Journal of Universal Computer Science, vol. 17, no. 12 (2011), 1673-1689
submitted: 15/10/10, accepted: 28/1/11, appeared: 1/8/11

360° Open Creativity Support

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Abstract: Open Innovation is a new paradigm that suggests including actors from inside as well as outside a company's boundaries in the innovation process. Open creativity refers to the creative phase in this process. In this article we investigate on open creativity support. We conducted interviews within companies in the German ICT sector to analyze the status quo of open creativity and the tools currently used to support it. In a second step we derive design guidelines and an architecture for IT systems supporting open creativity that lead to a holistic, 360° support for open creativity.

Key Words: open creativity, creativity support systems, open innovation
Category: A.1, H.1, H.5.3

1 Introduction

1.1 Open Innovation

Being innovative is nowadays one of the crucial success factors in enterprises [Cohen and Levinthal, 1990]. A lot of research has been conducted regarding appropriate business models within the last years [Garcia and Calantone, 2002]. The potential of innovation and ideas generated in a company can however, not be fully exploited: Many innovations "evade" a company's boundary such that companies can not profit effectively from them. In these cases the classic paradigm of innovation has to be dismissed in favor of the open innovation paradigm [Chesbrough et al., 2006]. Figure 1 depicts the open innovation funnel which represents the open innovation paradigm.

Following the traditional (closed innovation) paradigm, innovation processes were exclusively conducted in a company's internal research and development (R&D) department [Chandler, 1990]. In contrast, the open innovation paradigm allows the process to overcome the boundaries of the R&D department by including two types of sources:

– External sources outside a company's boundaries (e. g. customers, free lancers, partners).

– External sources inside a company's boundaries (e. g. employees from other departments, hierarchy levels, organizational units).

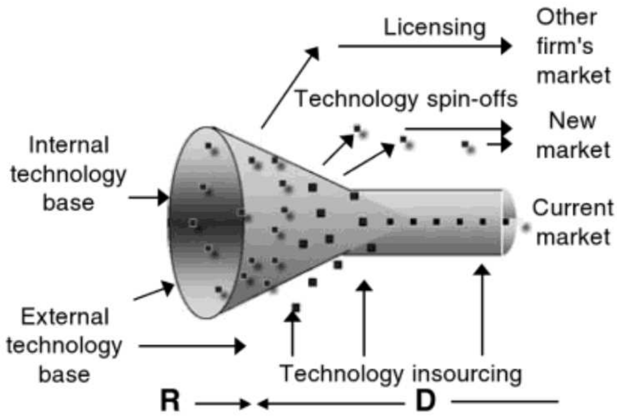

Figure 1: Open innovation funnel[Chesbrough et al., 2006]

Open innovation can be instantiated in several ways. Not necessarily open innovation has to resemble free/open source projects where typically many aspects are open: idea generation, development, typology of innovation process itself, etc. An instantiation may for example consist of opening the idea generation phase to customers only. Hence, our view of open innovation is characterized by several different degrees of openness and different types of external sources. Furthermore, due to the different external sources the open innovation process may produce very different outputs that range from products to implemented novel ideas that bring added value to the involved actors (e. g. optimize in-house processes).

1.2 Open Creativity

Every innovation process - no matter if it is open or closed - is based on creativity at its fuzzy front end. Creativity takes a central role in the process of being innovative, since *"all innovation begins with creative ideas"* [Amabile et al., 1996]. Analogous to the broader concept of open innovation, opening the creative process for external sources from in- and outside a company can be called **open**

creativity: "*In addition to a system's internal creativity (such as of an organization or a region), the synergetic interplay between internal an external sources of creativity at the individual and collaborative levels also needs to be utilized in the attempt to create innovations.* [...] *Such an approach is becoming more important as environmental and system complexity increases and also as higher degrees of innovation are required.*" [Steiner, 2009]

Findings in creativity research suggest that these additional, often heterogeneous sources can be particularly useful for fostering creativity, since they can provide a greater diversity of opinions and experiences than in closed scenarios [Nunamaker et al., 1991, Kurtzberg and Amabile, 2000]. On the other hand, it can be assumed that due to the increased amount of (potential and actual) sources, the activities related to open creativity tend to be more complex to manage and to organize than the ones conducted within the boundaries of the R&D departments. IT tools are typical means to assist humans to handle complexity. Moreover, it has been shown that IT tools can be used to successfully support creativity (so called creativity support systems (CSS)) [Nunamaker et al., 1997]. Also in regard to its role in the fuzzy front end of an innovation process, IT support is promising for fostering creative behaviour as it increases motivation of employees, transparency in the creative process and allows for an accounting of ideas (which e. g. can be used to resolve conflicts regarding patents etc.) [Boeddrich, 2004].

While research on creativity support systems has led to valuable suggestions for designing effective generic CSS [Shneiderman, 2007], little is known about how open creativity can be supported explicitly by IT. In this article, we present results that shed some light on this research question by deriving guidelines for an effective IT support for open creativity. The guidelines are conveyed from the results of expert interviews with 10 German companies to determine the status quo of open creativity. To make sure we grasp the concept of creativity as a whole, we based our work on the 4P framework of creativity that will be outlined in the following section.

2 The 4P - A framework for creativity

In his influential article from the 1960s, Mel Rhodes argued that creativity is too complex to be investigated as a single entity [Rhodes, 1961]. Therefore, by analyzing various models of creativity, he determined that there are four distinct dimensions of creativity (the 4P of creativity):

1. The creative process: What are the activities that lead to creative insights?
2. The creative person: Who is creative, and which attributes make some persons more creative than others?

3. The creative press: How does the environment / the context influence the other three dimensions?

4. The creative product: Which criteria can be applied to judge if an idea or an artifact is creative?

The 4P of creativity quickly became the standard framework for research on creativity, helping to classify the various efforts in this field. Since open creativity is a subclass of creativity in general, we also used this framework as foundation of our analysis.

In the early days, activities were mainly concentrated on the person perspective. An important finding was that creativity and intelligence are - even though being both cognitive processes - fundamentally different abilities. While a certain minimal degree of intelligence is needed to be creative, a higher IQ value does not correlate well with a person's creative performances. Even though different approaches to measure creativity were proposed (e. g. the Torrance test), the significance of creativity tests is heavily disputed [Albert and Runco, 1999]. In addition, the reliability of creativity tests is weak, making people score different values on different days. Creativity seems to be a much less stable attribute than intelligence, which in turn raises the question how to influence the creative performance. This considerations led to increased research efforts in the other dimensions, in particular concerning the creative process and the creative press [Amabile, 1996, VanGundy, 1988]. According to [VanGundy, 1988], the creative **press** can be divided into three categories: *Internal*, *external* and *interpersonal relationships*. While *external* refers to the physical (and other) factors that exist around the person, product or process, *internal* relates to the individual perception of this external climate. *Interpersonal relationships* are self-explanatory and overlap with creative **person**. Another major question was, what a creative **product** actually is. In regard to the theory derived from literature, it refers to a product or outcome of whatever kind, like an idea, a song, an algorithm, a car or anything different. Those kinds of "products" can be created collaboratively or even by single individuals. Typically, *novelty* and *usefulness* are the main criteria to estimate the "creativity" of a product.

3 The status quo of open creativity in Germany's ICT sector

A prerequisite to develop effective support tools is to gain a deep understanding of the domain. Therefore, we conducted a series of interviews with 10 employees each representing a different ICT company in Germany. The domain of expertise of the selected employees included knowledge on creativity and innovation processes in general but also specifically in their company. 5 companies were SME (less than 500 employees), while the others were large companies with up to

180.000 employees. All of the selected companies are internationally active. We focused on the ICT sector, since it is known to be reasonably innovation-driven due to the actual high competition on the market. Companies of the sector are also more likely open to novel concepts, technological trends and tools. Hence, it can be expected that the trend towards open innovation and open creativity will show up earlier than in other lines of business. Our interview partners were mainly product managers, one software engineer being the exception of the rule. Two of them had less than 5 years, while the others had more than 15 years of professional experience.

We investigated on the following three topics:

a) How can the typical activities related to creativity be described?

b) To which extent do they show characteristics of open creativity?

c) Which tools or means are used to support creativity?

These topics were investigated through a semi-structured qualitative interview [Bortz and Döring, 2006, pp. 308-318] whose goal was to provide insight into common practices for implementing creative processes. Given Rhodes' model as research framework we structured our questions accordingly. This resulted into sets of more specific questions addressing the role and occurrence of the dimensions person, process, press and products within the companies. Additionally in each part of the interview we were interested in state-of-the-art IT and non-IT support.

As initial step of the interviews we introduced Rhode's definition of creativity in order to aid the participants in identifying creative processes as well as the resulting creative products within their company. Thereby, we were especially interested in processes fitting into the definition of open creativity.

As there is a high amount of possible sources for potential team members in open creativity, the challenge of bringing together appropriate individuals was our first subject of investigation. More precisely, we asked on the difficulties related to organizational barriers such as spatial and temporal distribution, hierarchy levels and functional backgrounds. Moreover, we were interested in how far established best practices for team composition are currently utilized in the open creativity case.

The next part of the interview addressed topics related to the specific implementations of the creative process. Therefore, we asked whether and how the creative process is structured (e. g. preparation, execution, post processing, etc.). Furthermore, we questioned if they were familiar with creativity techniques and if they commonly use them as structured guideline.

As creative processes can not always be performed in the same spatial / temporal manner, in a next step we wanted to know under which circumstances specific situational settings and/or collaboration styles are performed and preferred.

For example, one question related to this topic was "*Do you prefer distributed or co-located creative collaboration if the team members are not familiar with each other?*".

We annotated the transcribed audio-recordings of the interviews by assigning the statements to our pre-designed questions. Then the questions, and thus the statements were clustered according to the 4P and the statements within each cluster inductively categorized [Bortz and Döring, 2006, p. 300] to gain more general conclusions. The most significant statements and results are included in the next four sections, each taking one of the four dimensions of creativity into account. In the fifth section the main findings will be summarized.

3.1 Process

Taking a process perspective, we wanted to characterize the creative processes conducted in the different firms, find out to which degree these processes are currently opened, and what means are used to support them.

All interview partners agreed that the problems they need creative solutions for are very diverse and regularly tangle various domains and people. Due to the heterogeneity of problem types and context, they find it hard to describe the activities in a "common" creative process, since the two factors mentioned influence the way the process is conducted. The activities within a creative process " [...] *heavily depend on the concrete problem and the number of people involved in solving it, and if these people are spatially distributed or not.*". In most cases, the creative process is initiated by an employee who has encountered a new problem or who has already found a promising idea that needs to be further improved. These processes are highly informal, communication-intense, spontaneous and challenging to manage. *"There is no standard approach, no standard process, no standard set of activities."*. On the one hand, this is seen as a way to encourage creativity. *"You let the people run on their own a little bit, so they have the chance to look in all directions without any restriction."*. On the other hand, the results of these sessions are seldomly documented, which can lead to unproductive repetitions of creative processes: *"We tend to reinvent the wheel from time to time."* For these unstructured creative processes, when face-to-face communication is not possible, tools that facilitate oral or textual communication are commonly used (telephones, Skype / email etc.).

Regarding open creativity, all interviewees confirmed that creative processes in their companies are regularly conducted with employees from different departments and that the way the processes are planned and conducted are basically the same whether the participants come from the same department or not.

In contrast to it, external sources from outside the company's boundaries are integrated only in certain situations, e. g. when a special expertise is required: *"I remember one occasion where we needed external help. That was a problem* *that we could not solve internally* [. . .] *We called an expert from outside who contributed in the solution of the problem."*

Slightly more structured forms of creative processes are found only in special cases, mainly in project kickoffs and project reviews. In these situations, the creative process is conducted in teams, and idea generation activities precede idea evaluation activities as performed in the brainstorming technique. In the companies we interviewed, the brainstorming technique was the sole creativity technique that was actually used, and the persons we interviewed had no experience with other techniques. In these cases, we observed that the idea generation and the idea evaluation activities can have different degrees of openness. Especially for idea evaluation, the companies expected to profit more from people that are not inherently connected to their network or organizational unit (which strictly relates to the open creativity paradigm mentioned in section 1.2): *"A new colleague coming from university perhaps has new ideas* [...] *In that case he makes things hum. A lot of things can perhaps be done better than the team has done up to that time."*.

The process is often moderated by a facilitator and is conducted in a meeting room. Typical tools are whiteboards or electronic text documents that are visible for all members of the team and are developed further cooperatively. The analog artifacts that are created during the sessions (whiteboard sketches etc.) are usually digitized for easier distribution and archiving after the sessions.

Overall, the interview partners were satisfied with the creative processes being conducted in their companies. Interestingly, they did not have the problem that there employees would generate too few ideas. In contrast, they considered the lack of resources for elaborating and implementing the ideas as the real bottleneck in their innovation process: *"We actually have too many ideas, we cannot even elaborate all of them."*

To summarize, it can be stated that creative processes described by the interviewees were diverse in many senses, e. g. problem type, domain or people involved. Besides of dedicated creativity meetings, the process is conducted in an informal and mostly unstructured way. The creative process in the companies we interviewed turned out to be open for external sources inside a company's boundaries, while external sources outside a company's boundaries are integrated less often. The companies use general purpose IT tools (not specifically dedicated for creativity support) for facilitating communication and for documenting results.

3.2 Person

In terms of creative persons we tried to elicit whether and which aspects regarding the creative dimension "person" play an important role in creative problem solving within companies of the ICT sector.

First, we could recognize two main discriminants of this dimension among the companies: Ideas are generated and evaluated either in *groups of persons* (i. e. teams), or *by oneself.* For both, evidence could be found among the participating companies.

Not surprisingly, all interviewees mentioned competencies as one of the criteria that matter for inviting people to creativity sessions. This was mainly mentioned because of the expectation that people from a specific domain can contribute more to solve problems in that domain due to their experience. In this context databases (non-IT as well as IT) containing information about skills are often applied to facilitate the filtering process.

Another mentioned component related to the dimension "person" were social networks. In this case social network does not only specifically denote social networking platforms like Facebook or LinkedIn but also implicit networks arising from collaboration or organizational structures. People more likely invite persons to creativity session that are part of their social network. The main reason for that resides in the compatibility of specific personalities within creative team work. Social networks play a similar role when the actors are distributed across organizational units, even outside a company's boundaries i. e. in the open creativity case. Among the interviewees several people were relying on traditional non-IT support such as the combination of address books and phone to find and contact appropriate people. Especially in the larger companies also social network platforms are occasionally used to facilitate the contact and foster collaboration between different organizational units [Richter and Koch, 2009].

To include unknown people depending on whether they are company internal or external, brokers, curricula vitae or other sources that can assess competencies are used. For example, people acquiring developers from the open source field, first ascertained the quality of their contributions in the published source code and/or their posts in forums and mailing lists. Despite of the available support systems, the last step of the "recruiting" process is usually performed without additional support in a face-to-face meeting. The reason seems to be the difficulty to assess in a formalized and operationalizable way the personality and social aspects of people. Some of these aspects can however be neglected for short term creativity sessions: *"I remember a situation where I knew he* [a colleague] *is very uncomfortable to discuss with. Nevertheless I invited him since I knew he could significantly contribute to the solution of this problem".* As a result it can be said that in some cases composing teams for short creative sessions may not require aspects such as the capacity of teamwork required in long term projects, especially when the quality of the result is of high importance.

As has been said in section 3.1 people feel occasionally, for specific problems (e. g. convergent phases of the creative process), to profit more from people that are not inherently connected to their network or organizational unit. Regarding the appropriate mix of participants for creativity sessions, the interviewees seem to prefer a mix of experienced and unexperienced members in their creative team in order to balance the trade-off between novel and feasible ideas. Moreover, people from inside the organization seem to be categorized as more trustworthy, regardless of the specific department they belong to. Therefore in certain cases heterogeneity by means of external sources outside the company is avoided even though thereby the quality of results may improve (as recognized by the survey participants during the interview). Thus, no evidence for support systems addressing this specific issue could be found.

Finally, with respect to the composition of creative teams, product managers tend to use their gut feeling which probably is tacit knowledge they acquired from past experiences. This aspect has been classified as very important by most survey participants.

An important aspect that influences the selection of appropriate participants for creativity sessions resides in aspects of the "press" dimension. Organizations are heavily dependent on organizational constraints such as availability, location and cost of people. Because of such aspects the best composition of a creative team can not always be assured. These aspects are usually regarded with the help of project management tools (e. g. MS Project) that visualize some of the organizational constraints.

To summarize with respect to the goals defined in section 3, we found evidence for activities in strong relation with the paradigm of open creativity: in certain cases people outside an organizational unit are included in a creative team because of e. g. missing expertise, new ideas needed or to evaluate existing ideas. These team members can be selected out of the social network, from external partners or from other organizational units within the company. Additionally, also concepts applying to creativity in general such as the general choice of people with respect to organizational constraints as well as skills, etc. could be identified.

In terms of support, the selection and composition of teams for (open) creativity sessions is rather complicated and turns out to have several facets. For this reason IT support is generally applied for activities occurring very often and that are easily operationalizable such as the selection of appropriate skills. More particular aspects tailored for creative processes are usually not considered or considered without supporting mechanisms, sometimes because of their challenging ascertainability.

3.3 Press

Concerning "creative press", our main focus was to examine the different kinds of creative situations (and their openness) that take place within the companies. Therefore, we analyzed the spatial and temporal parameters in which creative processes occur and explored which support tools were used. As result, we determined different categories of situations, in which (collaborative) creativity takes place. Those are **co-located / synchronous**, **distributed / asynchronous**, **distributed / synchronous** and **hybrid** settings. The latter combines co-located and distributed teams working together synchronously.

As all of the interviewees stated, one of the most common ways to be creative are co-located situations which involve about "a handful" of participants. Those are not only restricted to the same department and moreover may include customers or partners. Although co-located situations often occur unplanned, they are also instantiated in scheduled meetings or even workshops. Co-located situations are often preferred to address important problems/topics: *"If you know that it is an important topic, you want to communicate* [...] *in a direct and co-located way."* This communication not only relates to verbal communication but, more importantly to *"facial expression, mimic, gestures* [which] *are difficult to perform in a virtual meeting"* [as they] *"are only possible while being in the same* [physical] *room"*. Informal communication, which is especially considered important for creativity, future collaboration and mutual trust, does normally not take place in/after virtual, distributed meetings: *"within a video conference you won't start an informal conversation, simply because it is too exhausting and has a fixed deadline"*. This is supported by the statement, that co-located collaboration can also lead to stronger interpersonal relationships: *"Co-located is always preferred if people don't know each other"* , as it is often the case in open creativity, *"in order to meet each other in real life and to build natural relationships.* [...] *If I really need to solve problems which demand a large amount of creativity, I would prefer to do that in a co-located way"*.

Co-located situations are typically supported by non-IT tools such as whiteboards (combined with post-it cards) but also by software such as a text processing or mindmapping applications which are projected to a wall. In other scenarios, people used a collaborative application on their own laptops (e. g. Google Docs). However, in certain cases, this resulted in distraction from the actual task: *"It was culture that everyone did his own personal office work instead of participating"*.

Although co-located work still plays a major role in today's creative collaboration due to the reasons mentioned above, the technological progress in IT throughout the last decades has facilitated various ways of distributed collaboration. Especially for open creativity, this allows for the integration of spatially distributed actors, such as employees from other headquarters/departments, freelancers, customers or partners. The most common way to solve creative problems together in a distributed setting, is interacting asynchronously (e. g. by email or web-based systems). A different example for distributed asynchronous idea generation is using mobile handhelds and smartphones. One main reason given was, that ideas not only emerge during regular working time, but more often when people switch to another context of thinking: "*If I get an idea while lying in the bed in the evening, I write it down and send it to my email account*".

However, novel communication technology provides the ability to collaborate distributedly and synchronously (e. g. video-/audio-conferencing, web-based tools). Despite the obvious advantages like reducing costs/time for traveling and a more realistic/faster interaction than working asynchronously, there are still problems which hamper the acceptance of distributed synchronous communication. Those are for example delays in signal transmission and the unnatural way of communicating. Those problems were even stated in companies which use high-end video-conferencing systems for distributed collaboration: *"It is not the same as co-located, it's more exhausting* [...] *I think* [those problems] *result from the fact, that the human being is not made for this kind of collaboration."* An interesting use case involving distributed synchronous communication are virtual meetings with hundreds of participants, as it was the case in one of the interviewed companies: *"We also have tools especially suited for meetings in which several hundreds of people participate and ask questions or comment on topics."*

Summarized, we observed several situations which are typical for open innovation/creativity environments. In nowadays work-life, collaboration across physical and temporal boundaries between heterogeneous team members is getting increasingly popular. Nevertheless, co-located meetings are still needed. In this context it was emphasized, that working co-located from time to time is even of special importance for people who normally collaborate distributed worldwide, as co-locatedness is very valuable in regard to socializing and collaboration. Another indicator for the openness of creativity within the interviewed companies is manifested in the distributed cases, where sometimes even large numbers (up to several hundreds) of participants were involved and which allows for new ways of working together. The interviews also showed the need for a hybrid support, e. g. combining the possibility to work co-located with the integration of distributed participants.

3.4 Product

The results of the interviews showed a broad variety of possible creative products. As could be expected, a large amount of interviewees stated that solutions for special kinds of IT-related problems are considered as creative within their context. For example, *"such things like database design or finding an algorithm to solve a specific problem"*. Other examples were how to refactor interfaces or to label methods. Interviewees who are included in processes of product finding and decision making, also highlighted the importance of open creativity for idea generation. In these cases, products were mainly defined as textual fragments, sketches or pictures: *"We collected images, which express trends* [...] *We tried* *to find icons for specific topics"*, *"we write pretty much on flipcharts or whiteboards and take photos of the results"*. This way, "creative products" are not only created when looking for new products or projects, but also in company wide meetings, which aim at totally different goals, like e. g. discussing potentials for company internal improvements and involving employees from every department. In terms of openness, the creative product is obviously tightly coupled to the openness of the creative process, since by integrating external sources in the process, these sources unavoidably gain knowledge of the product.

3.5 Summary

The previous subsections documented the typical activities related to creativity as well as factors in relation with the concept of open creativity. Furthermore, they described the portfolio of tools for supporting creativity that are currently used in the ICT companies that participated in our survey. The following list, provides a compact overview of our main findings:

S1 Open creativity is characterized by a **high diversity** of process settings (problem type, number of people involved, time span), creative situations (in terms of spatial and temporal distribution), product artifacts and team composition strategies.

S2 The interviewed companies do not make use of **tailored IT support** (i. e. they only use standard software such as email or word processors, or do not use IT support at all) for neither creativity or more specifically open creativity (e. g. no explicit support for creativity techniques, no infrastructure to support team composition across organizational units' boundaries, no support for creative situations).

S3 All aspects of the four dimension are not disjunct and hence can **influence each other** (e. g. the "location" (press) influences the process type and the involved persons).

S4 Very **rarely** companies try to **optimize** aspects concerning the 4P due to e. g. time constraints, complexity or comfort. For example, assessing the suitability of people participating in creative processes or the environment in which the session takes place generates certain costs (by means of time / money). These costs always have to be compared to the expected results and payoff.

4 Guidelines for open creativity support

The findings from the previous section allow for making implications on guidelines that should be considered when designing IT systems for open creativity support.

Our empirical results show that all four dimensions of creativity play a role in the context of open creativity, but efforts for optimization have hardly been made so far (S4). This implies that all four dimensions are potential candidates to be addressed by tailored creativity support systems. Finding S3 states that there is evidence for an interplay between the 4 dimensions, which is in accordance with Rhodes' work [Rhodes, 1961]. Therefore, it can be expected that a *holistic* approach simultaneously taking into account all four dimensions of creativity in a **360° perspective**, can lead to synergetic effects. Effects that are not easily recognizable by humans can therewith be acquired and analyzed by the corresponding CSS components such that an insight into aspects influencing the creative process can be given. One possible future scenario can be for example the analysis of whether a particular constellation of team members is more proficient (in terms of e. g. creativity and feasibility of ideas) when working distributed or not. Furthermore it can be analyzed which creativity technique makes their work more effective in a particular setting. The holistic approach creates therefore many opportunities to obtain new knowledge through the data generated by the connection and interplay of support modules for the different four dimensions. Evidence of similar effects could also be found by Boeddrich [Boeddrich, 2004]. In his work he concluded that the application of appropriate creative problem-solving approaches is crucial for " [...] *creating and implementing idea pipelines in companies.*"

In contrast to the current heterogeneous portfolio of standard software that is used in the context of open creativity (S2), a holistic system is moreover not affected by the problem of media discontinuity and thus reduces transaction costs.

However, given the enormous diversity in terms of all four dimensions of creativity (S1), the open creativity paradigm demands for an especially *flexible* type of support. This demands for *highly configurable and modular* systems, that can be adopted to the varying instantiations of open creativity in a company and in particular to the needs of the users. For instance, if specific creative dimensions of the CSS such as the support for the selection of appropriate team members or for distributed collaboration is not necessary, it can be easily decoupled. This may be the case when a team has already been established or whenever teams are co-located.

Otherwise, the system is likely not to reach the acceptance necessary for a wide distribution among the innovating actors. A widespread distribution of a support system is especially beneficial for fostering cooperation in open creativity: Awareness of ongoing processes may attract contributors, awareness of participating actors may create new links between the innovating actors, awareness of the resulting creative products may induce new partnerships. Furthermore, such a common "playground" for creativity lowers collaboration barriers.

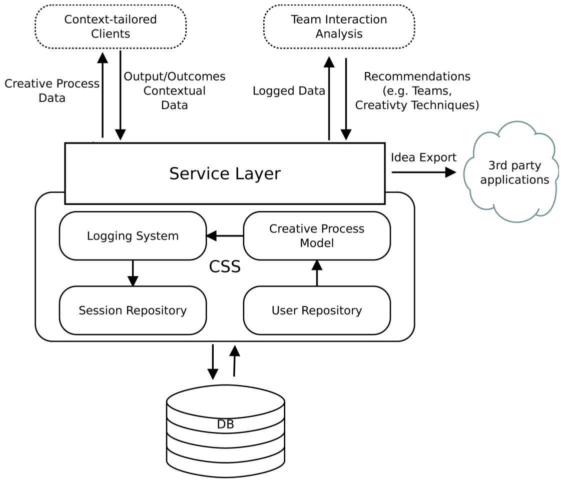

Figure 2: Architecture based on design guidelines

Finally, it is advised to allow the export of the artifacts emerged in the creative process, in order to gap the bridge between a CSS and tools supporting the subsequent stages of the innovation processes.

Figure 2 proposes an architecture that addresses the above mentioned elements of a 360° support system.

The service layer provides interfaces to external components (in Figure 2 the dotted rounded squares) for accessing the underlaying subsystems such as the logging system or the session repository. A convenient mechanisms for the communication between this layer and the external components are web services.

Context-tailored clients regard the various facets of the creative press and process. We thence propose an effective context-aware IT support which allows the combination of several human-computer interaction paradigms in order to addresses different possible creative situations by using a common infrastructure. These clients can be deployed on different devices that fulfill the requirements of these aforementioned interaction paradigms.

For distributed collaboration traditional web-based clients for the creativity support system combined with already existing communication tools such as audio/video conferencing or a chat can provide an adequate and familiar environment for creativity. This solution also makes the access from mobile devices possible such that also participation outside the working environment (e. g. during free time or field work) is possible.

For co-located collaboration special "*socio-technical systems which not only support collaboration but also mediate and foster human-to-human communi-*

cation and interaction" [Hilliges et al., 2007, p.1] are needed. Those systems "*can partly exploit the physical and social affordances of a traditional face-to-face collaborative environment and at the same time benefit from the affordances of digital technology such as persistent data storage, easy information access, and the possibility to review previous processes or to undo certain actions*" [Hilliges et al., 2007, p.2]. In this regard, single display groupware and particularly tabletop displays are proposed in related work [Stewart et al., 1999, Hilliges et al., 2007, Friess et al., 2010].

The choice of an appropriate client does not depend on the preferred hci paradigm but may also depend on other dimensions, i. e. the process or the person. For instance, some creativity techniques strictly requires individual workspaces (e. g. Brainwriting 6-3-5) which is not compatible with a shared display.

To participate in the creative process by using the context-tailored clients the creative process data is continuously obtained via the service layer. Data generated by the clients during the creative session is then steadily synchronized with the session repository such that the service layer can share the current state with all the connected clients. As a prerequisite all the clients have to use the same process model (again provided by the service layer) which is implemented inside the CSS (e. g. [Forster and Brocco, 2009]);

The logging system monitors the state changes in the repository and tracks the interaction between the clients.

Concerning the dimension person, data contained in the logging subsystem (e. g. in which context and with which creative process a team generated the most ideas) can be used to generate recommendations (e. g [Lappas et al., 2009]) for appropriate team members contained in the user repository. That can be valuable in open creativity environments where not all the actors are well known. This is achieved by a "Team Interaction Analysis" that requests the log data, analyzes it and then extracts team interaction knowledge out of it. This knowledge can be used to predict team behaviour for future teams. Moreover, the information gained from the logging system can help in finding and identifying actors that are very active. This allows for an automatic profiling of participants which corresponds to a quantitative assessment of user behaviour. In contrast to explicitely entered data in user profiles, this technique provides up-to-date information with less effort.

Also other recommendation services on the basis of this interaction analysis are possible such as recommending creativity techniques for specific press pecularities.

5 Conclusion

This article has shown and documented the presence of open creativity in companies of the ICT field and derived guidelines for an effective IT support. On the foundation of a theoretical framework which defines creativity as the interplay of four different dimensions, we clustered and analyzed the results of interviews with 10 ICT companies in Germany. Based on this analysis, we were able to determine guidelines for designing IT systems for supporting open creativity. Based on these guidelines, we proposed an architecture for a 360° support system. Additionally we gave examples for the instantiation of the architecture's components. In future work we will focus on how such a system can be realized/implemented and how each dimension can be supported in a convenient way. This will include approaches to design creativity support systems in a more context-aware manner with respect to the situations introduced in press, providing better tailored process support and regarding support systems that can be used to support the selection of appropriate teams for creative sessions. Thus, we will try to address the guidelines defined in section 4, and try to analyze which are the main challenges related to the design of such a system.

References

[Albert and Runco, 1999] Albert, R. S. and Runco, M. A. (1999). *A History of Research on Creativity*, chapter 2, pages 16–31. Cambridge University Press.

[Amabile, 1996] Amabile, T. M. (1996). *Creativity in Context.* Westview Press.

[Amabile et al., 1996] Amabile, T. M., Conti, R., Coon, H., Lazenby, J., and Herron, M. (1996). Assessing the work environment for creativity. *The Academy of Management Journal*, 39(5):1154–1184.

[Boeddrich, 2004] Boeddrich, H.-J. (2004). Ideas in the workplace: A new approach towards organizing the fuzzy front end of the innovation process. *Process. Creativity and Innovation Management*, 13(4):274–285.

[Bortz and Döring, 2006] Bortz, J. and Döring, N. (2006). *Forschungsmethoden und Evaluation für Human- und Sozialwissenschaftler*, volume 4. Springer.

[Chandler, 1990] Chandler, A. (1990). *Scale and Scope: The Dynamics of Capitalism.* Belknap.

[Chesbrough et al., 2006] Chesbrough, H. W., Vanhaverbeke, W., and West, J. (2006). *Open innovation: researching a new paradigm.* Oxford University Press, illustrated, reprint edition.

[Cohen and Levinthal, 1990] Cohen, W. M. and Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1):128–152.

[Forster and Brocco, 2009] Forster, F. and Brocco, M. (2009). A unified process model for creativity-technique based problem solving processes. In *Learning in the Synergy of Multiple Disciplines, Proceedings of the EC-TEL 2009.* Springer.

[Friess et al., 2010] Friess, M., Kleinhans, M., Forster, F., Echtler, F., and Groh, G. (2010). A tabletop interface for generic creativity techniques. In *Proceedings of the IADIS Multi Conference on Computer Science and Information Systems (MCCSIS): Interfaces and Human Computer Interaction*, pages 203–210, Freiburg, Germany.

[Garcia and Calantone, 2002] Garcia, R. and Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, 19(2):110–132.

[Hilliges et al., 2007] Hilliges, O., Terrenghi, L., Boring, S., Kim, D., Richter, H., and Butz, A. (2007). Designing for collaborative creative problem solving. In *C&C '07:*

Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition, pages 137–146, New York, NY, USA. ACM.

[Kurtzberg and Amabile, 2000] Kurtzberg, T. R. and Amabile, T. M. (2000). From guilford to creative synergy: Opening the black box of team level creativity. *Creativity Research Journal*, 13:285–294.

[Lappas et al., 2009] Lappas, T., Liu, K., and Terzi, E. (2009). Finding a team of experts in social networks. In *KDD '09: Proceedings of the 15th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 467–476, New York, NY, USA. ACM.

[Nunamaker et al., 1997] Nunamaker, J., Briggs, R. O., Mittleman, D. D., Vogel, D. R., and Balthazard, P. A. (1997). Lessons from a dozen years of group support systems research: A discussion of lab and field findings. *Journal of Management Information Systems*, 13(3):163–207.

[Nunamaker et al., 1991] Nunamaker, J., Dennis, A., Valacich, J., Vogel, D., and George, J. (1991). Electronic meeting systems to support group work. *Communications of the ACM*, 34(7):40–61.

[Rhodes, 1961] Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappa*, 42:305–310.

[Richter and Koch, 2009] Richter, A. and Koch, M. (2009). Zum Einsatz von Social Networking Services im Unternehmen. In Hansen, H. R. and Karagiannis, D., editors, *Internationale Tagung Wirtschaftsinformatik*, Wien. Österreichische Computer Gesellschaft.

[Shneiderman, 2007] Shneiderman, B. (2007). Creativity support tools: accelerating discovery and innovation. *Communications of the ACM*, 50(12):20–32.

[Steiner, 2009] Steiner, G. (2009). The Concept of Open Creativity: Collaborative Creative Problem Solving for Innovation Generation - a Systems Approach. *Journal of Business and Management*, 15:5–33.

[Stewart et al., 1999] Stewart, J., Bederson, B. B., and Druin, A. (1999). Single display groupware: a model for co-present collaboration. In *CHI '99: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 286–293, New York, NY, USA. ACM.

[VanGundy, 1988] VanGundy, A. B. (1988). *Techniques of Structured Problem Solving.* Van Nostrand Reinhold.