Socio-Technical Interaction Networks: A Discussion of the Strengths, Weaknesses and Future of Kling's STIN Model

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Abstract. The Socio-Technical Interaction Network (STIN) strategy for social informatics research was published late in Rob Kling's life, and as a result, he did not have time to pursue its continued development. This paper aims to summarize existing work on STINs, identify key themes, strengths, weaknesses and limitations, and to suggest trajectories for the future of STIN research. The STIN strategy for research on socio-technical systems offers the potential for useful insights into the highly intertwined nature of social factors and technological systems, however a number of areas of the strategy remain underdeveloped and offer the potential for future refinement and modification.

Keywords: Social informatics, Socio-Technical Interaction Networks, STIN, Rob Kling

1 Introduction

Kling, McKim, & King's [2003] article on electronic scholarly communication forums is Kling's attempt to detail the assumptions and use of what he called the Socio-Technical Interaction Network (STIN) methodology. This STIN strategy is an elaboration of Kling's earlier web models [Kling, 1992; Kling & Scacchi, 1982] designed to give social informatics and other researchers a tool for understanding socio-technical systems in a way that privileged neither the social nor the technical. Unfortunately, Kling's untimely death in 2003 left the STIN strategy without its prime evangelist. Other researchers, however, are taking up the STIN strategy in an attempt to more fully test and develop the concept.

This paper is organized in the following manner. First is a discussion of Socio-Technical Interaction Networks (STINs) and their salient features. Next is a discussion of some of the studies that have used STINs in a variety of settings. Third, the methods used in STIN research are discussed. Next is a discussion of the

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weaknesses and limitations of STINs. Finally, the paper concludes with some thoughts for the future of STIN research.

2 Theory

2.1 Similarities and Differences between Bijker, Latour and Kling

Kling's STIN approach [2003] is "an emerging conceptual framework for identifying, organizing, and comparatively analyzing patterns of social interaction, system development, and the configuration of components that constitute an information system" [Scacchi, 2005:2]. The STIN model is a more fully developed version of what Kling earlier [Kling, 1992; Kling & Scacchi, 1982] referred to as web models:

Web models conceive of a computer system as an ensemble of equipment, applications and techniques with identifiable information processing capabilities…as an alternative to 'engineering models,' which focused on the equipment and its information processing capabilities as the focus of analysis, and formal organizational arrangements as the basis of social action. [Kling, 1991]

The STIN approach draws both on the Social Construction of Technology (SCOT) approach associated with Bijker, Pinch and others, and on Actor-Network Theory (ANT), which is associated with Latour, Law, Callon and others. While these approaches are related, they are not identical. All are approaches which help to understand the role of social behavior in the of creation and use of technological artifacts, and all reject technological determinism as being too simplistic [Bijker, 2001:15523]. SCOT is particularly interested in the social construction process, wherein relevant social groups establish technological frames which help to understand the interpretive flexibility of artifacts and help to move toward a state of closure or stabilization [Bijker, 1995, 2001; Callon, 1987; Pinch & Bijker, 1987]. ANT can be viewed as a subset of SCOT, when SCOT is broadly defined [Bijker, 2001]. ANT adds a number of elements to other SCOT research, including the idea that non-human actants can have agency [Hanseth, Aanestad, & Berg, 2004; Latour, 1988], and that the closure discussed in SCOT results in black-boxing artifacts after a process of translation and enrollment [Callon, 1986]. The processes by which translation and enrollment occur are particularly important they help to explain some of the 'how' and 'why' questions raised by SCOT as various social groups come into contact and, potentially, conflict as they construct technology. As we will see below, the STIN approach differs from ANT in being much more conservative in attributing agency to non-human actants, is more prescriptive than SCOT or ANT, and focuses on patterns of routine use more frequently than patterns of adoption and innovation. The STIN approach is consistent with SCOT and ANT, however, in the sense that the identification of relevant social groups, understanding interpretive flexibility, and examining processes of translation and enrollment are crucial to developing a STIN model.

2.2 Socio-Technical Interaction Networks (STINs)

The STIN approach emphasizes that "ICTs do not exist in social or technological isolation" [Lamb, Sawyer, & Kling, 2000]. According to Kling:

Several fundamental assumptions underlie the application of the STIN methodology, and drive the methods used to construct STINs. These assumptions include [1] the social and the technological are not meaningfully separable…, [2] Theories of social behavior…should influence technical design choices…, [3] system participants are embedded in multiple, overlapping, and non-technologically mediated social relationships, and therefore may have multiple, often conflicting, commitments…, [and 4] sustainability and routine operations are critical. [Kling et al., 2003:56-57]

The first assumption, that the social and technological are not meaningfully separable, should be familiar to those familiar with the theoretical approaches of SCOT [Bijker, 1995; Pinch & Bijker, 1987] and ANT [Latour, 1987; Latour & Woolgar, 1979; Law, 1999], particularly ANT's concept of actants that can be human or non-human participants in a socio-technical system. The STIN approach extends SCOT and ANT, however, by problematizing information technologies and making the "association between STS [Socio-technical systems] concepts and IS research [which] is often not explicitly articulated as such in contemporary literature" [Lamb et al., 2000:1]. One of the major differences between Latour's and Kling's approached is that "Latour theorizes about how new technologies come to be; Kling and Scacchi theorize about how new technologies come to be used" [Orlikowski & Iacono, 2001:126]. The STIN approach is also less committed to ANT's concept of 'radical indeterminacy' [Hanseth et al., 2004; Latour, 1988] and is "much more conservative in attributing action to nonhuman agents" [Kling et al., 2003:66].

Kling argues that this integrated concept of socio-technical systems is more useful than the more common use of the term socio-technical to argue merely that technologies have consequences for social and organizational behavior. This highly intertwined nature of the social and the technical is central to the STIN approach.

The second and fourth assumptions reflect a normative element of the STIN approach. Arguing that theories of social behavior should influence technical design choices and that it is critical to consider the sustainability of socio-technical systems both reflect Kling's background in computer science and concern for social issues. This differs from SCOT, which does not generally concern itself with such prescriptive concerns, and also differs from ANT, which is much more theoretically oriented, to the extent that even ANT's methodological prescriptions are primarily methods of analysis and not methods of collection [Bowden, 1995]. While Kling did not reference the Technology Assessment (TA, or *Technikfolgenabschätzung*) literature, his interest in improving future technological systems based on outcomes of STIN research is consistent with TA's emphasis on influencing policy and communicating the results of socio-technical studies with a wider audience [Mohr, 1999].

Kling's third assumption regarding the multiplicity of social relationships and commitments for system participants is the key to understanding the contribution STIN makes to research into change in socio-technical systems. This ecological element of the STIN approach looks beyond the socio-technical system under study and also examines how other portions of an actor's social world are connected to

their use and understanding of technology. Thus, when analyzing the physics pre-print online server arXiv.org, a STIN model includes not just authors, readers and file servers, but also institutional linkages, funding models, the non-technical social responsibilities of authors, the nature and size of research collaborations, and the socio-political behavior of arXiv's founders [Kling et al., 2003; Meyer & Kling, 2002].

Another concept that Kling was also involved in developing ties in with the STIN framework, the social actor concept as an alternative to the concept of technology users: "A social actor is an organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry. In short, social actors are not primarily users of ICTs" [Lamb & Kling, 2003:218]. The social actor concept allows for analysis of less computer-intensive professionals who nevertheless routinely use information and communication technologies (ICTs) which shape what they do, how they perceive themselves and others, and how they interact with others. They are influenced by their affiliations, environments, interactions and identities as they shape and are shaped by ICT use [Lamb & Kling, 2003].

2.3 STIN Studies

Despite its relatively recent introduction, the STIN approach has been used to study a growing number of IT topics, including scholarly communication forums [Kling et al., 2003], democratization of scholarly publishing [Meyer & Kling, 2002], web information systems [Eschenfelder & Chase, 2002], online communities [Barab, Schatz, & Scheckler, 2004], digital libraries [Joung & Rosenbaum, 2004], and free/open source software developers [Scacchi, 2005]. A common element of these studies is that all not only deal with complex social systems, but that the STIN approach is used to explain the complexity rather than reduce it to overly simplistic terms. This is one way that the STIN approach shares a common view with both SCOT and ANT; all three approaches reject simplistic, positivistic explanations for complex social systems all too common among more mainstream sociological approaches [Star, 1988]. One way this complexity is addressed in the STIN approach is that many of the studies include STIN diagrams, graphical representations of the relationships between various elements within the STIN, including technologies, human actors, institutions, relationships, roles, and other relevant elements.

Kling et al. [2003], in their main article laying out what they call the STIN 'methodology', examined electronic scholar communication forums (e-SCFs) including arXiv.org, Flybase, ISWORLD, and CONVEX. Among the conclusions offered in the article are that technological developments themselves will not overcome issues embedded in the social contexts into which the technologies are introduced. Fast connections and good interfaces, they argue, would not have caused medical researchers to support PubMed Central, since the primary reasons for their non-support were based on long-standing institutional arrangements and the vested interests of gatekeepers and various interest groups[1]. They also found that for the e-SCFs, understanding the business models of the supporting organizations was necessary for understanding the STIN, and that understanding the social relationships embedded in the STIN helped to understand how the technological innovations of electronic publishing are used and sustained.

Scacchi [2005] uses STINs to understand Free and Open Source Software Development (F/OSSD). Scacchi argues that STINs have formed most clearly in four areas: joining and contributing to F/OSSD, building communities of practice, coordinating projects, and co-evolving systems for F/OSS. These STINs are not independent of one another, but interdependent and overlapping. Scacchi argues that using STINs to understand F/OSSD is particularly appropriate since the F/OSS developers are only loosely connected through a fragile web of alliances and communities, and thus the social connections within the STIN are often as important as the technological innovations of the software in explaining how well the web of relations for any given F/OSS project holds together over time.

In Scacchi's article, STINs are treated as entities that independently arise in the world, and that researchers are then able to uncover using the STIN 'conceptual framework' (in his terms). This is a somewhat different approach that Kling et al. [2003] took in which the analysts constructed STIN models that were somewhat simplified views of reality. This underscores one of the confusing aspects of STINs: are STINs entities that occur in the world, or are they models that reflect patterns of organization in the world?

Eschenfelder & Chase [2002] use the STIN 'framework' as a *post hoc* 'heuristic tool' (again, their terms) to understand web information systems at four large U.S. manufacturing companies. A key finding in this study was that some nominally peripheral actors, such as order fillers and professional peer groups, were key players in the success and use of the web IS. The various players identified in the research participated in the social construction of web IS by lobbying for configurations most suited to their needs, with the interests of some groups inevitably being privileged over those of other groups.

Barab et al. [2004] use STINs to understand the Inquiry Learning Forum (ILF), a web-based forum for math and science teachers. One important aspect of this article to note is that it combines STIN explanations with a theoretical perspective (activity theory) drawn from the authors' main field of education, an approach they argue synergistically "provides a richer view of the design activity and community functioning than either can offer in isolation" [p. 27]. This points to one aspect of STIN research, and social informatics in general, that is worth noting. Social informatics is both by circumstance and design a transdisciplinary approach [Lamb & Sawyer, 2005] that offers researchers perspectives that can be applied to studying technology in a variety of settings, particularly when the more traditional fields studying various groups have not adequately problematized technology in their domain. So, in the case of education where technology may be viewed as a simple phenomenon, social informatics and STIN offers a way to bring the technical more into consideration in an educational socio-technical system.

Meyer & Kling [2002] use STINs to examine arXiv.org, the electronic pre-print archive for physics and math research papers and to examine the claims of the Standard Model (as evidenced by numerous claims by arXiv's founders) that the resource served as a democratizing influence in scientific research. Using analysis of the authors posting articles to arXiv.org over time, Meyer & Kling find that the resource is not functioning as a leveling resource, at least with regards to authorship, and use a STIN model to explain how other social factors limit who publishes articles to arXiv.org.

Joung & Rosenbaum [2004] argue that it is possible to distinguish between successful and unsuccessful STINs in their discussion of whether the Library of

Congress' American Memory Project was widely used. Although they don't fully engage the question of what it means for a technical system to be successful, this raises a point for those interested in STINs: are they to be judged as successes or failures, and by what criteria? It is important, of course, not to exclude failed STINs, or even technology-implementation attempts that failed to develop any sort of sustainable network, from our analysis. Failures can be telling, often more so than uncomplicated successes [Brown & Capdevila, 1999; Markus & Keil, 1994; Suchman, 1996].

3 Methods

3.1 STIN Methods

Kling et. al. [2003] identify a list of heuristics for researching STINs that is meant to be illustrative rather than enumerative. These steps constitute a method for modeling a STIN. The eight steps are:

1. Identify a relevant population of system interactors
2. Identify core interactor groups
3. Identify incentives
4. Identify excluded actors and undesired interactions
5. Identify existing communication forums
6. Identify resource flows
7. Identify system architectural choice points
8. Map architectural choice points to socio-technical characteristics [Kling et al., 2003:57]

Some of these steps share elements with SCOT and ANT, but with important differences. For instance, Kling is careful to point out that while identifying the relevant interactors is similar to ANT's following the actor, in STIN research the analyst also attempts to understand the ecology of the interactors before undertaking the field work to identify likely interactors and, in step 2, likely groups of interactors. Step 3 involves understanding incentives (and thus, potential motivations) for interactors.

Step 4 is an important but often overlooked step in other types of socio-technical research – identifying actors who are left out of the socio-technical system and interactions that are undesirable to interactors. In most network diagrams, these actors and interactions would exist only in the white space between nodes and connections, but may play a key role in influencing the system's outcomes. Step 5 involves examining communication systems, which ties back into the communication regime framework discussed at the beginning of this paper. Step 6 can be thought of, according to Kling, as 'following the money.'

The last two steps are what allows STIN researchers to analyze social change in socio-technical systems. By examining choice points where alternatives are available to interactors within the STIN, the analyst can map those choice points onto the socio-technical characteristics of the STIN identified in the earlier steps of the research.

In reality, STIN research tends to also create a 'Standard Model', which is then subsequently disassembled. Kling et al. [2003] discuss in great detail the Standard

Model of e-SCFs, which includes beliefs in easy and ubiquitous access, low costs of production, and fast publication leading inevitably to widespread adoption of e-SCFs by scholars who will come to see the value of these technological systems and alter their behavior accordingly. Joung & Rosenbaum [2004], argue that the Standard Model of the American Memory Project focuses on the technology needed to digitize historical materials and create search interfaces, and "assumes that if digital libraries adopt these processes, they will have been constructed successfully, independent of the types of libraries and fields to be serviced by them" [p. 30]. Eschenfelder & Chase [2002] identify a range of studies that contribute to the Standard Model of web IS research[2], which views post-implementation processes as essentially an "orderly logical process unaffected by social phenomena", studies that "overlook the wide array of social influences continually shaping web IS" [p. 2].

This raises a point: if there is no Standard Model, no widely accepted understanding of technology held by those within the system and those operating within disciplinary boundaries, does the STIN approach work? Does using STINs require something to demolish? More importantly, is it engaging in the construction of straw men? I would argue that this is not the case. Instead, the creation of a Standard Model is both part of the critical perspective inherent in social informatics research [Lamb & Sawyer, 2005] and part of the storytelling that makes the arguments more accessible to the transdisciplinary audience for STINs.

Storytelling was one of the tools Kling used in his research, in his public speeches, and in his teaching. Many is the time that he would listen to several people debating a topic and then cut in with "Look, it is a simple story…" and then proceed to tell a compellingly simple story that also incorporated elements of complexity in the data that made his story seem more plausible than the 'common-sense' explanation that was dominating the public discourse on a topic[3]. This storytelling approach is inherent in how he chose to explain STIN research. First, set up a story about what 'everyone believes,' present data that draws these beliefs into question, and then tell a better story that incorporates social realities with technological features to better incorporate the available data.

4 Discussion

4.1 STIN Weaknesses and Limitations

One of the weaknesses of STIN that must be acknowledged is that to date it has mainly been adopted by close colleagues and former students of Rob Kling. If the STIN strategy is to have any longevity either in information science or in other fields that use the transdisciplinary approach of social informatics, it must be cited, used, modified and extended. Actor-Network Theory, for instance, has achieved widespread use beyond its initial audience in science and technology studies. Even ANT, however, did not achieve instant success. The earliest complete explanation of ANT is probably 'Science in Action' [Latour, 1987]. While this work has been cited over 2000 times by the end of 2005 according to the Social Science Citation Index, in the first two years after its publication it had been cited on a comparatively modest 38 times. Kling's main STIN paper [Kling et al., 2003] has been cited in 10 published articles by the end of 2005, and in a number of other unpublished

manuscripts and conference papers, some of which have been discussed in this paper. One test will be to see whether this number increases in the coming years.

Robbin [2005] has argued that Kling's publication record in general did not "create, (re)construct, or extend theory, or create new methodologies for understanding the empirical world of computers in organizations" [p. 23]. Instead, Robbin argues, Kling took a practical approach to appropriating theory and method as necessary to explain computerization in organizations and to build a corpus of empirically-based research that "made the unobvious, the taken-for-granted, and the ignored explicit, problematic, and visible" [p. 24].

As might be obvious from the discussion of selected STIN studies above, there is some lack of clarity regarding the language of STINs. STINs are described as a methodology [Kling et al., 2003], a type of entity [Barab et al., 2004; Scacchi, 2005], a framework [Barab et al., 2004; Eschenfelder & Chase, 2002; Scacchi, 2005], and a *post hoc* heuristic tool [Eschenfelder & Chase, 2002].

I would like to suggest that a better term to describe STIN research is to refer to the 'STIN strategy'. It is fairly clear that STIN does not reach the level of theory, nor is it a proper methodology. What I would like to suggest is that STIN is really an analytic strategy. No particular methods are tied to STIN research; in fact, STIN research, like most of social informatics, is wide-ranging in the selection of specific methods that can be used to gather the data necessary to construct STIN explanations at the analytic level.

I suggest the term STIN strategy is appropriate in the sense that a strategy is a goal-oriented plan of action. The goal in this case is to find more complete explanations and thorough understandings of the relationship between the social and the technical in socio-technical systems. Strategies are ways of going about things. STIN diagrams can help visualize relationships and important network nodes, but they are not a method in and of themselves. The STIN strategy leads to choosing particular methods, to favoring certain kinds of understandings about the world, but maintains the overall social informatics open-mindedness towards a variety of methods, and a preference for multiple method approaches to research questions. The STIN strategy is really an analytic perspective based on a strategic way of seeing the world. It is a strategy of approach, research problem selection and analysis, not a strategy of method.

At meetings of social informatics researchers, it has been remarked that in some sense we study the hyphen in socio-technical systems, the area where the connections between social organizations (as studied by sociologists and political scientists) and the technological artifacts (as studied by computer scientists and engineers) lie. Kling argues that "the STIN model shares the views of many socio-technical theories: that technology-in-use and a social world are not separate entities—they co-constitute each other. That is, it is fundamental to STIN modeling that society and technology are seen as 'highly' (but not completely) intertwined" [Kling et al., 2003:54].

One of the main concerns that has been expressed to me by several people in personal communications about the STIN strategy is whether a system that embodies both people and technology can be demonstrated <u>not</u> to be a STIN. In other words, is the notion that a system can be analyzed using the STIN strategy amenable to the null hypothesis that system X is not a STIN for reasons Y and Z. If this is not the case, then everything involved with technology becomes a STIN, and thus weakens the argument that STINs actually shed light on particular sorts of behaviors and

institutional arrangements. This is not, in my mind, a resolved issue, and is an area where I hope that future research will strengthen the STIN strategy.

Some of the weaknesses of STIN, while not published, have been discussed informally among social informatics researchers. For instance, the STIN strategy's inherently organizational bias limits its ability to deal with the broader non-organizational social implications of technology. Another limitation that STIN shares with social informatics research in general stems from its use of a variety of methods: "combining the need for extensive data collection with the complex conceptualizing of socio-technical phenomena means it is a difficult methodological toolkit for many scholars" [Sawyer, 2005:12]. This also points to another STIN limitation: the ability to successfully identify and analyze STINs is heavily dependent on the skill of the investigator at eliciting information from respondents and gaining access to individuals and organizations.

4.2 Future of STIN studies

A primary test of using STINs as a research and analytic strategy is whether scholars begin to adopt, test, modify, and extend the strategy in their studies. While some of Kling's close colleagues and former students are pursuing the STIN strategy, there has not yet been much adoption beyond this. It is hoped that this paper as well as research that the author is currently pursuing to refine and extend the STIN strategy for his dissertation on the use of digital photography will contribute to the further development of the STIN strategy.

The next step for the STIN strategy is to rigorously test it against empirical data. There are key questions researchers doing this should ask. First, is the STIN strategy falsifiable? Can it be shown that there are boundaries beyond which the STIN strategy fails to be useful? What types of problems exist within those boundaries? In other words, what is the appropriate STIN problem space? Second, for the problems that exist within the STIN problem space, is the STIN approach the most fruitful way to understand the problem at hand? What does the STIN approach offer that other, more widely adopted approaches cannot offer? What kinds of problems within the problem space are most amenable to STIN research?

A third challenge is a practical one necessary if more researchers are to be enrolled into using the STIN strategy: to more clearly articulate the methods and tools one would use to undertake a study using the STIN strategy. While it is not desirable to have a simplistic approach that involves plugging data into a rigid framework, at the current time the STIN strategy is probably too nebulous to attract the interest of new researchers and graduate students who may understandably be drawn to more concrete approaches. Part of this challenge is more clearly defining the terminology related to the STIN strategy. For instance, as mentioned above there is confusion over whether STINs are entities that occur in the world, or are models that reflect patterns of organization in the world. In other words, does one *uncover* a STIN that exists independently of the analyst, or is a STIN a model *constructed* by an analyst to better understand the world?

Sawyer & Tapia [2005] argue that while theory building is desirable in the extension of a new field like social informatics, a "more modest approach is to focus on developing, demonstrating and exporting analytic approaches…to bring theory and evidence together" [p. 13] and cite the STIN model as an example. The STIN

strategy allows for a nuanced examination of socio-technical systems by integrating the social and the technical, and provides a useful addition to SCOT's focus on case studies of mutual shaping and ANT's methods of following the actants, opening blackboxes, and examining inscriptions. STIN's inclusion of the social roles of interactors beyond their roles specific to the socio-technical system under analysis, the ability to track social actors whose roles are not primarily technical, an attention to excluded actors and undesirable interactions, and a focus on the importance of social change in socio-technical networks all make STIN a worthwhile addition to the social studies of technology and social informatics literature. Together, these approaches offer a set of analytic concepts and tools for studying technology in society.

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Notes

[1] This case is more thoroughly described in Kling, Spector, & Fortuna [2004].

[2] However, the authors don't actually use the term 'Standard Model' in their paper.

[3] An example that springs to mind came during the early days of collapse of Enron. The public explanation for Enron was that a bunch of greedy people let their greed overcome their common sense: the "bad apple" version of events. Rob felt that this was too simple and pat. Instead, he offered an alternate story that incorporated an understanding of the system of accounting rules, technological features within the corporate and government oversight system, and policy choices to understand how Enron came to fail. This broader point of view is now easy to find in discussions of Enron, but Rob was quite early in thinking in a systematic way about this issue. [Kling, R., personal communication, ca. 2001].