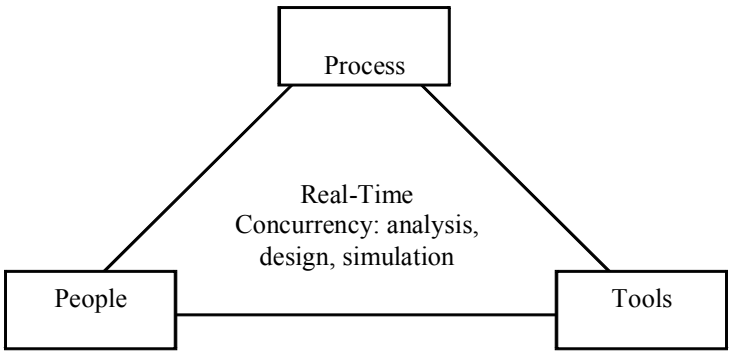

Figure 1. The three main elements in concurrent design

According to Rosendahl and Egir [Rosendahl and Egir 2007], people in the PPT-model consists of customer(s) (the customer take decisions and monitor the process), a facilitator (prime responsibility to ensure that the communication works according to the plan), project manager, and team members (different kind of experts and stakeholders). The process is carried out through well planned and designed sessions which are taking place in a Concurrent Design work arena. Each session will in the end be summed-up by the facilitator and evaluated.

2.4 Awareness in distributed collaboration

Collaboration in distributed environments can be problematic due to missing social cues. This leads to a lack of social awareness about each other, and ultimately problems in establishing trust among members. Since trust is essential for virtual collaboration [Asproth 2007], ways to enhance social awareness are required. However, digital spaces are not completely cue-less; there are a limited amount of cues, such as for example parlance. Low social awareness in text-based computer-mediated communication for collaborative situations can decrease the extent to which individuals develop and express views that are in oppositions to other members' views [Haines and Cheney Mann 2011]. This would be due to that missing cues makes members unable to differentiate each other [Haines and Cheney Mann 2011]]. Additionally, a work-in-progress indicates that in group-to-group video conferencing, it is vital that every participant is framed by a unique camera in order to get one group identity rather than two separate group identities dependent on location [Slovák et al. 2011]. Commonly, each group is framed by a camera so that all group members in the other location can be seen, framed together. The above mentioned study indicates that this makes an in-group/out-group tension between the two locations, with negative effects on trust [Slovák et al. 2011]. Hence, it is essential that individual member identities, as well as group identity are allowed to be expressed and developed in order for the collaboration climate to be fertile. Furthermore, in addition to delivering

facial and linguistic information to the other location(s), documentation should also be delivered [Vyas et al. 2008], to allow contextual awareness.

2.5 Decision making

Traditionally management is divided into three different levels in an organization: strategic, tactic and operative management. Keen and Morton [Keen and Morton 1978] have identified different characteristics of information by area of decision based on the managerial activities, strategic planning, management control and operational control. As the type of decisions that are to be made at the different levels are quite disparate the need for information differentiates. Strategic planning has completely different requirements on information than operational control. Operational control, for example, require detailed information of high accuracy with the sight adjusted to the present or the nearest future, while strategic planning requires aggregated information with low accuracy and a time horizon stretching into the future. Management control, on the other hand, has requirements on information that varies from the requirements on information for strategic planning to the requirements on information for operational control.
In later years the concepts *Normative*, *Strategic* and *Operative* often is used to describe the different levels of management in an organization. Schwaninger [Schwaninger 1990] exemplified what the objectives at different management levels are (see Table 1).

Table 1. Objectives at different logical levels of management [Schwaninger 1990]

Management level	Objective
Normative	Development
	Viability
Strategic	New value potentials
	Extant value
Operative	Profit
	Solvens

Schwaninger also states [Espejo et al. 1996] that only models on a higher level have a good prediction in relation to the model on the next lower level. Models of a higher level also see longer into the future what will happen on the next lower level.
According to Simon [Simon 1976, 1979] all decisions are based on a choice selected from a set of alternatives. These alternatives correspond with an organizational goal. All alternatives have consequences, intended or non-intended. Some of these consequences may be not clear or not detailed enough. The task of rational decision making includes three steps:

1. "the identification and listing of all the alternatives;
2. the determination of all the consequences resulting from each of the alternatives; and
3. the comparison of the accuracy and efficiency of each of these sets of consequences" [Simon 1976]

In CD the decision-making is made by a group of people. The advantages are that groups have more knowledge and a broader perspective and can consider more alternative solutions. On the other hand groups often work more slowly than individuals. Group decisions also involve compromises that can lead to less optimal decisions. It also often happens that groups are dominated by an individual, which means that the effect of a group process is minimized.

3. Assumptions for distributed concurrent design

In this section we discuss assumptions for DCD and decision-making.

3.1 Distributed concurrent design

The difference between CD and DCD is the possibility to work with the different tasks in a distributed way. Accordingly, much effort is put on the Tools in the Model. Anyhow, it is important that the tools should have a subordinate role in the work. The tools should be experienced as "invisible" or transparent during the sessions. According to the Process part of the Model, the project must be

tailored with respect to the difficulties geographically dispersed teams work under. The sessions must therefore be well planned and prepared. People in the project should be representatives for the tasks and the interests they represent as well as representative in some virtual aspect – if possible and if needed.

3.2 Awareness in distributed concurrent design

Since the beginning of mankind we have practiced reading social cues, but in digital space we are all beginners. Other ways of allowing cues are needed. With that not said that cues should be directly translated from physical space. Digital spaces must be allowed unique expressions of cues. Low social awareness can inhibit diversified views among members [Haines and Cheney Mann 2011]. Additionally, antagonistic tensions between locations can be created by group view cameras, compared to individual member view cameras [Slovák et al. 2011]. Hence, it is essential that DCD enables the possibility to express individual member identities, as well as develop one unifying group identity, for a fertile collaboration climate. In the case of DCD, member profiles could allow individual identities. Furthermore, the one-camera-per-member approach should be applied so that a unified group identity can be built regardless of the members locations. Meeting face to face prior to virtual collaboration creates a feeling of knowing each other, which is valuable for the upcoming collaboration [Asproth and Nyström 2012]. Hence, if possible, the members should meet face-to-face prior to the virtual collaboration. However, this might not always be practically, economically or timely feasible; enhanced social awareness through cues and expressed member identities are then even more essential.

In addition to delivering facial and linguistic information to the other location(s), documentation should also be delivered [Vyas et al. 2008]. Within DCD, this should not be complicated to accomplish, since documentation in the original, CCD, are already mediated/archived digitally in some way. It is essential for contextual awareness that all members gain access to the documentation.

An aspect of CD, when all members are located in the same physical room, is that the members can *over-hear* each other while working. This aspect is a valuable characteristic of CD, allowing members to have enhanced contextual awareness. How this could be accomplished in DCD without becoming overwhelming is unclear. The form of sound, as in CD, would not be suitable since it would result in unusable noise.

3.3 Decision making in distributed concurrent design

To make decision-making in distributed concurrent design effective there are certain actions to take. The following steps are to be taken into consideration.

- *Type of design*. First the type or level of the design must be stipulated. Is this a design on an operative management level or does it include strategic or even normative elements? Is there more than one organization involved or different divisions of an organization?
- *Initial decisions.* Based on type and level of design certain initial decisions have to be done. These decisions often concern the strategic and normative consequences. It is important that the correct prerequisites are set before starting the design.
- *Putting together the team.* Depending on the type and level of the design the group is put together. In the group there must be experts in the field of the design, but there must also be team members that have the power to make decisions. It is not efficient to interrupt the work to get back to the decision makers. This is extra important if more than one organization is involved. As the efficiency also decrease if the group is too big, every selection of member is significant. Team members from higher management levels than necessary can also be too dominant and undermine the creative group process.
- *Choosing facilitator.* The facilitator has to make sure that the work proceeds in the intended direction. Time limits and other restrictions are to be held. The facilitator must also let everybody's opinions speak and see to that no one gets too dominant.
- *Decision limits for the group.* It must be clear from the beginning what the limits for decisions are. During the process new issues may appear that affect another management level. To not

needlessly delay the design a procedure for feedback and decision-making must be ready in beforehand.

4. Conclusions

Before starting the DCD sessions there are some considerations to make and actions to take. These are to evaluate what type of design is in focus, make necessary initial decisions, choose team members and facilitator(s), and decide the limits for them to act within. If possible, members should meet face-to-face prior to the first DCD-session, in order get a feeling of knowing each other. Identity is needed both on member level and group level for a fertile collaboration climate in DCD. Individual member identities can be promoted by user profiles. One-camera-per-member is essential for a unified group identity. The present tools should have a subordinated role and be experienced as "invisible" or transparent. It is also important as mentioned in the introduction, that necessary information is present and that the communication between the participants, works smooth.
How to accomplish *over-hearing* in DCD demands further research.
During autumn 2011 and spring 2012, we intend to tailor and adapt CD so the method can be used distributed, Distributed Concurrent Design - DCD. The task in focus is a collaboration project between the county of Jämtland in Sweden and the counties of Sør-Tröndelag and Nord-Tröndelag in Norway. The collaboration project concerns activities for planning, exercise and learning in critical situations where collaboration between the three counties could be desirable and necessary. Situations could be flooding, train accidents, people stocked at the mountain roads in bad weather, and other incidents and accidents. The expected result is parallel sessions in Sweden and Norway where the participants representing different stakeholders, in the different collaboration rooms will:

1. Identify and describe the existing situation as experienced by the stakeholders,
2. Generate ideas concerning a "demonstrator"/prototype which should support collaboration between authorities and stakeholders in the different counties,
3. Test and use the prototype in a scenario.
4. Evaluate the outcome of the different sessions and how the result could be further developed and used.

The different sessions will be evaluated by observers. There will be well-defined activities carried out between the sessions with access to experts on databases and web design who are responsible for building the demonstrator.

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PhD. Christina Amcoff Nyström
Senior Lecturer, Assistant Professor
Computer and Systems Science/MidSweden University, Department of Information Technology and Media
Akademigatan 1, S-831 25 Östersund, Sweden
Telephone: +46(0)63165388
Email: Christina.amcoff@miun.se