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Project investigators and cooperation partners	**Prof. Gernot Grabher, Julia Maintz, Jana Priester Prof. David Stark, John Kelly**

Narrative part of the report

Abstract in English

The more recent debate on innovation and learning shifted the focus from formal organizational contexts of knowledge production to informal and personal networks. The lively debate on 'communities of practice' testifies this appreciation of decentralized and self-organizing networks in generating and sedimenting knowledge. Our research seeks to conceptualize the increasing diversification of personal learning networks and to empirically explore the role of virtual technologies for the different types of personal networks. The research starts from a differentiation of three network types.

We conceive *project networks* as task-oriented relationships of limited duration that primarily are enacted for the transmission of know-what. As an empirical exemplar of this network type we observed the usage of virtual collaboration and knowledge management tools in the project work of software professionals. Although we found key assumptions on project networks confirmed, our research revealed also significant differences to our conceptual framework. First, although professional procedural authority shapes the concrete usage patterns, motivations and interaction behavior also involve social and personal criterion (like sympathy) to a considerable degree. Interaction in project networks, second, is not confined to the exchange of specific professional know-what. Rather project networks are also used to generate the know-whom that shapes selection processes for subsequent project networks. Taken together, project networks are more multiplex then we had assumed.

Sociality networks in our framework denote lasting career-oriented relationships that primarily serve to accumulate know-whom. Our empirical research targeted the strategies of software and computer professionals to use social networking software. With regard to the persistence, focus and contents, the strategies of our interviewees corroborate our key assumptions on sociality networks. This type of networks in fact is less enacted to solve specific professional problems, but rather is used as a means to maintain and broaden the personal social capital. As we had expected, sociality networks display a comparatively high level of multiplexity. Private facets are strategically instrumentalized to deepen professional relations. Our research also provides strong evidence that, first, the systematic management of personal networks strongly correlates with the degree of perceived unemployment risks in volatile project labor markets. Second, interaction styles and perceptions on generalized reciprocity are not only molded by professional ethos' but also by the identification with Silicon Valley as an 'imagined community' tied together by a bundle of conventions and protocols of collaboration. The *modus operandi* is the *locus operandi*.

We defined *connectivity networks* as theme-oriented relationships that are only sporadically enacted to exchange rater specific professional know-how. Our empirical research on these 'socially thin' networks focused on weblogs (or short: blogs) that are concerned with software-related issues. Contrary to our expectations on the ephemeral nature and the strict on-topic professionality of blogs, our analyis, first, revealed an unexpected degree of relational density and stability. Blogs, phrased differently, are not restricted to sporadic one-to-many communication but also used as a technology to establish and maintain lasting relationships. Second, these emergent structures are not purely the aggregate result of individualistic decisions by atomized actors. In addition to choices made according to specific professional interests, the linking behavior of bloggers is related to their embeddedness in a wide range of technology, academic, cultural, political and social offline and online networks.

In conclusion, our research elucidates that the technologies we explored cannot straightforwardly be mapped onto our network typology. First, the differentiation of network types along different knowledge types (know-what; know-whom; know-who) in particular turned out to be problematic. Know-whom seems to play a chief role in the evolution of each of the three network types. Learning networks in general crystallize to a lesser extent around discrete pockets of specific professional knowledge then around personal contacts that indirectly open access to various sources of specific know-what and know-how. Second, although particular technologies are primarily

adopted to serve particular purposes, they do not determine usage patterns in a rigid fashion. More typically, they open up a corridor of usage strategies. Users learn, functionalities improve. In general, our research supports the view of a 'loose coupling' and co-evolution of technology and social enactment. Third, the various network types hardly represent distinct categories. Our notion of an *ecology* of technologies, in fact, captures the fluid and transformative nature of the field we explored. The flexible and simultaneous use of various technologies induces mutations, generates new applications, and shifts usage patterns from one technology to another. Our research indeed reveals 'migration biographies'. With the increasing saturation of certain technologies (through 'contact hunting' in the case of social networking software, for example), users shift the respective function (network management) to adjacent technologies (like blogs). In general, then, our research to a lesser extent corroborates a rigid categorization of network types. Rather we see a chief accomplishment in revealing the dynamics, directions and drivers of transformative paths across an increasingly diversifying ecology of technologies.

Abstract in German

Die jüngere Debatte um Innovationsprozesse hat das analytische Interesse zunehmend von formellen organisatorischen Voraussetzungen der Wissensproduktion hin zu informellen und personellen Netzwerken gelenkt. Diese Umorientierung hat ihren wohl deutlichsten Ausdruck in der Diskussion um „Praktikergemeinschaften" gefunden, die den zentralen Stellenwert von selbst-organisierenden und informellen Netzwerken zur Produktion und Speicherung von Wissen hervorhebt. An dieser Stelle setzte dieses Forschungsvorhaben an. Es zielte darauf ab, die zunehmende Ausdifferenzierung von persönlichen Netzwerken zu konzeptionalisieren und die Rolle virtueller Technologien für diese persönlichen Lernnetzwerke empirisch auszuloten. Den konzeptionellen Rahmen unserer Forschung bildet eine Differenzierung von drei Netzwerktypen.

Wir konzeptualisierten *project networks* als tätigkeitsorientierte Netzwerke beschränkter Dauer, in denen es primär um den Austausch von ‚know-what' geht. Konkret untersuchten wir den Einsatz von Kollaborations- und Wissensmanagementtechnologien in der Projektarbeit von Softwareexperten. Wenngleich zentrale hypothetisch unterstellte Parameter von Projektnetzwerken auch zutrafen, so zeigten sich auch wichtige Differenzen zu unserem konzeptionellen Rahmen. Erstens, obwohl die professionellen Kollaborationsbeziehungen die konkreten Nutzmuster erheblich prägten, so waren Motivationslagen und Interaktionsverhalten keineswegs frei von sozialen Momenten und persönlichen Kriterien. Zweitens blieb der Austausch nicht auf projektrelevantes Sachwissen beschränkt, vielmehr spielen Projektnetzwerke auch für strategische Erweiterungen von persönlichen Netzwerken eine Rolle. Über Projektnetzwerke vermittelte sich also nicht nur ‚know-what', sondern auch zunehmend ‚know-whom'. Projektnetzwerke stellten sich also insgesamt deutlich multiplexer dar als angenommen.

Sociality networks konzeptionalisierten wir als karriereorientierte persönliche Netzwerke von unbeschränkter Dauer, in denen es primär um die Akkumulation von ‚know-whom' geht. Konkret untersuchten wir, in welcher Weise Computer- und Softwareexperten soziale Netzwerksoftware nutzen. Sowohl im Hinblick auf die Persistenz, wie auch den Fokus und den Inhalt entsprachen die von uns beobachteten Nutzungsmuster den theoretisch konzipierten sociality networks, die vor allem eine Funktion erfüllen: strategische Investitionen in das eigene Sozialkapital. Wie erwartet kennzeichnen Sozialitätsnetzwerke auch eine höhere Multiplexität: privaten Aspekten kommt eine wichtige Funktion zur Stabilisierung und Vertiefung von Netzwerkbeziehungen zu. Zwei Befunde sind hier besonders hervorhebenswert. Erstens korreliert die systematische Pflege des eigenen Kontaktnetzwerkes stark mit subjektiv empfundenen Beschäftigungsrisiken auf volatilen Projektarbeitsmärkten. Zweitens sind die Interaktionsstile deutlich von spezifischen beruflichen Konventionen geprägt, aber auch von der Identifikation mit Silicon Valley als einer Art ‚imagined community', die durch ein Bündel von Konventionen und Reziprozitätserwartungen geprägt wird. Der *modus operandi* ist der *locus operandi*.

Wir definierten *connectivity networks* als themenorientierte persönliche Netzwerke, die eher sporadisch zum Austausch von fachspezifischem ‚know-how' aktiviert werden. Als Beispiel für derartige ‚sozial dünne' Netzwerkbeziehungen unterzogen wir Weblogs (oder kurz: Blogs), die sich spezifischen Softwarethemen

widmeten, quantitativen und qualitativen Analysen. Allerdings entsprachen diese professionellen Blogs nur bedingt unserer Konzeption von strikt fachbezogenen Kontakten. Erstens verdeutlichen unsere Analysen, dass Blog-induzierte Kontakte ein unerwartet hohes Maß an Stabilität und Kohärenz entwickeln können. Blogs sind, anders formuliert, nicht auf punktuelle One-to-many-Interaktion beschränkt, sondern werden auch als Medium genutzt, gezielt Kontakte aufzubauen und langfristig zu unterhalten. Zweitens sind diese emergente Strukturen nicht allein das aggregierte Resultat individueller Entscheidungen atomisierter Akteure. Zusätzlich zu diesen durch professionelle Interessen geleiteten Einzelentscheidungen, wird das Verknüpfungverhalten der Blogger durch ihre Einbettung in eine Vielzahl von akademischen, kulturellen, politischen und sozialen offline- und online-Netzwerken geprägt.

Insgesamt traten also die Kriterien der Netzwerktypologie in den von uns untersuchten konkreten empirischen Fällen weit weniger deutlich konturiert zutage als unterstellt. Erstens kommt der systematischen Erweiterung des know-whom eine grundsätzlich größere Bedeutung in der Genese und Reproduktion aller Lernnetzwerktypen zu als erwartet. Persönliche Lernnetzwerke kristallisieren sich also weniger um spezifisches Problemlösungswissen als um know- whom, das eher indirekt vielfältige Quellen von know-what und know-how erschießt. Zweitens sind die spezifischen Nutzungsmuster nicht in eindeutiger und unveränderlicher Weise durch die Technologie determiniert. Nutzer lernen, Funktionalitäten verschieben sich. Die Beziehung zwischen Technologie und sozialer Nutzungsform entspricht also eher einer ‚losen Kopplung'. Drittens stellen sich die einzelnen Netzwerktypen und -technologien nicht als distinkte, randscharf abzugrenzende Kategorien dar. Vielmehr erscheint der Begriff der Ökologie in diesem Kontext tatsächlich angebracht: die flexible und gleichzeitige Nutzung mehrerer Technologien induziert Mutationen, generiert neue Applikationen und verschiebt Nutzungsformen auf benachbarte Medien. Wir konnten regelrechte Migrationsbiographien erkennen. Durch die Sättigung oder inflationäre Nutzung einzelner Technologien (wie das ‚contact hunting' mit sozialer Netzwerksoftware zum Beispiel) und die daraus resultierende eingeschränkte Funktionalität werden die ursprünglichen Nutzungen (Netzwerkmanagement) auf benachbarte Netzwerktechnologien (wie Blogs) übertragen. Zusammenfassend liegt als der zentrale Ertrag des Forschungsprojektes weniger in einer empirischen Erhärtung eines rigiden Kategorienrasters als im Aufdecken der Dynamik, Richtung und den Treibern von Transformationspfaden in der sich ausdifferenzierten Ökologie von virtuellen Lernnetzwerken.

Report on the scientific results

I. Background and aims: understanding learning in personal networks

The more recent debates on innovation and learning have indicated a remarkable shift in the locus of knowledge production. Up until the early 1990s, innovation research focused mainly on knowledge production and learning in *formal* organizational arrangements. The prime focus, in other words, was on firms, their ties with clients, suppliers, and research institutions. During the 1990s, however, interest increasingly shifted to informal and personal networks as effective vehicles for producing, storing, and disseminating knowledge. The burgeoning literature on 'communities of practice' is the most conspicuous manifestation of this interest in informal and personal learning networks.

Although research on communities of practice has yielded a wealth of insights into learning in informal networks, the limitations of this notion have also been revealed. Particularly in the highly volatile organizational context of project-based industries, learning takes place in a diverse range of personal networks that adhere to different social logics and display different relational architectures. We start from the assumption that these different personal networks cannot simply be subsumed under the single notion of the community of practice. More specifically, our research seeks to advance our understanding of personal learning networks in three directions.

1. Moving beyond the notion community of practice
Our research starts from the assumption that the very notion of *community* connotes with a level of persistence, homogeneity, and familiarity that appears rather alien in the current context of a relentless reshuffling of organizational arrangements and rewiring of personal ties.

2. Appreciating innovation in weak-tie networks
Debates around the notion of communities practice privilege the 'strong tie'-end of Granovetter's paradigmatic network dichotomy. However, it is rather through weak ties and sporadic contacts that bridge structural holes between different clusters that new information becomes available.

3. From the single tool to ecologies of virtual technologies
Our exploration of personal learning networks seeks to appreciate the increasing utilization of virtual technologies in sustaining and extending these relationships. We were, however, not interested in the study of a singular tool but rather seek to shed light on the movements of network members in this ever-extending ecology of network technologies.

II. The conceptual framework: a typology of personal learning networks

The basic conceptual framework for attaining our analytical objectives is a differentiation of personal networks into the three distinct types of *project networks*, *sociality networks*, and *connectivity networks.* This typology is driven by a differentiation of the duration, focus, contents, and governance of personal networks (see figure 1).

Figure 1: Nature of ties in personal learning networks

Type of ties	**Project networks**	**Sociality networks**	**Connectivity networks**
Duration	limited (project)	lasting (biography)	sporadic (theme)
Focus	task-oriented	career-oriented	theme-oriented
Contents	know-what	know-whom	know-how
Governance	procedural authority	networked reputation	professional ethos
Virtual technology	collaborative workspace	social networking software	weblog
Virtual interaction style	synchronous and asynchronous; many-to-many	asynchronous; one-to-one	asynchronous; one-to-many and many-to-many

1. Project networks: collaborative workspaces

A project network is temporally formed around a particular project task. The limited duration of projects hardly allows for the evolution of enduring and strong ties, project networks rather operate in weak tie-milieu. Project networks are governed by a common procedural authority that also defines the 'know-what' for the individual project member. We started from the assumption that virtual collaborative workspaces epitomize key features of project networks. Virtual workspaces provide tools for information sharing, virtual project rooms and news fora, amongst others. Interaction in project networks, consequently, evolves in synchronous or asynchronous many-to-many contexts.

2. Sociality networks: social networking software

We conceive sociality networks as career-oriented relationships. Whereas project networks are focused on a particular task, the prime aim of sociality networks is to deepen and widen 'know-whom'. In the absence of personal experience with a particular person or firm, network members rely on networked reputation that is basically the word-of-mouth judgments of friends-of-friends. Whereas project and connectivity networks are relatively distant from the private realm, sociality networks instrumentalize the private dimension of relationships (such as shared hobbies) to advance professional interests. We regard social networking software that systematizes the maintenance of personal networks through electronic contact management as emblematic cases of sociality networks. Communication is taking place through relational chains that is in asynchronous one-to-one configurations.

3. Connectivity networks: weblogs

We construe connectivity networks as theme-oriented networks characterized by sporadic interaction. Connectivity networks are all about sharing 'know-how' and specific information around a particular theme, like specific software, for example. Since this exchange of know-how and collaborative problem solving is more distant from the private realm, the socially rather thin connectivity networks are primarily governed by the particular professional norms and ethos'. We expected that key features of connectivity networks characterize interaction patterns in blogs. Blogs are theme-oriented frequently up-dated websites hosted by one or more persons to which distributed discussants post comments and links. Interaction style is asynchronous one-to-many or many-to-many communication.

To empirically explore the specific features of these three network types and network technologies respectively we applied qualitative and quantitative approaches. Whereas our research on project and sociality networks is based on qualitative empirical work we combined quantitative and qualitative methods in our analysis of connectivity networks to provide systematic evidence of the relational features of blogs. Our three research modules targeted professionals in the software and computer industry and, with regard to the analysis of blogs, software-related themes. We choose these industries due to their particular high affinity towards virtual technologies and their position at the very forefront of the adoption curve. They can be regarded, in other words, as significant precursors of developments that will diffuse into other fields after a certain time lag. At the same time, this selection also implies that our findings are not relevant to the same degrees in other industry contexts that, for various reasons, display a lower affinity to utilize virtual workspaces, social networking software or blogs.

III. Exploring project networks: from know-what to know-whom?

Data

In our analysis of project networks, we interviewed 31 employees of Microsoft Unterschleissheim, Germany (13 interviews), Microsoft Neuss, Germany (3 interviews) and SAP Walldorf, Germany (15 interviews) in between 5 March 2007 and 5 April 2007 (Appendix 1). In these semi-structured interviews (with an average duration of 90 minutes) we focused on the use of collaboration management tools in project work contexts. The tools comprised both enterprise software produced by the target companies (MS Sharepoint, MS NetMeeting, MS LiveMeeting, MS Messenger, Outlook, Groove, SAP Netweaver, SAP Collaboration Room, C-Folders) and other social communication tools (like Interwise, WebEx, discussion forums, mailing lists). The tools under investigation, broadly speaking, seek to systematize, link and document work processes in collaborative project contexts.

Utilization patterns

The utilization of these technologies, in a static view, resembles our characterization of project networks. These tools are primarily used to support task-oriented interaction in many-to-many contexts for rather specific purposes. E-mail is used for exchanges that are supposed to be documented. The chat tool serves for spontaneous and short communications, frequently involving private contents. Often the chat tool is associated with an overlap of interaction modes. It is combined with other communication modes and importantly also used in face-to-face meetings for discrete parallel one-to-one conversations. Although video-conferences were important in projects involving distributed project partners, they could not compensate for face-to-face meetings. The need for face-to-face meetings increases when (1) information and tasks are diffuse; (2) strategic decisions have to be made and (3) at the inception and close to the deadline 'when it is important to gesticulate'. Despite the exceptionally high affinity of both corporations to the use of virtual tools (after all, they produce them), both are keen to nourish a strong face-to-face culture (enhanced by joint lunches and coffee breaks; meeting spots like coffee corners and sports facilities on the corporate campuses) to foster informal and accidental exchange.

Increasing multiplexity and relationality

Despite these robust usage patterns, however, the permanent switching of professionals between various tools seems to induce change of and cross-fertilization between different technologies. This generative and transformative dimension corroborates our notion of en ecology in particular. MS Sharepoint, for example, allows access to MySites and thus extends the principal function of a tool of document management in a collaborative virtual workspace, in two dimensions. First, MySites also involve personal information. The spectrum of these personal facets, naturally, remains within the narrow confines of information deemed suitable for the corporate contexts of the typical coffee-corner conversation (hobbies, children etc.). Nevertheless, it indicates that even in the strictly professional context of project networks, personal dimensions 'creep in'. Project networks, in other words, seem to become more multiplex then we assumed. Second, MySites also provide access to relational data (like senders and receivers of preferred mailing lists or dedicated links to preferred collaborators). These project networks, phrased differently, seem not strictly confined to know-what but also involve increasing fractions of know-whom, at least in a rudimentary form. Rather cautiously, this might be interpreted as an indication that the tools to sustain project networks we studied might be extended from tools of managing pockets of specific information (embodied in documents, forms, or routines) to tools that provide the relational tracks to experts on those specific pockets of information.

Generative dynamics

Although project networks in fact might be task-oriented and socially thin at their inception, they almost unavoidably get socially richer and more multiplex in the course of a specific project. Our interviewees stressed that project networks usually turn into incubators of personal relations bound together by mutual sympathy or a shared passion. These personal relations (which are semi-publicly displayed through all sorts of mutual links on the intranet) typically, in turn, afford the social infrastructure or pre-selection filter for subsequent project networks. This generative dimension of project networks alerted us to the pitfalls of strictly separating our three different network types. In practice they permanently cross-fertilize (or contaminate, for that matter) each other. The social creeps into the purely professional, and vice versa.

IV. Exploring sociality networks: towards a reflexive construction of the social world?

Data

Our empirical research on sociality networks is based on 25 interviews with users of the professional networking software LinkedIn in computer and software industries in between 14 March and 26 March 2006 (21 users in the San Francisco Bay area, 4 users in New York City; 24 face-to-face interviews, one phone interview; Appendix 2). Our interviews (with an average duration of 90 minutes) targeted the motivations to join LinkedIn, preferred functions and perceived limitations of LinkedIn and learning effects in the course of usage. LinkedIn, broadly speaking, compiles strategic information on corporations and the career of individual network members by Web crawling and the use of information that is accessible through the software users' personal networks. The friend-of-friend principle enables to electronically trace a link from a user who intends to address a targeted person through his own personal network.

Usage patterns

The usage patterns of LinkedIn in fact corroborate key features of sociality networks that primarily are career-oriented lasting ties to accumulate, manage and (publicly) display know- whom. This knowledge is systematically developed by constantly monitoring the own social environment and by specifically searching for particular actors. Careers can be followed-up, relational ties can be reconstructed (who is tied to whom?). This social knowledge, first, affords a dynamic filter in an excessively rich information environment: it validates the trustfulness of information sources but also prioritizes incoming requests. Second, this know-whom of course is a key resource to advance the own career and a chief safeguard against unemployment risks in a highly volatile job and project market. Our interviewees stressed that in particular after the experience of the crash of the new economy early 2000, they more systematically began to invest time to develop and sustain robust networks that can provide a safety-net. Interviewees described their investment into these personal networks quite literally as 'payments into a bank account' on which they would draw in an economic down-turn. Not surprisingly, then, the use of LinkedIn peaks in periods of increased perceived employment insecurity and actual job hunting. In this sense, we found our proposition of a highly strategic behavior in sociality networks confirmed.

Face-to-face and virtual network interdependencies

Similarly as in the case of project networks, shared educational or professional episodes provide the most important source of establishing contacts for sociality networks. Consequently, the geographical spread of sociality ties gravitates towards places of shared professional activity. However, we also found a strong propensity to link up with actors in the major regional hub of the industries we studied that is Silicon Valley (particularly for network neophytes who seek to establish credibility through a link to a renown expert in Silicon Valley). From this potential of contacts with actors of a shared (or expected) professional activity only a portion turn into more robust network ties. Piling up an impressive number of (virtual) business cards only translates into an actually useful resource if, and only if, these links can be enacted in various situations (ranging from finding a project partner to getting the ear of the chief recruiter of the targeted company). Actual face-to-face-experience and the proverbial 'beer at the convention' (as the typical paraphrase for some degree of light sociality) play an important role in this transformation of a contact into a robust tie. With regard to the depth of the private dimension of network ties, our findings are somewhat ambiguous. Whereas one group of interviews reiterated the professional character of ties (that, of course, might be enhanced by some sort of informality) others draw no distinction between their LinkedIn profile and their offline network of friends.

Silicon Valley as imagined community

The major hub of our industries, Silicon Valley, showed not only up in actual (and aspired) contact portfolios. Silicon Valley played also an important role in the governance of sociality networks. Governance, in other words, was not only based on networked reputation and a strong professional ethos. Moreover, Silicon Valley was referred to as a sort of 'imagined community' tied together by a bundle of conventions and general norms of reciprocity. These conventions, time and again, were described as a 'help out'-mentality and the expectation to 'give' even if there are no immediate prospects to 'take'. It is not our point here to judge if these behavioral conventions actually square with a reality in which open competition is *the* quintessential drive not just in the business realm, but in social life more generally. The point here is rather that these conventions explain the behavior of our interviewees when asked for referrals or endorsements (displayed at the LinkedIn profile). In this sense, the question of the relation between virtual technologies and the face-to-face world is not just to what extent the former substitutes the latter. The theoretically more interesting point is to what extent our social face-to-face-world informs norms and conventions that govern our virtual networks.

Migration and reflexivity

We found further empirical indications for the evolutionary and transformative dimension of our notion of an ecology of technologies. The actual usage of LinkedIn appears as one phase in migration biographies of actors adopting and subsequently abandoning social software tools from Ryze and Plaxo, Orkut, Friendster, Spoke, and VisiblePath, to blogs in particular. These migration biographies are driven by two dynamics. First, our interviewees in the software and computer business conceive of themselves as first movers (and actually are also conceived as forerunners by others). With the increasing diffusion and saturation of social software products, these professionals shift to new technologies, driven by the social pressures to remain ahead of the

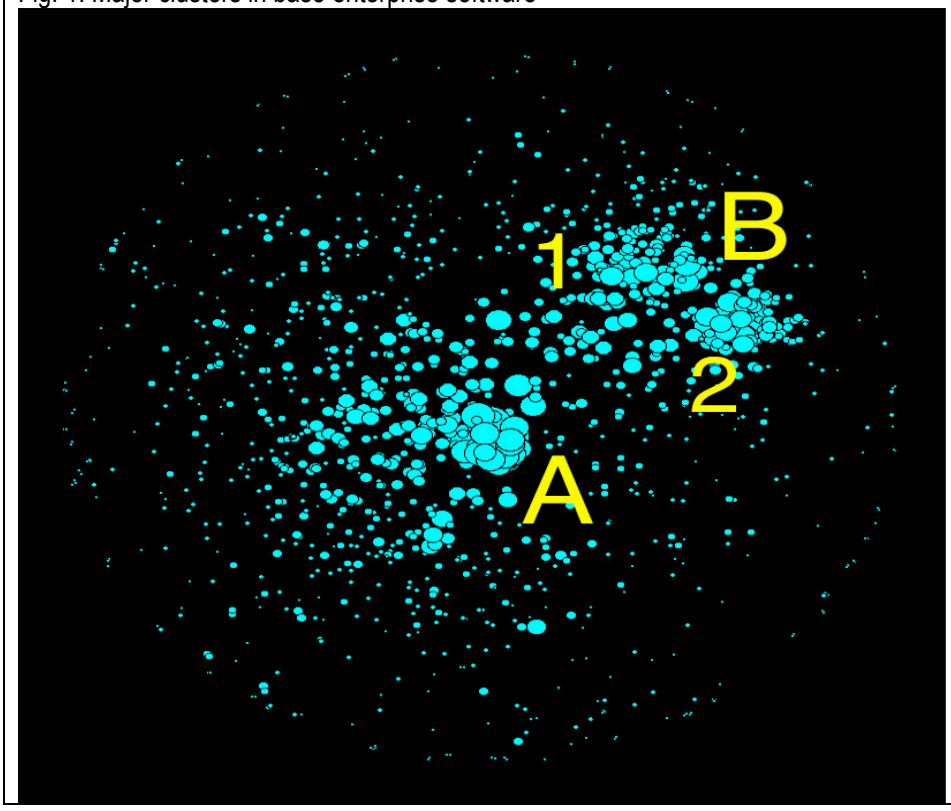
curve and the ambition to shape and stretch the corridors of utilization. Second, although we assumed that our interviewees would of course learn in the course of the usage of LinkedIn, the degree of reflexivity was unanticipated. Our interviews not only became much more selective in accepting invitations from hardly unknown contacts (particularly so-called 'contact hunters' with a portfolio in excess of the threshold of 500 contacts indicated at the LinkedIn profile). They also shifted from a more unconscious pattern of homophily (that is to link up with actors who are similar to oneself) to more deliberate strategies to enrich their portfolio with actors with complimentary profiles. In general, the degree of network literacy of our interviews was unexpected. Although our questionnaire did not contain any respective triggers, our interviewees regularly brought up network concepts of Mark Granovetter ('strength of weak ties'), Duncan Watts ('small worlds') and, to a lesser extent, Ronald Burt ('structural holes'). Dunbar's number (the alleged maximum size (150 nodes) of a network an actor can sustain) provided a recurring point of reference for interviewees when reflecting about their network strategies. The notion of networks, in this sense, not only represents an analytical template to describe empirical realities. For our interviewees, the notion of networks more and more turns into a socio-technical means to deliberately furnish their social world.

V. Exploring connectivity networks: blogs a networking technology?

Data

Our empirical research on connectivity networks focused on quantitative and qualitative analysis of blogs on the enterprise software tools MS Sharepoint, MS .net, MS SQL Server, SAP, MySQL, and open source software like Linux and Apache. This research module drew heavily on the data-base of our project partner John Kelly (Columbia University, Center on Organizational Innovation) that includes about 200,000 of the most highly connected English language blogs. We extracted through key word search and on the bases of the tags authors use to categorize their posts over 4,000 enterprise blogs concerned with enterprise software as well as relevant companies (SAP, Microsoft, Oracle, MySQL, SUSE, and Red Hat). We used a snowball procedure to identify other blogs in the same ‚network neighborhood' by chasing outlinks from our seed blogs, and pulling in new blogs strongly connected to the seed core. While most of blogs captured are those of software professionals, our set of 7336 blogs also captures other blogs densely interlinked with them, including blogs by venture capitalists, software executives, Silicon Valley luminaries, technology journalists and various flavors of Internet 'gurus'.

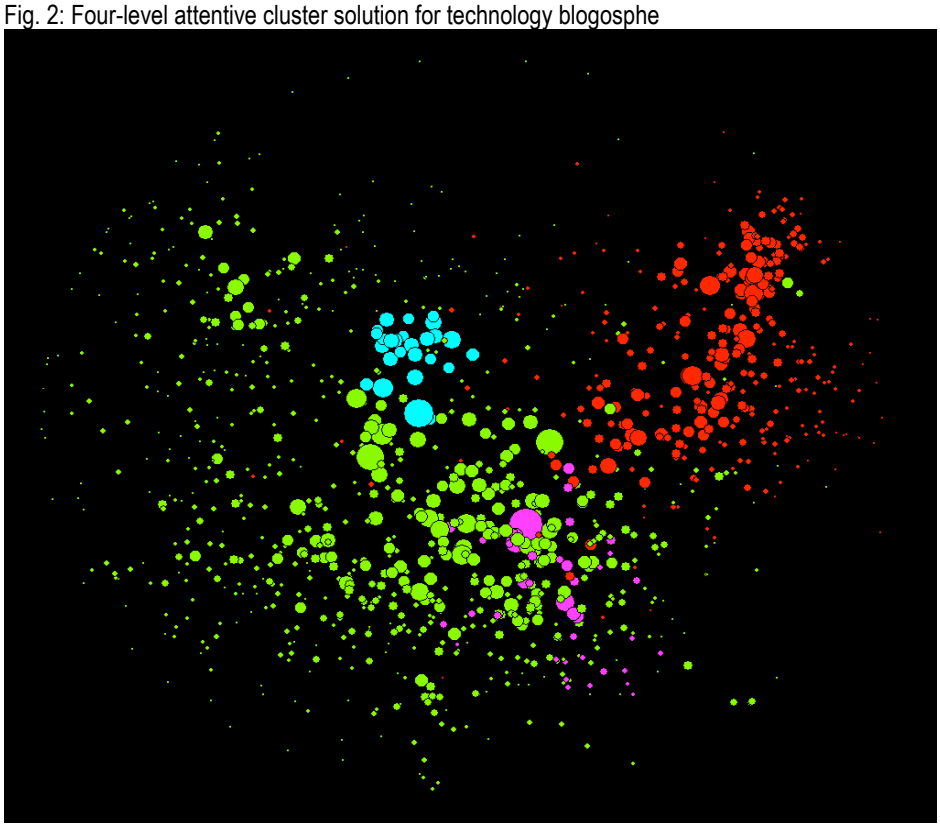
Fig. 1: Major clusters in base enterprise software



Increasing relationality

We conceived connectivity networks as theme-oriented networks that are only sporadically enacted to exchange very specific know-how. In a sense, we conceived of the technology blogosphere as a sort of library in which particular sections are consulted for specific purposes only. Contrary to these expectations, however, the enterprise software blogosphere displays an unexpected degree of clustering and relational stability. We used Fruchterman-Rheingold plots to map these clusters and relational features of the blogs (fig. 1; each circle represents a particular blog; the size of the circle indicates the degree of the blog within the network, i.e. the number of other blogs it is linked to; the position of the circle indicates which other blogs it is most densely connected with). The network map featured a central cluster (A), with a number of high-degree, central 'A-list' bloggers, as well as an interesting secondary, 'dual' cluster (B). The second cluster was less central in the overall network, but featured two thickly interlinked, yet distinct, sub-clusters (B_1, B_2), each with a large number of medium-degree bloggers.

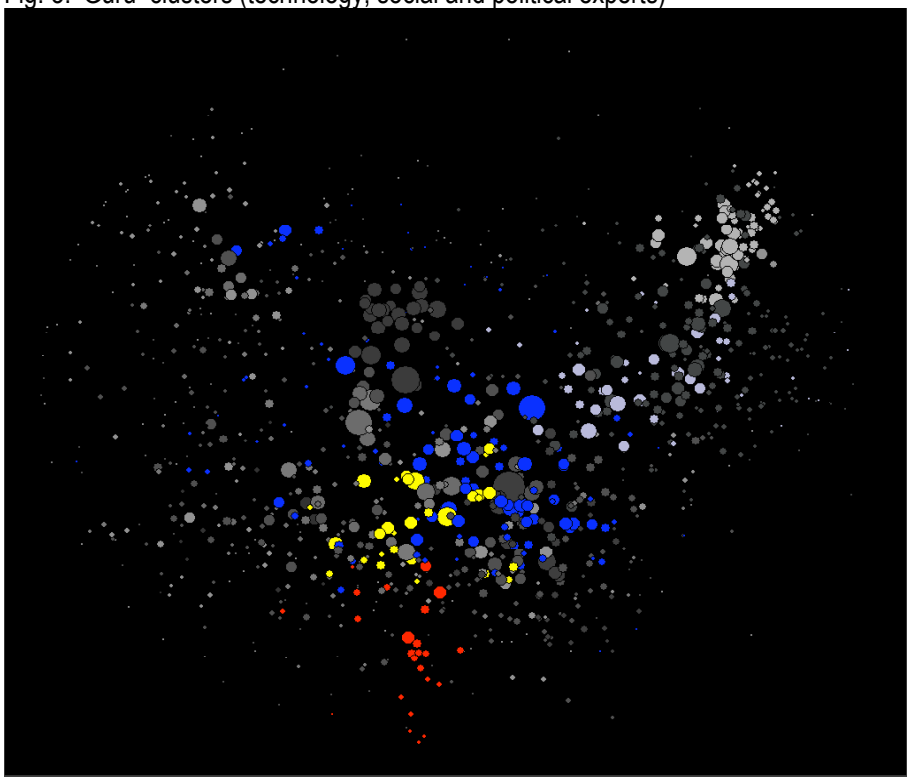
Fig. 2: Four-level attentive cluster solution for technology blogosphe



Attentive clusters

To understand principles and dynamics of these clusters, we performed an 'attentive cluster analysis' developed by John Kelly. In this procedure blogs are clustered into attentive clusters by analyzing their link histories as mathematical vectors, finding groups of bloggers with similar link profiles. Blogs in the same attentive cluster, in other words, share similar informational worlds, which is to say that they more frequently link to the same online sources (including other blogs, news and informational websites, URLs of organizations, and all other varieties of links; fig. 2). The largest network of clusters (green) involves a complex set of relationships among nodes concerned with Open Source software, Silicon Valley resources, sub-networks of programmers, ‚gurus', politics, and the mainstream media. Despite its global reach (with sub-networks of various languages and nationalities), this network is most strongly tied to Silicon Valley. The second largest sub-network (red) is built around Microsoft, with three parts that frequently access the bundle consisting major domains belonging to Microsoft, and yet also individuated by differential link preferences for other bundles. Finally, two small sub-networks, one more connected to the central open source core than the other, are defined clearly by the highly self-referential linking preferences around two commercial publishing ventures (ZDnet and Weblogs, Inc.). Crucially, clusters crystallize not only around certain topics but also around certain principles and communicative styles.

Fig. 3. ‘Guru’-clusters (technology, social and political experts)



Multiplexity and embeddedness

Contrary to our initial proposition on connectivity networks as socially thin one-to-many interactions, the attentive cluster analysis revealed that connectivity networks are more multiplex than we had expected. First, these emergent structures are not purely the aggregate result of individualistic decisions by atomized actors. In addition to choices made according to specific professional interests, in a kind of ‚selective exposure’ paradigm, the linking behavior of bloggers is related to their embeddedness in a wide range of technology, academic, cultural, political or social networks. The emergent fabric of blog networks thus reveals the traces of many offline networks. Second, the identified networks strikingly cluster around high-profile expertise of certain sorts, namely ‚gurus’ (fig. 3). One set of experts (blue) concerns themselves with the business side of technology; another type (yellow) focuses on the social, legal and cultural side (like Lawrence Lessig and his ‘creative commons’-blogs); a third (red) is focused on conservative politics. The kind of knowledge on offer from these circles is a mix of strategic knowledge (about the future), values knowledge (including moral, ethical and legal aspects of technology), and cultural knowledge (rituals and shared symbols). In other words, the network revolves around some more fundamental questions that engage members as professionals and in fact as citizens, even as it concentrates particular know-how relevant to practitioners into small pockets of expertise easily discovered by search.

Institutional footprints

The attentive cluster breakdown also demonstrates that institutions leave clear footprints in the network. Rephrased in terms of our research aims, the interdependence between the formal domain (of institutions) and the informal sphere (of our networks) become visible here. Stated more precisely, linking choices that are institutionally coordinated across many blogs cause structural regularities that are more easily detected by network analytic algorithms than the more subtle structural features that emerge from the uncoordinated choices made by diverse individual bloggers linking according to their own priorities. Such across-blog coordination can be relatively ‚harder’ (e.g. ZDnet’s unified design for their journalist’s official blogs) or ‚softer’ (e.g. Microsoft’s policy that members of the Sharepoint product team should maintain blogs), but institutional coordination produces local network densities that are higher than those generally found in more purely emergent structures.

VI. Assessment of network typology

Our empirical research revealed that the technologies we explored (virtual workspaces; social networking software; blogs) cannot straightforwardly be mapped onto our typology of networks. First, the differentiation of network types along different knowledge types in particular turned out to be problematic. Know-whom seems to play a chief role in the evolution of each of the three network types. Learning networks in general crystallize to a lesser extent around discrete pockets of specific professional knowledge then around personal contacts that indirectly open access to various sources of specific know-what and know-how. Second, although particular technologies are primarily adopted to serve particular purposes, they do not determine usage patterns in a rigid fashion. More typically, they open up a corridor of usage strategies. In general, our research supports the view of a 'loose coupling' and co-evolution of technology and social enactment. Third, the various network types hardly represent distinct and crisp categories. Our notion of an *ecology* of technologies, in fact, captures the fluid and transformative nature of the field we explored. The flexible and simultaneous use of various technologies induces mutations, generates new applications, and shifts usage patterns from one technology to another. Our research indeed reveals 'migration biographies'. These migration biographies are propelled by both the social pressures to remain ahead of the adoption curve and the ambition to constantly stretch the boundaries of conventional usage patterns.

Self-evaluation in comparison with the original objectives and working plan

I. Unexpected results

Although we deliberately choose the notion *ecology* of technologies to appreciate the diversity and fluidity of the field we explored, we in general underestimated the generative and transformative dynamics within this ecology. The mapping of technologies onto particular network types and usage patterns, as a result, turned out to be more problematic than we had expected (see above). More specifically, several findings on sociality networks/social networking software and connectivity networks/blogs in particular were unexpected.

We anticiapted that the usage patterns of social networking software would reflect the relational traces of our face-to-face world. We considered the relation between online and offline networks, in other words, not in terms of substitution but interdependence. As our analysis of social networking software elucidates, this interdependence is more complicated (and theoretically much more interesting) than expected. Silicon Valley not only acts as an incubator of personal networks by affording a (real) site where professional biographies intersect. Moreover, Silicon Valley is perceived as an 'imagined community' bound together by a shared understanding of protocols and conventions of interaction in the virtual realm. The *modus operandi* is the *locus operandi*.

Although we assumed, of course, that users of virtual technologies would learn and become more strategic and selective in their use of network technologies, we were surprised by the degree of reflexivity and network literacy. Our interviewees regularly brought up key notions of network research (like strength of weak ties; structural holes; Dunbar's number) as central points of reference in their attempts to more deliberately manage their networks. Following Annelise Rise, networks then in fact are "turned inside out", from an analytical template to a socio-technical strategy device to furnish the own social world.

Although we assumed that blogs indeed are networking technologies, the degree of relational cohesion and coalescence with other networks were unexpected. The emergent fabric of blog networks does not only reflect aggregate outcomes of individual choices, but rather seems inextricably interwoven with a range of professional, social, cultural and political networks. Taken together, as a network the technology blogosphere is a site of intersection among a great many networks, which are partially enacted through it even as their edges are blurred by participation in it.

II. Extension of empirical base

We decided to extend our focus on corporate products (MS Sharepoint, SAP software plus MS .net, MS SQL Server) and moreover to integrate online debates around open source technologies (MySQL, Apache). This extension of the empirical base beyond our original conception allowed us to capture more fully the relational features and the cluster dynamics in the technology blogosphere. This more diverse data-base afforded a richer and broader view on the diverse networking strategies, exchange patterns and communicative styles (ranging from strictly professional over the 'light sociality' of coffee corner conversations to truly multiplex) in the various quadrants of the enterprise software blogosphere.

Added value gained through interdisciplinary and international cooperation

The interdisciplinary and international composition of the research team added up to a highly complimentary set of skills that allowed us to combine qualitative and quantitative methodological approaches (qualitative interviews, quantitative social network analysis, content analysis of online content) in a highly productive fashion. This mix of approaches afforded the tools for methodological and data triangulation which yielded richer insights and more robust conceptions of the different network logics in the online ecologies. Whereas our qualitative approach helped us to uncover motivations, strategies and learning effects of individual users in a bottom-up perspective, the quantitative analysis provided us with a top-down view on the relational features and cluster dynamics of the aggregate networks. The quantitative tools, more specifically, allowed us to conceptualize the diffuse blogosphere in network theoretical terms.

Future perspectives and sustainability of the project

The cooperation with David Stark and John Kelly offered most valuable learning opportunities (for the entire Bonn research team, including our student assistants) with regard to quantitative analysis of large network data sets. In particular the 'attentive cluster analysis' developed by Kohn Kelly, and further refined in this project appears a highly productive research tool that we are keen to employ in our future research.

More generally, the collaboration with David Stark and Kohn Kelly brought us in touch with a research community to which we so far had no connection. Establishing links with the diverse community of Internet-related research thus opens up an entire new spectrum of conferences and publication outlets for our research that follows on from this project.

Amongst others Gernot Grabher and David Stark will present a paper on Sociality networks at the workshop on "Socioeconomics, Markets and Space: Performing Markets", Frankfurt, October 16th – 18th, 2008.

Contribution to the specific aims of the funding initiative

First, our research lends support to the research strand that seeks to push beyond a perception of innovation as a rigid and linear sequence that origins in the scientific discovery in the research laboratory and then moves on to the product development department and ends with diffusion in the market. We seek to elucidate that innovation is an ongoing practice embedded in and sustained by piecemeal learning processes involving multiple actors.

Second, our research also provides evidence that learning and innovation are not limited to knowledge production in the formal organizational context of research labs and development departments. As our findings demonstrate, learning takes place in informal and personal networks, in an increasingly systematic level. Our research, in a sense, affords insights into the 'soft infrastructure' of innovation. The project in particular sheds light on the increasing diversity of personal learning networks sustained by virtual tools.
Third, our detailed analysis of the various virtual learning networks also provides insights into the interdependence between technological and social dimensions of innovation. New technologies do not determine new learning and innovation practices in a quasi-deterministic fashion. Rather, as our empirical material

suggests, new technological affordances and social practices co-evolve.

Public relation activities and resonance in the media

Slater Dashka, "Breakout at Tiffany's." *San Francisco* 5/2006: 92-100.
This article in the *San Francisco* journal reports on Prof. Gernot Grabher's interview with Tiffany Shlain (film-maker, founder and CEO of the Webby Awards) conducted on 21 March 2006 in San Francisco, and presents the research project "Learning in personal networks: Collaborative knowledge production in virtual forums", and comments on Ms Shlain's networking approach.

Economic Sociology – The European Electronic Newsletter, 03/2008, Volume 9, Number 2.
This newsletter includes insights gained from the research project "Learning in personal networks: Collaborative knowledge production in virtual forums" based on Prof. Gernot Grabher´s interview with Patrik Aspers (editor), University of Stockholm and Max Planck Institute for the Study of Societies, Cologne.

Tabular part of the report*	
Participating researchers and students, separated by institution and funding source	Julia Maintz, University of Bonn, researcher, August 1, 2005 – September 30, 2007, Project resources "Learning in personal networks", Volkswagen Foundation. Sabine Würkner, University of Bonn, student assistant, October 1, 2005 - July 31, 2006, Project resources "Learning in personal networks", Volkswagen Foundation. Jana Priester, University of Bonn, researcher, February 1, 2008 – May 31, 2008 and student assistant, December 1, 2006 - December 31, 2007, Project resources "Learning in personal networks", Volkswagen Foundation. John Kelly, Columbia University, Center on Organizational Innovation, researcher, Project resources "Learning in personal networks", Volkswagen Foundation.
Additional cooperation partners in the project (not applicants)	-
Theses written in the course of the project	Julia Maintz, "Space as Actor-Network Component. Interacting in the Web-based Blended Learning Course E-learning Training and Management", doctoral dissertation, July 2006. Sabine Würkner, "Soziales Kapital und Karrierenetzwerke. Der Nutzen von e-fellows.net", diploma thesis, September 2006.
Publications	Gernot Grabher and Julia Maintz (2007), "Learning in personal networks: Collaborative knowledge production in virtual forums." In Hof, Hagen and Wengenroth, Ulrich (eds.) *Innovationsforschung – Ansätze, Methoden, Grenzen und Perspektiven*, Münster, LIT (pp. 187 – 202; App.3). John Kelly and Gernot Grabher (2007), "Blogs as networks of practice." (to be submitted to *New Media and Society;* App. 4). Julia Maintz and Gernot Grabher (2007), "The scientific management of personal relations: The role of social networking software in maintaining networks." (to be submitted to *Environment & Planning A;* App. 5).

Specific events, e.g. workshops	General Online Research Conference, Leipzig, 26-28 March 2007 (App. 6). Workshop on "Socioeconomics, Markets and Space: Performing Markets", Frankfurt, 16-18 October 2008.
Abstracts directly related to the project	John Kelly, Gernot Grabher and Julia Maintz, "Software ecologies: Blog networks for enterprise software." Abstract for General Online Research Conference, Leipzig, 26 - 28 March 2007 (App. 7). John Kelly, Gernot Grabher and Julia Maintz, "Blogs as social networking sites." Abstract for Danah Boyd and Nicole Ellison (Eds.). (2008). Special Issue *Social Network Sites: People, Practice, and Culture. Journal of Computer-Mediated Communication* (App. 8).
Patents directly related to the project	-