What makes online ties sustainable? A Research Design Proposal to Analyze Online Social Networks

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Abstract:
Recently, the Pew Internet & American Life Project published a study about the number of social relations people maintain online and the omnipresent question was raised again: are actual face-to-face contacts declining over time and are they replaced by online social interactions. Our virtual life is scattered in online profiles across sites such as openBC.com, Friendster.com, Match.com or MySpace.com. There are currently more than 400 different online social networking sites – with new sites popping up every day. Building on existing factors of persistence and sustainability of network ties in general, we address the key research questions: *Which factors lead to the creation, maintenance, decay and reconnection of online network ties?* Our research draws on prominent issues in the social network literature, which address the gap between research on offline and online social networks. We examine individual, dyadic, structural and content-related characteristics to understand how and why actors in different phases of their life cycle turn to online ties. Within the presented research framework, we derive propositions and develop a research design to collect and analyze qualitative and quantitative network data. The overall goal is to develop recommendations on how online social networks can become sustainable over time, and we develop questions and avenues for further research.

1. Introduction

Drawing on Granovetter's (1973) seminal work on the strength of weak ties, researchers have been interested in the study of tie strength and tie durability for many years. Most of the existing literature shed's light onto the role of ties in all types of social networks, such as individual, intra-organizational, or inter-organizational networks. In recent years, the Internet has given rise to a new type of research stream, which focus on online social networks. Building on earlier work regarding online communities or virtual teams, scholars are increasingly interested in the study of the Internet and its effects on social ties and networks. In consequence, online social networking and social software have become important issues areas in the academic and practitioner literature.

Although substantial research has been conducted to examine online communities, much fewer studies tried to illuminate whether the Internet has an effect on our understanding of social ties. In times, where all types of networks, both professional and private, are becoming virtualized, it is very important to understand how our conceptualization of social networks and social ties is being affected by internet technology.

How do people *create*, *maintain*, *cut*, and *re-establish* online ties? Very little research is available that addresses this question in the four different maturity phases of online social networks. Our paper proposes a research design, which aims at exploring the following research question: *What factors contribute to the sustainability of online ties over time?* We seek to understand how and why people create or abandon online ties over time. We review the results of relevant research on sustainability of network ties and derive propositions to guide our research design and next steps. We include the differences between online and offline ties into our discussion, but apply the propositions to a specific setting and concentrate on online ties only.

The paper is organized in five sections: Section 1 starts with the development of four distinct characteristics, which influence tie sustainability. Section 2 reviews the social network literature to delineate differences between online and offline social networks. Section 3 includes the development a research framework to examine online tie sustainability. We present our research design to explore online tie sustainability in Section 4. We conclude this manuscript with a brief discussion of open questions.

2. State of the Art: Sustainability of network ties

There is a large body of research, which has been evolving over the last couple of years focusing on different factors of sustainability in social networks. We are looking at four different factors that help to predict whether ties are sustainable or are abandoned over time, namely individual, dyadic/group, structural and content related characteristics.

2.1 Individual characteristics

Personal or individual factors refer to personal traits that effect the creation of a tie and potentially the neglect of a tie over time. Moreover, when actors share interest areas, values and understandings it is more likely that they are able to maintain their relationships over

time. *Homophilous* actors have more opportunities to contact or meet each other over and over again.
There is evidence that shows that *changes in personal status,* such as the changes in family or professional status alter the composition of one's personal network. Over the course of life, people add friends because of their specific contact needs: we add friends at school, might get out of geographical reach from them when we go to college, where we add new people to our network. In the next stage, when we transition from being a student to being a professional, we add more professional ties to our circle of contacts, which might gradually change the composition of our friendship network, when professional ties evolve into social contacts. *Life cycle changes*, such as getting married, childbearing add a different dimension and different types of ties to the network (Stueve & Gerson, 1977): people tend to hang out more with people who are in similar life cycle specific situations: women create more ties to other women who are also mothers (Rotolo, 2000).
Age as an individual characteristic is closely connected to influence the choice of sex specific ties over time as well: women tend to increase their ties to other women over time and drop their male acquaintances. In addition, younger actors tend to accept additional ties to their network more than older actors, who are more persistent in the maintenance of existing ties and don't accept new ties at the same rate as younger actors (Rotolo, 2000).
We hypothesize that *personality traits* such as extroversion and introversion effect the creation, maintenance and potentially decay of relationships: extroverts potentially keep their friendships alive by contacting the actors in their network more often and are willing to add new people to their existing network easier. On the other side, introverts might be more reluctant to contact new people by themselves, instead of waiting until people approach them (Amato, 1990).

2.2 Dyadic characteristics

Dyadic characteristics focus mainly on the relationship between two actors and include two factors: *homophily* and *friendship*. Both factors influence the reciprocity of a contact and therefore the likelihood of frequent interaction, which in turn fosters tie sustainability.
Homophilous network ties are more sustainable over time – as Lazarsfeld and Merton note: "Birds of a feather flock together" (Lazarsfeld & Merton, 1954). Actors who share specific personal attributes, such as education, age, but also geographic proximity and shared values are more likely to have repeated opportunities to interact with each other. They are therefore able to maintain their ties over time (McPherson, Smith-Lovin, & Cook, 2001).
In addition, preexisting *friendship* ties, which indicate a positive content of the tie, have shown that people are more likely to stay connected (Fischer, 1982). This also includes reciprocated contacts that are revisited because two actors feel emotionally close.
Moreover, *common membership within a group*, such as in a sports team, a community group, a shared time spent at the same college, or membership in an online discussion group can effect the feeling of being alike. In contrast, research also shows the ties created over time life span of a group can dissolve when the legitimacy for being existent disappears over time (Martin & Yeung, 2006). This can be the case when when people graduate from college or when online discussion group have resolved the problems, which they were aiming for. In rather formal settings for instance, such as in firms, organizational boundaries enforce natural barriers for people to disappear from a personal or professional network. When we think of online social networks, such as *LinkedIn* or *openBC*, as a set of many subgroups,

people are more likely to create ties within specific subgroups as opposed to creating ties with any random people in the overall network.

2.3 Structural characteristics

Structural characteristics include properties of the network's overall architecture and how they affect the sustainability of a dyadic tie.
One of the most prominent studies on how structural network properties influence the survival of organizations focuses on relational *embeddedness* (Granovetter, 1985; Uzzi, 1999). Embeddedness can be seen as an exchange system with unique opportunities relative to markets. As the studies show, firms that are highly embedded in networks of relationships have higher chances of survival than do firms with only arm's-length market relationships. Cummings/Higgins (2006) showed that people who are the core of a network and are therefore more embedded in the overall network structure, are more likely to keep their ties stable compared to those at the periphery of a network. This c*ore-periphery structure* of the overall network adds to a higher closeness of the individual actor and with that more opportunities to interact.
At the *triadic* level, based on arguments of *balance theory*, the social influence among triadic friendship ties might also be a factor, that influences tie sustainability. Holland/Leinhardt (1970) showed in their study that if *a* chooses *b* as a friend (a -> b) and *b* chooses *c* as a friend (b -> c), then *a* will choose *c* as a friend as well (a -> c).
Furthermore, the *small world* phenomenon is becoming conceptualized in many network studies. Based in the network dynamics literature, Milgram found that everyone is connected to everyone else by a maximum of six degrees of separation (Milgram, 1967; Watts, 2003; Watts & Strogatz, 1998). From a sustainability point of view, these findings might suggest that there is an informal pressure for stable relationships. This is due to the fact that when new contacts are added to a personal network and overlapping ties are identified, former relationships might become revisited over time („ ... oh what a small word!").
Bridges connect otherwise disconnected areas within the overall network and therefore span a structural hole between two disconnected areas (Burt, 2002). Burt shows in his study on relationships among bankers that bridges tend to d*ecay* and *dissolve* quicker than other ties over time (Burt, 2000; Burt, 2002). Only actors, who are more experienced with building bridging ties, are able to maintain and sustain bridging ties over time.

2.4 Content-related characteristics

Depending on the *content* of a network relationship, frequency of interaction is changing over time and therefore influences the sustainability of ties. Cummings/Higgins (2006) found that ties that are high in psychosocial support have a higher emotional closeness than career ties. Therefore, ties that are more emotion-loaded are more likely to be strong and stable.
Earlier work by Granovetter (1982; 1983) and Marsden/Campell (1984) show that emotional intensity and intimacy of tie content leads to more frequent interaction and longer durations of communication (*strong ties*). In contrast, content that is based on temporary overlapping interests, formal affiliation, or extrinsically motivation tends to create rather weaker than stronger ties.

3. Difference between online and offline network ties

In the course of the last two decades, research on social networks has spread from sociology into various new disciplines such as political science (Mintrom & Vergari, 1998; Reinicke, 2000), information and computer science (Butler, 2001; Mesch & Talmud 2006), organization science (Ahuja & Carley, 1999; Attewell, 1992; Cross & Sproull, 2004; Hansen, 2002; Pennings & Harianto, 1992), management science (Hansen, Mors, & Løvås, 2005; Moran, 2005; Rodan & Galunic, 2004; Uzzi & Lancaster, 2003; Zaheer & Bell, 2005) and recently even natural sciences, such as physics or biology (Barabasi, 2002; Newman, Barabasi, & Watts, 2006; Newman, 2004; Watts, 2003; Watts et al., 1998). Scholars increasingly apply social network methods to understand how ties between individuals and organizations affect the behavior of the connected actors or how structural and relational characteristics of such ties affect the actor's performance.
The pool of interesting literature is vast. Although the notion of individual or organizational networks is omnipresent in the literature, the particular focus of each study is slightly different. It is therefore very interesting to classify existing studies into distinct social network categories. Therefore, we developed the following network typology:

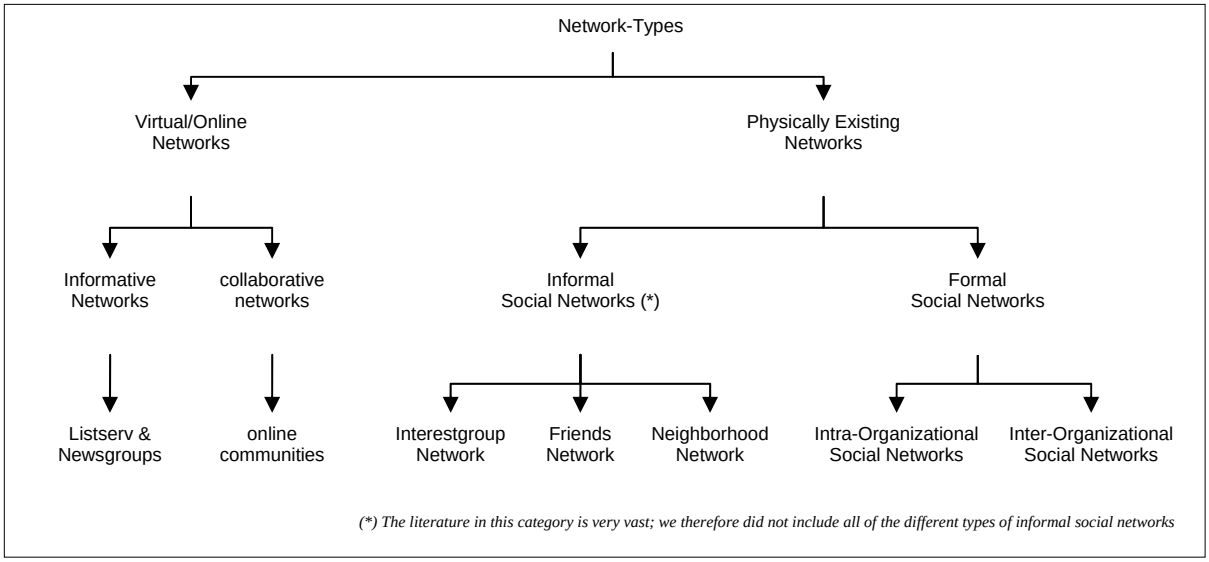

Figure 1: A Typology of Social Networks

We identify two main types of social networks: *virtual/online* and *physically existing social networks*.

3.1 Physically existing networks

We found empirical evidence for two distinct types of physically existing networks, namely *formal* and *informal social networks*. While formal social networks are mostly conceptualized in an organizational context, informal social networks are mostly studied in the context of interaction among individuals with respect to friendship, common interests, or health issues.

3.1.1 Formal social networks

In the last twenty years, substantial work has been done regarding formal social networks. Especially in the field of management and organization science, scholars have intensively studied inter- and intra-organizational networks.

With respect to *inter-organization networks*, social network analysis is a persistent theme in the literature on alliances (Gulati, Nohria, & Zaheer, 2000; Rindfleisch & Moorman, 2001; Rowley, Behrens, & Krackhardt, 2000), interfirm collaboration (Ahuja, 2000; Owen-Smith & Powell, 2004; Uzzi, 1997), capability development (McEvily & Marcus, 2005), and knowledge management and learning (Powell, Kogut, & Smith-Doerr, 1996; Uzzi et al., 2003). Across research streams, scholars utilize structural and relational network constructs to examine the determinants of performance in a particular setting. Along these lines, structural network characteristics are mostly associated with the process of sourcing, sharing, and transferring mission-critical resources, such as information, knowledge, or skills. Furthermore, studies found network structure to be a good predictor of access and control over network partners. Relational network characteristics such as trust or closeness are used to explain interfirm differences in sharing and transferring complex and hard to codify knowledge or skills, which eventually influences organizational performance.

With respect to *intra-organizational networks*, scholars examine how individual action and interaction affects performance of the organization as a whole. Valuable contributions have been made in the area of the effects of social capital on firm performance (Moran, 2005; Subramaniam & Youndt, 2005), the effects of tie characteristics on knowledge transfer (Hansen, 1999), the effect of embeddedness on task effectiveness (Gargiulo & Benassi, 2000), and the effects of intra-organizational social networks on decision making (Cross & Parker, 2004) or career progression (Ibarra, 1993, , 1995). In comparison to inter-organizational studies, research on intra-organizational networks has a slightly stronger focus on the relational aspect of interaction among individuals. Constructs such as social capital or network embeddedness emphasize not only the structural configuration of an individual's network of personal and professional relationships. It also emphasizes the relational aspect of engaging in a broader social network.

We therefore define formal networks in the context of this paper as connections among actors (individuals, departments, firms, etc.) that are created intentionally based on contractual or hierarchical requirements.

3.1.2 Informal social networks

Scholars are studying informal social networks in the context of marketing (Brown & Reingen, 1987), entrepreneurship (Renzulli, Aldrich, & Moody, 2000; Ruef, 2002), communication (Uzzi et al., 2003), or social studies (Bian, 1997; Rulke & Galaskiewicz, 2000; Shah, 1998). The overarching theme in the literature is the examination of how social network characteristics can help individuals to achieve a personal goal.

Brown and Reingen (1987) for instance study social network characteristics and word-of-mouth referral behavior. They find that weak ties foster the flow of general information through the network, while strong ties are mostly activated for the flow of referral information. In a similar vein, studies on entrepreneurial networks show that knowledge heterogeneity in a social network and diverse ties to potential business partners are important determinants of how successful small business can be established (Renzulli et al., 2000; Ruef, 2002). Building on Granovetter's (1973) theory on the strength of weak ties,

scholars provided empirical evidence of how well tie strength or structural network characteristics support job search in different cultural, geographical, and institutional environments (Bian, 1997; Shah, 1998).
We define informal social networks in the context of our research as spontaneous, context-driven and voluntary communication among actors and the consequences of their ties (Festinger, 1950). Informal ties cross formal hierarchies are independent from official or formal report paths and routines. They can be more effective, especially in exceptional circumstances in which unexpected problems have to be solved and where the formal ties are not helpful any longer. They can allow unconventional and sometimes quicker access to network resources. Informal social structures are often not as obviously visible as the formal structure because of their more complex nature and different types of network ties – moreover, actors themselves might not be aware of them themselves.
The following table shows an exemplary classification of formal and informal types of network ties:

Formal network ties	Informal network ties
Workflow network ties	Friendship/kinship network ties
Advice network ties	Trust network ties
Report network ties	Hindering network ties
Expressive/instrumental network ties	Information network ties

Table 1: Formal and informal network ties (Mergel, 2005, p.37)

3.2 Virtual and online networks

Research on virtual and online social networks seems to be less developed than research on physically existing networks. However, with the rise of information and communication technologies, online social networks have increasingly gained interest among social network scholars.
Although the distinction is not so straight-forward and open for discussion, we propose to distinguish between *informative* and *collaborative* virtual/online networks. Our proposition draws on prior work regarding computer networks (Wellman et al., 1996), eMail networks (Haythornthwaite & Wellman, 1998), and general information exchange groups such as discussion groups or listservs (Butler, 2001).
Informative networks refer to information sharing and knowledge transfer networks (Dodds, Sheridan, Roby, & Watts, 2003). A central web-based platform lists discussion topics and information updates in a chronological manner. Network members visit the platform regularly and extract the information that is most valuable for them. Although discussion and interaction takes place among network members, the major concern of the individual is to extract valuable insights, information, or knowledge. Research shows that members of this kind of online community are most likely to have strong ties and a functioning social network in the real world (Matel & Ball-Rokeach, 2001). The more an individual is embedded in a physically existing social network, the more likely he will find the same or similar people in an online social network. However, the internet becomes an additional source of information and, as such, an add-on to the real world social network (Haythornthwaite, 2002).

Some studies find that with the rise of new platforms and online tools, individuals increasingly use the Internet as a venue to create new relationships. Such relationships can be both personal as well as professional (Mesch et al., 2006). Similar to offline social networks, homophily in terms of shared interests are among the core drives of online relationship development. In contrast to informative online networks, we use the notion of collaborative virtual/online networks to account for the high degree of interactivity, which is embodied in such platforms. Prominent examples of how the Internet helps individuals to build and maintain new contacts online are platforms such as *myspace.com*, *openBC.com*, or *match.com*. The ultimate target of engagement on such platforms is to get in touch and interact with new acquaintances that might become real-world friends and relationships over time.
In summary, researchers are starting to examine social networks in the context of virtual/online networks, which have been proven to be functioning in physically existing networks before. With respect to ties and tie strength for instance, earlier work has found that there are no significant differences between virtual ties and online ties. As a matter of fact, online ties are much weaker than ties that have been established in a real-world setting. Along these lines, it is suggested that virtual/online social networks, which are built on real-world connection among individuals, are sustainable, while virtual/online social networks that are mostly established on the web need much more time, effort, and commitment of its members to keep them up and running (Butler, 2001).

4. Understanding sustainability in online social networks: A research framework

In the next section of this manuscript, we construct a research framework, which address the study of online ties sustainability. At first, we derive propositions regarding the sustainability of online ties. Each phase is characterized by a specific outcome and graphically represented in form of sustainability factors.

4.1 Factors influencing sustainability of online ties

Drawing on the existing literature, we found that most studies focus on one specific phase in the lifecycle of a relationship between network actors, namely *the maintenance of an existing tie*. However, we think that the life span of online ties in general and the four different phases of sustainability in particular need to be studied on a longitudinal basis. We therefore suggest to look at four distinct phases in the lifecycle of an online tie: (1) *creation of new online ties*; (2) *maintenance of existing online ties*; (3) *disconnection or abandonment of existing ties*, and (4) *reconnection with former ties*. In the remainder of this section, we construct propositions for each phase. The propositions are developed based on existing studies and the qualitative insights from the authors' prior work. Some of the propositions are exploratory in nature, because of lack of existing research in this field.

4.1.1 Phase 1: Online tie creation

During the creation phase new contacts are added to the existing online network. Both situational and contextual factors are most likely to effect the a) self-initiated and b) requested addition of new online ties.

Personal characteristics and the creation of online ties

During the creation phase, *personality traits* might less hinder the voluntary and progressive action of adding new "friends" to a personal online network: the virtual environment makes it easier for actors to overcome introversion which might hinder active initiation of contacts in offline contexts. A greater *anonymity* and a lower level of commitment make it easier to create a tie (and also to disconnect it). Moreover, the *non-committal context* of online networks is facilitated by the fact that most of the time, online ties do not have a face-to-face component: all other rules of communication are usually neglected (such as orthography, synchronicity of responses, etc.). Another important factor is age. Different stages in the life cycle of each person moderate the creation, maintenance, dis- or reconnection of online ties. Moreover, the context and content people are interested in at different ages will have an impact on their behavior towards the four phases of creation, maintenance, dis- and reconnection of online ties:

Dimension	Factor	#	Proposition
Personal characteristics	Degree of extroversion	Proposition_1	In comparison to introverted individuals, extroverted individuals are more likely to self-initiate online ties.
		Proposition_2	In comparison to extroverted individuals, introverted individuals are more likely to be invited to create an online tie.
	Average age of the network members	Proposition_3	The propensity to create online ties varies across age groups.
		Proposition_4	The higher the difference in age between two actors, the lower the propensity to establish an online tie.
	Average life cycle stage of network members	Proposition_5	The propensity to create online ties is more likely within life cycle stages than across life cycle stages.
		Proposition_6	Maturity in the lifecycle has a negative effect on the propensity to create new online ties.

Dyadic characteristics and the creation of online ties

The second dimension of sustainability refers to dyadic characteristics of online ties. We can distinguish between completely new ties, which did not exist before and *pre-existing face-to-face ties*, which are converted into online ties. Preexisting ties increase the pressure to reciprocate online and face the challenge of peer pressure – not connecting or keeping in contact online might result in offline conflicts.

Adding new ties to a personal network can also be triggered by *homophily*: Shared interest in a specific topic initiates participation in online social networks: over time, when interaction creates common online experience, the creation of online ties is much more likely.

Dimension	Factor	#	Proposition
Dyadic characteristics	Degree of common interests among network members (friendship)	Proposition_7	The more two individuals share common interests, the higher the likelihood to create online ties.

Dimension	Factor	#	Proposition
		Proposition_8	Individuals, who are already connected through offline ties, have a higher likelihood to create online ties with each other.
	Degree of shared norms and common understanding among network members (homophily)	Proposition_9	Individuals, who share common norms and have a common understanding regarding a distinct activity, action, or event , have a higher likelihood to create online ties.

Structural characteristics and the creation of online ties

Besides personal traits and dyadic characteristics, structural characteristics also affect the creation of online ties. For instance, we can see the application of the *small world phenomena* more clearly in the context of online social networking: „The experience of meeting a complete stranger with whom we have apparently little in common and finding unexpectedly that we share a mutual acquaintance is one with which most of us are familiar – „It's a small world!" we say." (Dodds et al., 2003:493).
In addition, formalization of online social networks as well as the embeddedness of network members affects the creation of online ties. Rather formalized online networks resemble organizational forms and tend to reduce an individual's tendency to connect to random people[1]. Furthermore, individuals who are already highly embedded in an online community will become less likely to increase their number of online ties. In contrast, highly connected individuals will be more likely to be contacted through other network members, who want to create an online tie with an embedded member:

Dimension	Factor	#	Proposition
Structural characteristics	Ease of access to the network	Proposition_10	The easier it is for individuals to access online social networks, the easier is it to create online ties.
		Proposition_11	The easier it is for individuals to create an online tie, the more likely network members connect to random individuals.
	Degree of formalization of the network	Proposition_12	Increasing formalization of the online social network reduces the frequency with which network members create novel online ties.
		Proposition_13	The degree of formalization has a negative effect on each member's propensity to connect to random individuals.
	Embeddedness of network actors	Proposition_14	The more an actor is embedded in his/her network, the less likely it is that he will self-initiate the creation of online ties.
		Proposition_15	The more an actor is embedded in his/her network, the more likely it is that he will be request to connect with other actors

[1] See the example of *aSmallWorld.net*, where random connections to other individuals are not appreciated.

Content-related characteristics and the creation of online ties

The last dimension, which affects an individual's tendency to create online ties, is the content of the tie. We identified two factors, *emotional load* and *degree of formalization*, which influence and individuals propensity to connect online.

Dimension	Factor	#	Proposition
Content-related characteristics	Degree of emotion load of ties	Proposition_16	In comparison to individuals where the emotional load of an offline connection is low, ties with higher degrees of emotional loading are more likely to be replicated in online social networks.
	Degree of formalized content	Proposition_17	The higher the degree of formalization of online tie content, the less likely is that individuals create self-initiated online ties.
		Proposition_18	The higher the degree of formalization of online tie content, the more likely is that individuals create requested online ties

4.1.2 Phase 2: Maintaining online ties

Making the effort of staying in contact is highly dependent on the *frequency and intensity of contact opportunities*. More intense overlapping interests trigger the potential of possibilities to reconnect now and then, so that ties are kept alive and revisited. These are in turn affected by factors such as overlapping interest (homophily) or the pressure by third parties to *reciprocate* (joined friendship or formal ties). Retaining online ties even after the original reason why a tie was created dissolves might not be as important as at the time of the creation. It is therefore important to understand how the maintenance of online ties is being affected by the different sustainability factors.

Personal characteristics and the maintenance online ties over time

When it comes to maintaining online ties, personal characteristics are important. Maintaining an online tie requires effort and willingness to stay connected. We argue that extroversion, age, and *lifecycle stage* affect the likelihood of a network member to maintain an online tie in a very distinct manner.

Dimension	Factor	#	Proposition
Personal characteristics	Degree of extroversion	Proposition_1	Extroverted network members will be more likely to maintain online ties over time than introverted network members
		Proposition_2	Online ties between extroverted members are less likely to be maintained over time, thsn online ties among introverted network members.
	Average age of the network members	Proposition_3	Member age is negatively related to the propensity to maintain online networks over time.
		Proposition_4	Increasing age difference between network members is negatively related to the

Dimension	Factor	#	Proposition
			propensity to maintain online ties over time
	Average life cycle stage of network members	Proposition_5	Increasing maturity among network members is positively related to the member's propensity to maintain online ties over time
		Proposition_6	Increasing age difference between network members is negatively related to the propensity to maintain online ties over time

Dyadic characteristics and the maintenance online ties over time

We argue that dyadic characteristics are the second important factor to answer the question of how network members maintain online ties over time. Common interests, shared norms, and a common understanding among network members ensure that online ties can be maintained over time:

Dimension	Factor	#	Proposition
Dyadic characteristics	Degree of common interests among network members (friendship)	Proposition_7	Friendship among network members increases their likelihood to maintain an online tie over time.
		Proposition_8	Common interests among network members increase their likelihood to maintain an online tie over time.
	Degree of shared norms and common understanding among network members (homophily)	Proposition_9	Shared norms and a common understanding with respect to a particular event, action, or activities among network members increases their propensity to maintain an online tie over time.

Structural characteristics and the maintenance online ties over time

We think that structural characteristics of an online social network will also influence the likelihood of an individual to maintain an online tie over time:

Dimension	Factor	#	Proposition
Structural characteristics	Ease of access to the network	Proposition_10	The lower the entrance barriers to access a social network, the higher the likelihood to maintain his online ties over time.
		Proposition_11	Network complexity decreases an individual network member's propensity to maintain his online ties over time.
	Degree of formalization of the network	Proposition_12	The lower the degree of formalization, the higher the likelihood to maintain his online ties over time.
	Embeddedness of network actors	Proposition_14	The lower an individual network member's degree of embeddedness within his/her social network, the lower the likelihood to maintain his online ties over time.

Content-related characteristics and the maintenance online ties over time

The content that is exchanged through online ties also affects an individual network member's propensity to maintain the tie over time. In case the content is valuable and of high importance to the member, he will put more effort into tie maintenance and vice versa. We therefore derived the following propositions:

Dimension	Factor	#	Proposition
Content-related characteristics	Degree of emotion load within tie	Proposition_15	The higher the emotional load of an online tie, the higher the likelihood o maintain the tie over time.
	Degree of formalized content	Proposition_16	The higher the degree of formalization of an online ties, the higher the likelihood to maintain the tie over time.

4.1.3 Phase 3: Decay of online ties

Ties which are exclusively maintained online and do not have a face-to-face equivalent are characterized by a non-committal nature. Low pressure to reciprocate makes it relatively easy to replace or disconnect online ties. Moreover, the extent to which actors can potentially create new online ties is theoretically unlimited, so that it is easy to compensate for decaying ties. The mere variety and extent of access to thousands of potential contacts on a social networking platform might add to the low commitment to once created online ties.

Personal characteristics and abandonment of online ties over time

The decay of online ties is a function of the efforts network members invest into the maintenance of a tie. In consequence, personal characteristics of network members can have a significant impact on the willingness to interrupt or disconnect from ties, so that they decay over time:

Dimension	Factor	#	Proposition
Personal characteristics	Degree of extroversion	Proposition_1	Extroverted network members are potentially over-connected and therefore more likely to abandon ties over time.
		Proposition_2	Introverted network members are potentially less connected and therefore less likely to abandon ties over time
	Average age of the network members	Proposition_3	The younger and the less committed a network member is, the more likely it is that he will abandon ties over time
	Average life cycle stage of network members	Proposition_4	Lifecycle stage is negatively related to a network member's propensity to abandon online ties over time

Dyadic characteristics and abandonment of online ties over time

We think that the decay of online ties is also a function of the characteristics of the tie between two network members. The more both members have in common the less likely it is that the tie will decay over time. We formulate our propositions respectively:

Dimension	Factor	#	Proposition
Dyadic characteristics	Degree of common interests among network members (friendship)	Proposition_5	The higher the degree of common interest among network members, the less likely they will abandon online ties over time.
		Proposition_6	The higher the reciprocity between network members, the lower the likelihood that they will abandon online ties over time
	Degree of shared norms and common understanding among network members (homophily)	Proposition_7	The more network members share norms and understanding the less likely they will abandon online ties over time.

Structural characteristics and abandonment of online ties over time

Structural characteristics can also contribute to abandoning online ties over time. When navigation and interaction becomes fairly complex, the network members might loose their incentive over time. Keeping all other factors equal, increasing complexity would thus be positively related to the decay of online ties.

Dimension	Factor	#	Proposition
Structural characteristics	Ease of access to the network	Proposition_8	The easier the access to the online network, the less likely is the decay of online ties.
	Degree of formalization of the network	Proposition_9	The higher the degree of formalization of an online network, the less likely it is that network ties will abandoned their ties over time.
	Embeddedness of network actors	Proposition_10	In comparison to less embedded network actors, highly embedded actors are more likely to abandon online ties over time.

Content-related characteristics and abandonment of online ties over time

Similar to the case of tie maintenance, the content of an online tie can become a critical determinant. The more valuable the content transferred through a network tie, the less likely a member will abandon this tie over time:

Dimension	Factor	#	Proposition
Content-related characteristics	Degree of emotion load within tie	Proposition_11	The higher the emotional load of a tie, the less likely is the abandonment of the tie over time.
	Degree of formalized content	Proposition_12	Degree of formalization of the tie content is negatively related with the propensity of a member to abandon the tie over time.

4.1.4 Phase 4: Reconnecting former online ties

Online social networking platforms provide people with the opportunity to find (long lost) friends, even though factors such as life events, geographic location, and profession might have contributed to the former disconnection of ties. Websites such as Stayfriends or openBC allow users to find former colleagues, friends, students and follow their professional career. However, the propensity to reconnect with former online ties is contingent on some of the sustainability factors, which we have outlined earlier.

Personal characteristics and the reconnection with former online ties

Reconnecting with prior acquaintances requires time and effort. Personal characteristics are therefore important determinants to understand the propensity of a network member to reconnect with former ties:

Dimension	Factor	#	Proposition
Personal characteristics	Degree of extroversion	Proposition_1	The more extroverted an actor, the higher the likelihood to reconnect with former (online and offline) ties.
		Propostion_2	The more introverted an actor, the more likely it is to reconnect with former online ties.
	Average age of the network members	Proposition_3	The older a network member, the more likely it is that he will reconnect with former online ties.
	Average life cycle stage of network members	Proposition_4	Increase maturity in the lifecycle of a network member increases the member's propensity to reconnect with former online ties.

Dyadic characteristics and the reconnection with former online ties

As we have seen in the previous three phases of online tie creation, maintenance, and decay, dyadic characteristics are important for the tie. We suggest that also in the phase of reconnecting with former contacts common interests, shared norms and understand support the willingness to rethink the reasons for disconnection and support the reconnection with former online ties:

Dimension	Factor	#	Proposition
Dyadic characteristics	Degree of common interests among network members (friendship)	Proposition_5	The higher the degree of common interests between two network members, the higher the likelihood of each of the member's to reconnect with his former online tie.
	Degree of shared norms and common understanding among network members (homophily)	Proposition_6	The higher the degree of shared norms and interests between two network members, the higher the likelihood to reconnect with his former online tie.

Structural characteristics and the reconnection with former online ties

Structural characteristics of an online social network influence a network member's propensity to reconnect with former online ties. The easier it is for network members to identify and connect with former online ties, the higher the member's willingness to revisit the tie:

Dimension	Factor	#	Proposition
Structural characteristics	Ease of access to the network	Proposition_7	The easier the network access, the higher the likelihood of a network member to reconnect with former online ties.
	Degree of formalization of the network	Proposition_8	The more formalized a network is, the lower a network member's propensity to reconnect with former online ties.
	Embeddedness of network actors	Proposition_9	The higher the degree of individual embeddedness, the lower the likelihood to reconnect with former online ties.

Content-related characteristics and the reconnection with former online ties

The content of former network ties can embody important information or knowledge for a network member. Therefore content of a former online tie is positively related to the propensity of a network member to reconnect:

Dimension	Factor	#	Proposition
Content-related characteristics	Degree of emotion load within tie	Propostion_11	The higher the emotional load of a tie, the higher the likelihood to reconnect with a former online tie.
	Degree of formalized content	Propostion_12	The more formal the content of a former online tie is, the less likely it is that a network member reconnects with a former online tie.

4.1.5 Overview: Effect of sustainability factors on the online tie lifecycle

The following table provides an overview of how each sustainability factor influences the different phases in the lifecycle of an online tie:

		Phase_1 Creation	Phase_2 Maintenance	Phase_3 Decay	Phase_4 Reconnection
Personal characteristics	01 Degree of extroversion	**+/-**	**+/-**	**+/-**	**+/-**
	02 Average age of the network members	**-**	**-**	**+/-**	**+**
	03 Average life cycle stage of network members	**-**	**+**	**-**	**+**
Dyadic characteristics	04 Degree of common interests among network members (friendship)	**+**	**+**	**-**	**+**
	05 Degree of shared norms among network members (homophily)	**+**	**+**	**-**	**+**
	06 Degree of common understanding among network members (homophily)	**+**	**+**	**-**	**+**
Structural characteristics	07 Ease of access to the network	**+**	**+**	**-**	**+**
	08 Degree of formalization of the network	**-**	**+**	**-**	**-**
	09 Embeddedness of network actors	**-**	**-**	**+**	**-**
Content-related characteristics	10 Degree of emotion load within tie	**+**	**+**	**-**	**+**
	11 Degree of formalized content	**+**	**+**	**-**	**-**

Table 2: Overview Propositions

4.2 The sustainability canvas: a tool for comparative analysis

We draw on the previous two sections to create the *sustainability canvas for social networks*. In Section 2, we have identified four main dimensions according to which sustainability of social networks can be determined. Each dimension contains a set of factors, which we use to characterize the sustainability of online ties.

Dimension	#	Factor
Personal characteristics	1	Degree of extroversion
	2	Average age of the network members
	3	Average life cycle stage of network members
Dyadic characteristics	4	Degree of common interests among network members (friendship)
	5	Degree of shared norms among network members
	6	Degree of common understanding among network members
Structural characteristics	7	Ease of access to the network
	8	Degree of formalization of the network
	9	Embeddedness of network actors
Content-related characteristics	10	Degree of emotion load within tie
	11	Degree of formalized content

Table 3: Sustainability factors

By measuring each factor on a Likert-Scale (e.g. low relevance, medium relevance, high relevance), we can develop an understanding of how relevant each factor is for the sustainability of online ties. By examining each factor, we construct a curve for each social network under study. The following graph depicts a theoretical example.

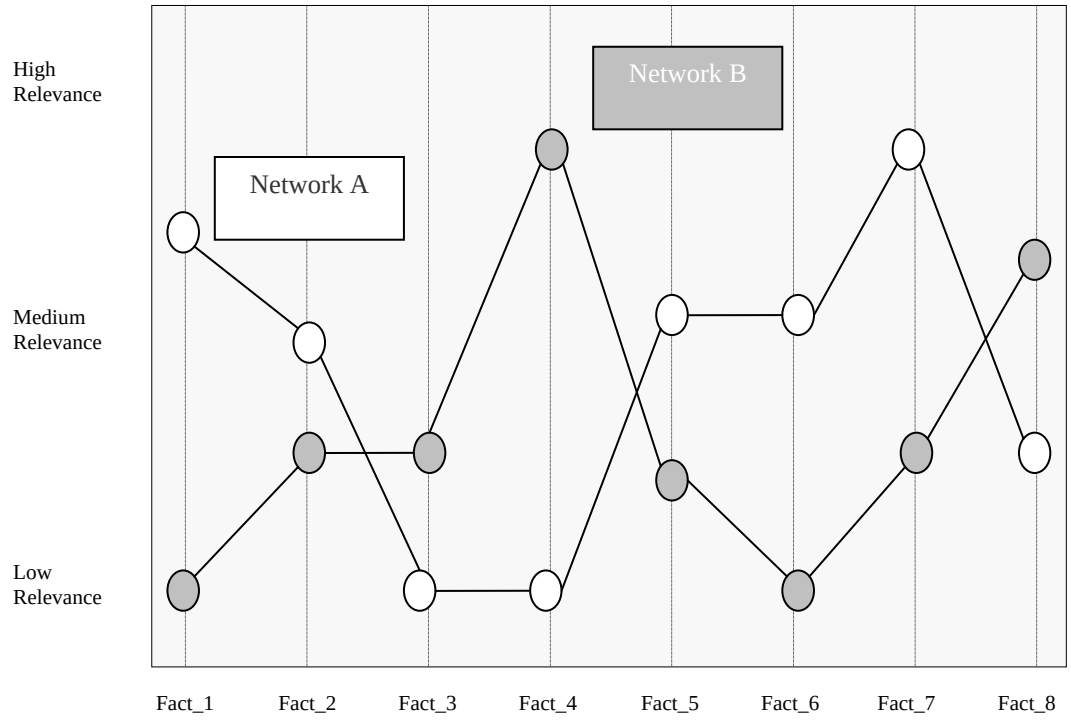

Figure 2: The Social Network Sustainability Canvas

The sustainability canvas curves help to understand the key determinants of online ties sustainability. By plotting multiple curves within one diagram, the network analyst will be better able to understand why some social networks will be more sustainable than others.
The essence of the sustainability canvas is to study the relative sustainability of online ties in comparison to online ties in another setting. Relative sustainability in this context refers to the relevance of factor A in network A in comparison to network B. While for instance the degree of extroversion is more relevant for actors in an offline social network, extroversion plays an only minor role in online social networks (Ellis, 2003; Kavanaugh, Carroll, Rosson, Zin, & Reese, 2005). Building on the resulting curves, the sustainability canvas helps to distill sustainability patterns for each type of social network.

5. Research Design

The last section of our manuscript outlines the research design, which we attempt to pursue in order to study online tie sustainability. We will collect both qualitative and quantitative data test the hypotheses derived in section 4. A summary of the steps is shown in Figure 3 below:

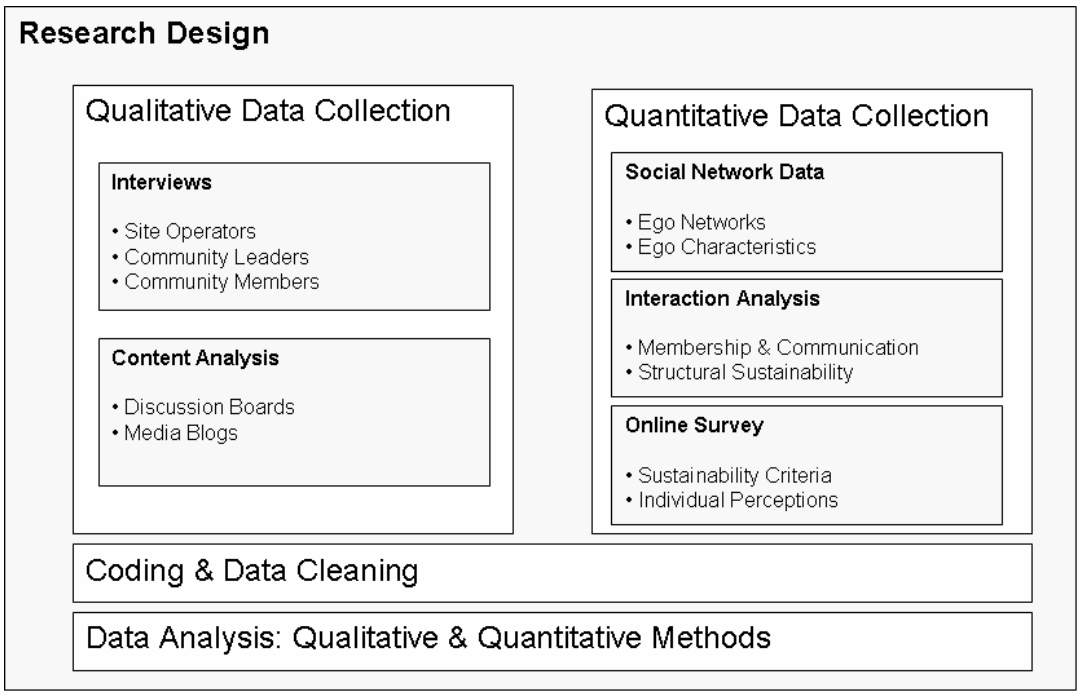

Figure 3: Research Design

5.1 Data Collection – Online Social Networks

Our research design builds on a mixed data collection approach. We apply qualitative and quantitative data collection methods to examine the sustainability of online ties. We build on prior research in the domain of online communities and online social networking (Haythornthwaite et al., 1998; McWilliam, 2000; Wang & Fesenmaier, 2004).

5.1.1 Qualitative data collection

In the initial data collection phase, we will collect secondary data about the studied social network platforms and add in-depth insights using interviews. We have identified two main targets for the interviews: a) site operators and b) community members.

Site Operators: We will conduct interviews with the operators of the online networking site in order to get a deeper understanding of the community's scope. This will also help to understand the original purpose of founding the network, get background information on the historical development, understand the initial idea of the business model and how new network members are recruited, and what kind of efforts are pursued by the operators themselves to ensure online tie sustainability. The interviews will be semi-structured with a strong focus on social network sustainability.

Community Members: We contact community and sub-group leaders and ask them about their individual strategies to create, maintain, and interrupt/cut network ties and when they make the decision to reconnect or revisit former ties. In addition, we interview community members to understand how the community is being perceived by the individual members and especially what kinds of networking activities are conducted.

5.1.2 Content analysis of interactions

We focus on two main sources for qualitative data regarding user interaction: discussion boards and member blogs.
Discussion boards are valuable sources of information regarding information exchange and knowledge creation (Lakhani & von Hippel, 2002). We build an analysis scheme, which draws on prior research and input from the operators and users of the respective online networking site (Crowston & Howison, 2005). A discussion board is a subset within the overall network with a clear boundary. Data will be collected from the interactions on a discussion board and includes: a) all actors who are either actively posting messages (= whole network), b) interactions in the format of responses and answers by members who react to a posted message, and c) the content of the interactions.
Blogs are useful sources of information regarding personal characteristics and profiles of community members. When available, we analyze the front page of a blog in order to collect information about the member, emotive features, identity, and gendered language. We will use content analysis to create language scores for tone, semantic features, and content of a blog (Huffaker & Calvert, 2005). Besides textual media, blogs can also be composed of interactive media such as photographs or videos.

5.2 Quantitative data collection

We follow a three step process to collect quantitative data and test our hypotheses. First, we conduct a social network analysis of each online networking site (*social network data collection*). This helps us to understand the individual-level structure of the community. In a second step, we analyze the interaction among members on rather quantitative basis. We measure community size and activity level in order to derive conclusions with respect to community sustainability (structural analysis of member interaction). The third step comprises an online survey, where we address questions regarding each member's behavior within the community (online survey). In so doing, we attempt to establish a robust quantitative basis for understanding sustainability of online ties. We use structured questionnaire items to identify (1) personal characteristics, (2) community behavior, and (3) networking behavior (Franke & Shah, 2003).

5.2.1 Social network survey

We administer an online survey instrument in order to collect data for the analysis of online ties. We address each characteristic from section 2 in a set of survey items. The goal of the survey is to develop a sustainability curve for each online social network, which we are going to examine. The items in the survey draw on our research framework, which we outlined in section 5.2.2.
In collaboration with the operators of each online networking site, we will construct a network database, which helps us to visualize the relational evolution of each online social network (Moody, McFarland, & Bender-deMoll, 2005). We attempt to collect the following network data:

Items	Description
actorID	The actorID helps us to identify each node in the overall community network
registerDate	The registration date helps us to identify the age of each network node. It furthermore helps us to understand the evolution of the online social network
networkTies	We collect all the actorID's who the community member under study is connected to
evolutionTies	Ideally, we also get access to the evolution of the ties, which means that we will be able to track when ties between members are becoming created or deleted.
nodeDemographics	We also collect demographic information about the actor from each website. This helps us to construct control and dummy variables for subsequent analysis.

5.2.2 Operationalization of the sustainability research framework

To understand the perceptions of each individual actor on the social networking platform, we collect behavioral data including the frequency of interaction and seek to find seminal moments and types of interactions which trigger creation, rejection/abolishment and reconnection of online ties.
We operationalize the sustainability canvas by defining an evaluation and assessment scheme for each sustainability factor. We use the factors listed below as indicators that will help us to predict the frequency and intensity of repeatedly revisited ties:

Factor	Format	Operationalization
Degree of Extroversion	7 Item-Likert Scale	How open is the network member towards meeting new people (offline vs. online)? (1) very open → (7) completely closed (by invitation/recommendation only)
Average Age of the Network Members	Observed	a) What are the formal access regulations with respect to members' age? b) What is the age range of contacts being added by members within their network?
Average Life Cycle Stage of Network Members	Numeric answer 7 Item-Likert Scale	a) What is the stage of life-cycle of each member? b) How relevant is the life-cycle stage for members to generate the maximum value possible from the network? (1) not relevant at all → (7) highly rele vant
Degree of common interests among network members (friendship)	Selection of purposes + open 7 Item-Likert Scale	a) What is the main objective of the social network? b) To what extent do network members share a common interest? (1) very little → (7) very much
Degree of shared norms among network members (homophily)	7 Item-Likert Scale	To what extent do network members share common norms? (1) very little → (7) very much
Degree of common understanding among network members (homophily)	7 Item-Likert Scale	To what extent do network members share a common understanding on how to network? (1) very little → (7) very much
Ease of access to the network	Enumeration of potential access restrictions (1-…)	What are access restrictions?

Factor	Format	Operationalization
	7 Item-Likert Scale	How easy is it for network members to access the network? (1) very easy → (7) very hard
Degree of formalization of the network	7 Item-Likert Scale	a) To what extent is the interaction among network members formalized and/or regulated? b) How high is the barrier for the individual to engage in the network? (1) extremely low → (7) extremely high
Tie Content	7 Item-Likert Scale	How much does the transferred content among ties determine the sustainability of the network? (1) very little → (7) very much
Structural Embeddedness of Network Actors	7 Item-Likert Scale	How important are structural characteristics for network actors with respect to (a) degree centrality (1) not important → (7) very important and (b) ego network density? (1) not important → (7) very important

Table 4: Sustainability Evaluation Scheme

5.3 Planned data analysis procedure

We decided to approach this project using an integrated data collection and analysis procedure, where the results of the first qualitative study will inform the data collection of the second quantitative study (Creswell, 2003). Depending on the insights we draw from the interview data, we will reformulate our theoretically driven quantitative questionnaire. Based on the results of both studies, we will conduct in-depth interviews with selected network actors. We see strength in this iterative design and triangulation approach: by linking qualitative and quantitative data, we will get deeper insights into the field and anticipate generalizable results.

5.3.1 Transcription of interview and discussion threads content

The qualitative interviews will be transcribed in order to prepare the content for analysis. We code the content of the interview and discussion data in order to extract patterns and common themes. The results will inform the items and language of the theoretical concepts of the network questionnaire.

5.3.2 Structural analysis of member interaction

In this step, we test our hypothesis with the collected data. For each online social networking site, we will select a stratified random sample of discussion boards, which represent a variety of topical focuses and member populations. Within the population, we will control for the technological infrastructures and whether or not the forums are mechanically functional. We will collect information on membership count, communication activity, and connectivity among members daily during the sampling period. We measure membership size by counting the number of community members in a forum at the beginning of each month during the sampling period. We will measure communication volume by counting the

number of messages exchanged within the forum. Sustainability is measured in terms of monthly member gain or member loss (Butler, 2001).
The network data will be re-codified from the "download-format" into an "analysis format" and mainly used to compare observed vs. perceived behavior.

6. Challenges, limitations and open questions

We see challenges in different parts of our research design, which also highlights the limitations of the suggested research methods and leave us with some open questions, which need to be answered before starting with our data collection.
The challenges and open questions are listed below and we would like to encourage discussion on the following questions:

- Did we include all relevant sustainability factors or did we forget important factors that have explanatory power?
- The examination of sustainability is crucial to our research. It is therefore very important to address all relevant factors right from the outset.
- What type of online social networks should be included in our data collection?
- When it comes to comparing tie sustainability across online networks, it might be important to use network sites, which are somehow similar. Also, to generalize our results it might be useful to pursue a consistent sampling strategy.
- What should our sampling strategy look like?
- With respect to theoretical sampling, we need to clearly delineate network boundaries: what are relevant actors and what is the network's subset that holds our analysis requirements (external validity)?
- What type of analysis software should we use?
- Will we be able to use existing software to address our research questions, and are tools such as UCINET or PAJEK feasible tools to implement our research design? With the described research design, will we be able to limit the network boundaries to a format/extend that is still analyzable for standard social science software tools?
- What about our qualitative / content based analysis strategy, do we have the right approach?
- Is the presented approach to analyze blog content and discussion threads an appropriate approach to extract content of the ties and interactions?
- Quantitative data collection: What are appropriate ways to extract quantitative network data?
- We attempt to collect network data from both qualitative and quantitative sources. During our interviews we want to extract network relevant information. Furthermore, we want to download network data from the online network sites. Are there any experiences or is there some knowledge available?

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