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Towards Virtual Co-location in Functional Product Innovation

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Abstract: The shift in industry towards Functional Product Innovation implies more collaborative efforts between the partners forming joint ventures, i.e. cross-company collaboration. Hence, new demands are put on collaborative technology. Insights into needs for both industry and collaborative design teams provide the possibilities for *'virtual co-location'* to be enhanced. Following a workshop format, the radical innovation workshop, industrial criterions for collaborative technology has been analyzed based on empirical data from five Swedish manufacturing companies. During the workshop three scenarios were put forward by the industry as most relevant; (1) the design review, (2) to on-site remotely collaborate with an expert and (3) the day-to-day communication. Based on these scenarios, three industrial criterions emerged, namely efficient collaboration, effortless setup of communication and the capability to create trust without touch. Technologies to support Functional Product Innovation seem to insist on meeting these criterions.

1. Introduction

In manufacturing industry a change is taking place, life-cycle commitments where the manufacturer takes extended responsibilities for the product in use has emerged. A life-cycle commitment is contracted on the characteristic to provide *'functions per unit'*, e.g. power by the hour or thrust on wings [1]. This way of expressing what the product has to do is similar to providing services; thus, product development needs to be addressed in a new way. Joint ventures, partnerships and networks of collaborative companies, i.e. cross-company collaboration, are part of the solution to gain access to additional competence and share the increased risk, both needed for life-cycle commitments [2]. In the research project presented in this paper, the new situation perceived by the manufacturing companies is referred to as Functional Product Innovation (FPI), with related areas being Product Service Systems (PSS) [3] and Integrated Product Service Engineering [4]. FPI is used to describe a situation where the function provider not only retains the responsibility for the physical artefact throughout the life-cycle but also has the obligation and capability to through innovations continuously improve the product.

The intention for manufacturing firms to develop physical artefacts as carriers of life-cycle commitments implies that additional competencies and knowledge from other companies are needed. Hence, an increased collaboration between partner companies is needed. However, in all cases, physical co-location is not practicable and perhaps not even preferable, since, for example, team diversity is useful in the innovative process. The idea of *true collaboration* is vital in heterogeneous teams. However, a situation *"…where diversity and competences of the whole team can be utilized and where team members can think together rather than merely exchange information, opinions and divide work"* [5, p11], is found critical. Product development aiming for life-cycle commitments becomes more dispersed, firms refer to this as global product development.

The members of a design team experience global product development by travelling to the sites of other members. Travelling is both time-consuming and expensive, and the demands for technology-mediated environments capable to support communication and collaboration in geographically distributed teams are increasing. In the vision of FPI, companies have suggested that collaboration in design teams demand more joint efforts on an even more frequent basis. To achieve FPI, manufacturing companies emphasize cross-boundary collaboration, a form of a virtual product development process in an extended enterprise setting. The design team members may experience this as '*virtual co-location'*.
As concluded by the EU funded framework programme Collaboration4Innovation [6], virtual teams are considered the most relevant collaborative settings in the future. Yet, the design of both physical and virtual environments can create and reinforce barriers for collaboration, as well as support collaborative behaviours.

Unfortunately many existing tools, designed to support collaboration in virtual team focus on technology, and force the user to work in a specific way. The technology focus – *'what can'* approach takes the basis in integration and communication technologies, whereas the user focus – *'what needs'* approach requires a deeper understanding and analysis of the communication and collaboration processes. A typical example is video conferencing that supports communication between team members, but forces the user to work in a specific way (e.g. side conversation is not possible [7], eye contact is difficult to archive, and users should sit in one place and not walk around in the room). In this paper we present a method to create scenarios of future co-located collaborative work and the find the underlying criterions for the scenarios.

2. Objective

Insights into the work of collaborative design teams provide possibilities for virtual product development to be enhanced. The main objective in this research project is, therefore, to identify issues related to product development activities for collaborative design teams. To contribute to that, the study presented in this paper aim to: *identify industrial criterions for co-located and dispersed collaboration in design teams to feed input into the development of 'virtual co-location' for Functional Product Innovation.*

3. Methodology

The work described in this paper is based on the Scenario Based Design approach [8], chosen for its potential to provide users with an opportunity to participate actively in the design, as well as keeping users in the focal point. The approach is based on the creation of scenarios, i.e. concrete descriptions of work activities. Scenarios are very flexible, allowing researchers to devise products and services that are innovative and to address possible ways of conducting collaborative work. Scenarios are used to provoke questions and *'what if'* discussions. *Problem Scenarios* are descriptions of how users work today – what problems they encounter in their daily work activities. On the contrary, *Solution Scenarios* are descriptions of a desired work situation in the future. Both scenarios should be solution independent, i.e. they should describe desired situations and not the technologies that might be used to solve the problems. A main focus has been to generate data on the perceived user needs of the participating companies, as opposed to their desires for specific solutions. The rationale is that a need lasts longer than a solution [9]. For example, the need to store data has not changed much, but the solutions have varied from floppy disks to flash drives. The focus on needs also lends to a bigger solution space for research issues than the expression of specific solutions. Needs from the participating companies are analysed and transformed into industrial criterions that focus and act as the drivers for the research.

The main data for this paper has been generated in two workshops with participants from five Swedish large manufacturing companies; the first workshop focusing on *'Problem Scenarios'* – descriptions the current work situation, the second workshop focused on *'Solutions Scenarios'* – descriptions of a desired work situation of the future. The generated data from the workshops has been analyzed and categorized into industrial criterions, which will be presented in this paper. All quotes were given in Swedish, but have been translated into English for this paper. To complement the workshops ethnographic methods [10] were used to follow both co-located and distributed meetings at two of the companies. A questionnaire was also sent out and in total to ten companies participated in the study.

4. Design Work and Settings

Besides concept formation, evaluation of cost, sizing, etc, the design activities incorporates the task for people to share a common perspective and agree on significant issues [11]. Design is not a solo activity; on the contrary, it is primarily preformed in teams. Hence, the continuous social interaction between team members is a fundamental part of designing [12]. Design or product development consists of divergent phases, where the solution scope is expanded, and convergent phases, where the solutions are selected and refined [13]. During divergent phases it is beneficial for designers to create and maintain an open atmosphere that supports creative activities [14]. Supporting creative distributed sessions is difficult; it has been identified that creative activities in distributed sessions, such as bodystorming, is limited supported by technology [15]. The embodiment of concepts and the ability of participants to mimic and build on the concepts of others play an integral part of a bodystorming session. This is preformed naturally in co-located sessions, though this communication is hampered due to the technical setting in distributed sessions [15].

Olson et al. [16] discuss the coupling of work and denote coupling as the extent to which communication is required by the work. Tools for distributed work were found to be more successful if introduced as an aid into a loosely coupled work environment than in a highly coupled work environment [16]. In highly coupled co-located work, i.e. interdependent work performed in dynamic and engaged teams, extreme co-location in war rooms is a strategy [17]. In the war room, the context of work becomes apparent from the activity in the room and team members are easily made aware of what is going on based on what position other team members have in the room. Olson et al. [16] highlight that the spatiality of people and objects are of particular importance for human interaction in a co-located team. Objects and people and the role they play in the ongoing discussion may be indexed by location in space. Teasley et al. [18] found this type of co-location in a dedicated room, as for example a war room, to be beneficial for highly coupled work.

Further, physical co-location offers a greater presence than virtual co-location. Harrisson et al. [19] denote presence as '*the richness of detail of about the other participants and the event itself that is available in a communicative event'*. When meeting face-to-face a wide variety of information is available, whereas virtual co-location via videoconferencing may be described as looking through a window to the remote places. The window may be further away and smaller or nearer and larger depending on the technology. The goal of most emerging technology is to widen the window, i.e. increase the sense of presence. Wolff et al. [20] conclude in their review of tele-collaboration technologies that there are four significant challenges for future systems. First, a challenge is to support consistent synchronous object manipulation between remote sites. Second, a challenge is to support the feeling of touch when interacting with virtual objects. Third, a challenge is to support a more realistic representation of human embodiment. And, fourth, a challenge is the integration and acceptance of tele-collaboration technology at workplaces.

The commercial state of the art has the last years has focused on improving telepresence by using higher resolution, higher bandwidth and by replicating local meetings. Commercial high-end system is available both from DVE [21], Tandberg, Cisco and HP Halo. The telepresence systems are very expensive and focus on recreating formal meetings, creating an impression of a shared room, which is often not good for creative design meetings. A second trend is lightweight web based systems such as WebEx, Adobe Acrobate Connect, Marratech and Live Meering, all systems provide a web portal where the users can communicate using document sharing, audio and video (often using java based applications). One large advantage for these types of systems, since they are web based, is that they can communicate trough firewalls. Another trend is the unification of different technologies such as instant messaging, document sharing, and synchronous tools. Microsoft has quite recently released Unified Communications [22] based on Microsoft Live Meeting, Exchange Server and Office Communicator. Tandberg has recently released a system that that allows Microsoft Live Meeting, software conferencing systems, 3G-phones normal Videoconferencing systems and telepresence solutions coexist in the same meeting. The Collaboration4Innovation [6] framework emphasizes a basic need to improve the ease of use of e-collaboration. The tools have to be intuitive and easy to use, the individual and collaborative work have to be seamless without the user noticing the technology.

5. The Radical Innovation Workshop

A number of methods have been developed to enhance the collaboration between industry and academia through different types of creative workshops. Design or product development problems are regarded as wicked [23, 24]. In innovative projects the starting position is blurred, since it is not clear what to design [25]. To tackle and embrace the ambiguity related to innovative design work, the strategy in a radical innovation workshop is to utilize creative methods to promote new ideas and visualize different perspectives on a specific problematic situation. In creative methods, a common goal is to aim for quantity of ideas and several perspectives and thereby create a more nuanced picture of the situation.

The radical innovation workshop, is a workshop format inspired by tiger teams [26]. To tap into the creative power of the participants, we have identified the change of the meeting format, from a traditional informative meeting style to an open dialogue focused format, as important. An open and welcoming atmosphere helps people feel more relaxed and, thus, engage and contribute to the issue at hand.

The facilitator, whose role is to support the creative process, moderates the radical innovation workshop. The facilitator has to be an expert in the processes and the methods used, not an expert in the particular topic. An important characteristic of the facilitator is his or her ability to enable involvement, engagement and commitment. The facilitator guides the team in a promising direction and explains the *'rules of the game'*. Besides guiding the participants the facilitator also ensures that everyone at the workshop participates actively by not allowing one person to dominate; all input is considered equal. Another important characteristic is the ability to encourage people to step outside of their comfort zone, by promoting personal reflection. An extended discussion about the characteristics of a facilitator can be found in McFadzean [27].

During the workshops several methods were used to find real problems, and the statements that describe them. This was done by visualising the situations from several angles. The workshop process promotes participants to visually present topics and ideas. To guide the process while retaining visual presentation, facilitation maps, procedures displayed on large posters are used. Some of the procedures are described below.

- *A day in hell* asks the participants to draw from their past experience and present their version of a day in hell to the others in the workshop, i.e. when nothing worked or when

everything went wrong. This is a type of storytelling that effectively creates a mutual understanding of the problem area.

- *The word association* is designed to span up a solution space, create a common ground and an understanding of different views. Often a heterogenous team uses a word in a vague manner, such as the word *reliability*, which may have different meanings for different people. In the exercise all participants associate words building on each other and on the central topic word.
- *Now, Wow! How?* builds on the Future workshop proposed by Kensing and Madsen [28]. As used for early brainstorming, it is divided into three parts. In *Now*, participants are asked to describe their current problems, in *Wow!* participants try to describe a desired state – here no constraints are allowed, everything works, while *How?* is the implementation where the participants try to come up with ideas that can change a *Now* problem into a *Wow!*.

6. The Workshops

The workshop is used for the purpose of generating data in the form of statements from the participants. In the workshop the participants are striving for a common goal and have a settled topic before the workshop begins. The researchers bias are kept to a minimum even though they participate in the workshop as facilitators, since the topic of the workshop is not the same as the objectives for the research. For the purpose of generating a nuanced data it is an advantage to use creative methods. A creative method asks the participant to reflect on the problem area in a way that s/he otherwise perhaps would not do. In the workshop the same basic problem is brought up in a number of different creative methods thus more nuanced data may be collected.

Another aspect is that in these types of workshops, similar people from different industries are brought together to discuss a common issue. The industry representatives have stated that they perceive the creative workshops as a learning experience. This type of meeting is found useful since they learn from each other and, also, an opportunity to devote time to reflect on their daily work.

7. Industrial Scenarios

Even though very advanced technology exists today the most sophisticated use of collaborative technology in industry today is generally limited to H.323 videoconferencing between two or three conference rooms, combined with application sharing and shared document repositories. Audio and video quality is generally low due to bandwidth restrictions and poor interoperability between videoconferencing systems. Web-based collaborative tools providing audiovisual communication and application sharing are also used in industry to some extent, but are generally also targeted at low bandwidth use that limits quality, interactivity and the feeling of presence. Distributed meetings using only a conference phone are still very common.

During the exercises from the first workshop, it was clear that while each company has technology and support personnel for, e.g. videoconferencing, the users still experience difficulties in using the technology, the most prominent being usability. The second one is robustness, since the users cannot be certain that the system actually works as intended or if the recipient party has compatible technology. In the workshop it became apparent that aside from these difficulties, the format of distributed meetings in relation to the focus of the participants was a concern. Some quotes from the workshop; *"there is only one video/audio feed"*, *"it is difficult to know who is speaking"*, *"we cannot interact with or use physical objects"* and *"the meeting starts late and no one is concerned with keeping time"*. These statements and others were retained to fuel the discussions during the second

workshop. Furthermore, three typical problem scenarios were identified and described during the first workshop:

- The first scenario that emerged was *design review*. This meeting was flagged as a problem scenario, since it is a commonly held meeting. The current strategy is to travel to carry out meetings when they are performed off site, since the support for distributed meetings was identified by the participants as insufficient.
- The second scenario builds on being in contact with remote experts, i.e. *on-site collaboration with a remote expert*. One company expressed their interest to stay in touch with the main engineering department even when travelling and visiting clients. For some meetings an expert engineer is required to travel with the sales personnel, mainly as a backup to be able to account for engineering related issues. But, oftentimes the engineer's expertise was not required during these meeting. Another company described a common meeting in the facilities of a newly assembled industrial plant, which today are co-located, were experts' travel to the plant only to review a particular problem for typically less than 10 minutes. The basic situation in these separate scenarios is the same – to on-site remotely collaborate with an expert.
- The third problem scenario is *the day-to-day communication* between engineers or staff who are not co-located. Companies find that the geographical distance hampers collaboration and communication in general, but for the emerging daily collaborative efforts in particular.

8. Industrial Criterions

The second workshop focused on *Solutions Scenarios* – descriptions of a desired work situation of the future. The scenarios were used as a base for discussion at the workshop, and from these discussions the industrial criterions initially emerged. The industrial criterions can be categorised as follows:

8.1 Effortless Set-up of Communication

The possibility to easily set up a technology supported session and to be able to communicate in accordance to the intentions or the agenda was present in the scenarios. The workshop participants had all experiences of the situation when their collaboration systems have failed. Rendering them unable to perform their work, and making them to either reschedule a new meeting or to conduct a meeting with limited capabilities. When rescheduling a meeting, the meeting have to be postponed more than a week due to the difficulty in getting everybody rescheduled for a new meeting on such a short notice. In a project described by one of the participants, a delay caused by a failing collaboration system and postponing meeting is unacceptable partly due to the tight time schedule, but also due to partner relations. A participant of the workshop stated; *"Some meetings are too important, we cannot allow them to fail. As a result, we resort to travel to make sure that the meeting is a success. If not, we stand to loose time and ultimately loose a lot of money or even a whole business case."*

We have found that users are not interested in wrestling with systems, their interest is in doing their work. Hence, the derived industrial criterion is *'effortless setup of communication'* which implies that the start-up of a collaborative session must be made as easy and natural as, for example, similar to the effort of sending an e-mail or answering the telephone. The communication must to be effortless, i.e. the communication flows naturally, as it mimics the communication behaviour already established as part of a co-located work.

8.2 Efficient C`ollaboration

From one angle, travel to and from meetings was seen as negative, one of the participants said: *"To just reduce the travel by one-third would be wonderful then I will have more time to do my work"*. Travel was not only seen to have a negative impact on work efficiency, but also on life outside of work. *"Travel takes a lot of my spare time, I sometimes feel guilty that I can't take on more of the workload at home and help my spouse. Travel also limits my participation in my children's activities."* Aside from avoiding loss of personal and work time due to travel, distributed meetings may prove more efficient. One participant stated, *"Everyone is really happy every time we have a video meeting because they take up half the time that a normal meeting would take. You come more prepared and focused."*

However, from another angle travelling was seen as positive. Those who travelled less than once a month for their work generally viewed travel as a privilege. A typical statement was, *"I like the amount of travel I do because it is fun to get out of the office"*. Also other factors influence why people like business travel. One company representative jokingly said, *"Perhaps we could have a duty-free shelf for the videoconferencing room. That way people might choose to go there instead of flying."* Besides tax-free goods, there are other incentives for going on a business trip such as frequent flyer points, points for hotels and rental cars. The points are often used for personal benefit. These incentives may be a contributing not to change the collaborative behaviour.

Based on a general consensus between the participants the industrial criterion *'efficient collaboration'* emerged. The very essence of efficient collaboration is to use available resources as efficiently as possible. A step in that direction is to have the capability to collaborate remotely, especially with experts. Another step is to incorporate the capability to collaborate on-site, thus using the expert's time in a more efficient way, as in the scenario *'on-site collaboration with a remote expert'*.

8.3 Create Trust Without Touch

One workshop participant said that he travels because, *"...meeting people face-to-face is important to establish a personal relation, to understand them better and to create a common ground."* Another said, *"A personal relationship is built when people meet in person."* So, another aspect of travelling to remote partners is found in the establishment of trust that is not easily gained through technology-supported distributed meetings. As a strategy for Functional Product Innovation, creating trust with remote partners is crucial to gain access to additional competences, knowledge and for the collaborative networks to be sustained. In this context, companies and partners cannot afford to rely on existing distributed technology because relations may be in jeopardy if the meeting fails. An industrial criterion for distributed technology was formulated to capture this situation, *'create trust without touch'*. Thereby, the key in the industrial criterion *'create trust without touch'* is that the collaborative technology lends itself to building and maintaining the relationships between partners so that trust can be created despite not performing face-to-face meetings. The sharing of knowledge and on-site information, when remotely collaborating with an expert, may strengthen the trust between partners. A lack of trust is perceived to prohibit communication, but an increased day-to-day communication is likely to build trust between the partners of an extended enterprise. However, a lack of trust often prohibits this communication on all levels or any other communication to begin with.

9. Conclusion and Future Work

The radical innovation workshop format proved to promote a rich and metaphorical analysis of the problems that companies perceive in their efforts to collaborate in a virtual product development process. The identified industrial criterions, viz. *efficient*

collaboration, *effortless setup of communication* and the capability to *create trust without touch*, will act as a guide for future research. For the companies that participated in this study these industrial criterions are imperative for a successful development and implementation of collaborative technologies for *'virtual co-location'*. Technologies that address these criterions are likely to be easier adapted and used in industry.

The research intention is that the industrial criterions will be quantified into more tangible requirements for collaborative technology. For example, *'effortless setup of communication'* indicates that technology could be seamlessly integrated into the environment becoming more invisible but still readily available for the user. The potential of such technologies is perceived by users as continuously ready-at-hand, and effortless to activate and use. In this study it became apparent that the format of distributed meetings in relation to the focus of the participants is a concern, thus needs more attention in future research. Also of note, the design of both physical and virtual workplaces can create barriers to true collaboration as well as promote and support collaborative behaviours and relationships.

The identified industrial criterions will be used as a basis for experimental research aiming to support e-collaboration. The research will be performed in the design observatory, at Luleå University of Technology [29]. The environment is built to enable the research team to design setups of both the physical place and technology to study remote team collaboration, while retaining the capability to observe both *'local'* and *'remote'* team simultaneously. The design observatory also has the possibility to record a design meeting, by using video and audio capture, as well as storing interactions and transactions in the environment. The captured data will create a permanent data corpus that includes the capture of complexity that is impossible to record by simply observing the event [30]. This approach enhances the reprocessability – i.e. all data can be re-examined or processed again, within the context of the whole design event and will provide researchers from across the design community the opportunity to interpret the data and perform collaborative multidisciplinary analysis to form an unbiased view of the events. For future research the industrial partners that participated in this study will hold some of their meetings in the design observatory to provide further input to the issue, as well as participate in the evaluation of the use of collaborative technology that has been set up on the basis of the identified industrial criterions. Thus, the participating companies are provided with the opportunity to use the observatory as a test bed for *'virtual co-location'*.

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