Exploring the Workplace Communication Ecology

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ABSTRACT

The modern workplace is inherently collaborative, and this collaboration relies on effective communication among coworkers. Many communication tools – email, blogs, wikis, Twitter, etc. – have become increasingly available and accepted in workplace communications. In this paper, we report on a study of communications technologies used over a one-year period in a small US corporation. We found that participants used a large number of communication tools for different purposes, and that the introduction of new tools did not impact significantly the use of previously adopted technologies. Further, we identified distinct classes of users based on patterns of tool use. This work has implications for the design of technology in the evolving ecology of communication tools.

Author Keywords

Communication, Collaboration, Computer Mediated Communication, Phone, Email, Instant Messaging, Blogs, Wikis, Face-to-face, Evaluation

ACM Classification Keywords

H.5.3 Group and Organization Interfaces.

General Terms

Human Factors.

INTRODUCTION

Effective communication is a critical component of successful collaboration. It enables collaborators to foster ideas, to build common ground, and to develop complex interpersonal relationships [5, 12, 30]. As new communication technologies emerge, their use is becoming increasingly common in the workplace. The office is no longer just telephone, email and FAX. CSCW researchers have studied successful use and adoption of instant messaging/chat [13, 16, 19], virtual worlds [1], social networking sites [2, 28, 10], Twitter [32], wikis [8, 20, 21] and blogs [11, 15] in the workplace, and have found them to be beneficial.

With the wide variety of technologies in use, workers are building their own ecologies of communication technologies, with each technology fulfilling a specific role, allowing different expression or providing a critical service.

Different tools support different levels of information, expressiveness and context. They provide communicating parties with varying levels of awareness and leave behind differing records of communication acts. Each tool has its own strengths and weaknesses. For instance, email provides a persistent record of its messages, but does not convey non-verbal signals. Face-to-face communication, on the other hand, provides a wealth of information about the communicating parties, gleaned from facial expressions, body language, verbal pauses, and other sources, but generally leaves only an imperfect trace (in participants' memories) of exactly what was said.

In this paper, we seek to characterize the current communication ecologies that workers assemble. We investigate communication practices over a period of a little more than a year, identifying what communication technologies are adopted and how adoption differs for different groups of people. We then build an understanding of why particular tools in a user's ecology are selected and how the tools are used in combination.

Our analysis profiles communication practices at a small company located on the West Coast of the United States. Small companies with fewer than 100 employees make up over 85% of all US companies [31]. We believe that studying and designing communication technologies for small companies poses different challenges than for large companies or universities. Furthermore this demographic is under-represented in HCI research. Unlike studies of large organizations, in a small company a significant portion of the organization can participate in the study, providing a clearer picture of its overall communication pattern. As we discuss later, this allowed us to articulate different classes of users and how each class impacts the company's communication practices.

While there have been many studies of a single specific communication tools in the workplace, we believe that we are one of the first to take a broad view of the communication landscape since the introduction of new communication technologies (e.g. social networking sites, blogs, wikis and virtual worlds). The contribution of this work centers on three main themes: trends in communication practices in the workplace, how different groups of people adopt new technology, and the strengths and weaknesses of technologies in use.

RELATED WORK

The CSCW research community has a rich tradition of investigating collaborative practices of organizations and their members. In this section, we discuss prior work that is

most related to ours, and describe how our research builds from, extends, or differs from past work.

Theoretical frameworks for selecting communication media

One proposed basis for selecting communication media is the richness of the communication channel [7]. Face-to-face is the richest medium since it provides rich feedback, multiple cues such as intonation, body language, language variety, and a personal focus. The media richness theory predicts that communication will be more effective face-to-face than through other media.

However, competing theories point out several shortcomings of the Media Richness Theory. One of them is that people seem to adapt to the communication media [9] and compensate for signals that a channel cannot carry. As a result, it has been hard to prove that seeing a person's face makes a difference in task performance [e.g. 23, 27].

Channel Expansion Theory [3] explains how less rich media can be experienced as richer than predicted by Media Richness Theory. According to this theory, the richness of communication media is not explained as static characteristics of the media, but as an effect of individual knowledge-building experience with the media. The perception of a medium is built on a person's knowledge about the medium and about communication partners, more than on the number of times a person used the medium. The organizational context can also influence the choice of media. For instance, Hinds and Kiesler [14] found that users preferred synchronous communication tools when interacting outside their immediate workgroup and with their superiors, while asynchronous tools were preferred for within-workgroup communication.

A third theory, proposed by Robert and Dennis [26], is built on cognitive models of communication rather than on individuals' subjective experience. This theory adds the dimensions of *motivation* and *ability to process information* to the Media Richness Theory. These two dimensions make it possible to explain why email sometimes is preferred over face-to-face, since it allows the person to process information more deeply than if the same information were given face-to-face. This theory can explain the finding by Kim *et al*. [19] that technical workers favor email for communicating highly technical content.

There are some similarities between the concept of common ground and the Media Richness Theory. Common ground is important for successful communication [5]. Different communication media support establishing common grounds in different ways. Clark and Brennan [4] propose eight different constraints that a medium imposes on communication: copresence, visibility, audibility, cotemporality, simultaneity, sequentiality, reviewability and revisability. Face-to-face supports the first five, while email supports the last two [24]. This theory also can explain why technical workers favored email for technical content. Email would allow them to review and revise the content when it was important for their work.

One problem with media selection theories is that media selection is viewed out of the context of larger ongoing communication in the workplace [29]. One communication act, such as an email or a phone call, is often part of a larger communication context. This context may affect the selection of particular communication media. Neither do the existing media selection theories explain how people take up new communication media.

Interpersonal Connections

Although communication involves multiple people, the role of interpersonal relationships is not well explained in media selection theories. However, several studies have investigated how communication technologies impact interpersonal relationships. Nardi [22] explains that successful interpersonal communication depends on a person's communicative readiness. Many communication technologies, Nardi argues, are not by themselves sufficient for providing this readiness. Thus, combinations of communication media are needed to build the appropriate social bonds, commitments, and attention awareness. Likewise, Olson and Olson [24] found that even with sufficient common ground and well-described responsibilities, distance collaboration suffered when participants were not able to build interpersonal connections.

More specifically, Connell *et al*. [6] studied various communication tools and asked users to rate how well the tools supported interpersonal connections. Not surprisingly, results showed that the choice of communication technology affected interpersonal qualities, such as a collaborator "acting like [one] self" or "behaving as intended."

In our research, we seek to further understand the relationships among modern communication tools and their role in supporting interpersonal connections. Building on past work, we seek to articulate the perceived tradeoffs of using computer-mediated communication technologies in the workplace and how they support interpersonal connections.

Studies of Communication Tools in the Workplace

As new technologies have been introduced, the research community has been quick to study their impact in the workplace. Several studies [13, 16, 19] of instant messaging (IM) and chat have shown wide adoption and value of their use in the workplace. Handel and Herbsleb [13] show IM to be a useful tool for facilitating exchange of technical content as well as a tool for facilitating coordination and building awareness. In a similar study, Isaacs *et al*. [16] emphasized that while IM is predominantly used for casual social interaction at home, such use does not dominate workplace IM use.

Studies of wikis [8, 20, 21], blogs [11, 15], and social networking sites (SNS) [2, 10, 28] have also shown the value of these technologies in the workplace. For instance, Danis and Singer [8] found that an enterprise wiki was a useful clearing ground for shared information. This, in turn, provided greater transparency of organizational content to all stakeholders. Similarly, as described by Efimova and

Grudin [11] and Huh *et al*. [15], blogs have proven to be a useful tool for cross-organizational communication and collaboration within large corporations. Skeels and Grudin's [28] research also showed high use and value of SNS in the enterprise. Workers reported that SNSs were useful for maintaining external professional networks and for creating and strengthening ties with peers. Virtual worlds (VW) have been tried in distributed teams of large organizations. In their work, Bessière *et al*. [1] found that the technological and collaborative readiness was insufficient for wide adoption of virtual worlds.

While these studies provide insight into the value of specific communication tools, none has specifically sought to understand their strengths and weaknesses when used in combination with other communication tools. Our work seeks to identify relationships among everyday tools, and to characterize how they fit into the socio-technical ecology of the workplace in a small organization.

STUDY

To obtain a better understanding of the mix of communication tools people use as well as the tools' strengths and weaknesses, we conducted two surveys a year apart, in May 2008 and 2009. A few months after the second survey, we conducted detailed interviews with a subset of the participants in the 2009 survey. The interviews probed their communication use and history.

The research was conducted in a small US corporation with approximately 50 employees and contractors. All employees of the company are co-located on one floor. The education level of participants ranged from Bachelor's degree to Ph.D.; their age ranged from the late twenties to the late fifties. Participants were all knowledge workers who frequently used computers. They generally worked in teams on several projects at a time, where the project team members varied by project. Some teams included individuals from other organizations, often located in another country.

2008 Survey

The first survey solicited information about the use of various means of communication: face-to-face, telephone, email, physical notes, instant messaging (IM), SNSs, blogs, wikis and virtual worlds. We asked whether each method was used for private life, work, or both, with the exception of wikis, where we asked only about wiki use related to work.

We asked how frequently the methods were used, where responses included Never, Not in the last year, Less than once a month, Monthly, Weekly, or Daily. For some methods, such as instant messaging and social networking sites, we also asked how often they used particular clients. For IM, respondents were asked how frequently they used various features, including text chat, voice chat, video chat, and file sharing. People also had the opportunity to comment on their use of the methods.

The survey was administered in a two-week period. A total of 40 people completed the survey. Participants included 23 researchers, 7 programmers, 3 managers, 2 interns, and 5 administrative employees. Thirty percent of the participants were female.

2009 Survey

Much of the second survey was a repeat of the first one, with some changes and additions. In addition to the information included in the first survey, we asked how often respondents:

- Read information on a project wiki,

- Used canned or customized status messages in IM (both their own and others),

- Read blogs and microblogs (e.g., Twitter), and

- Posted an entry on a work or personal blog, a microblog, or a status on a social networking site.

We updated the clients and features for IM, and applications in virtual worlds to reflect observed frequencies and new options. We also included the category Hourly for frequency judgments.

Further, we made two major additions to the survey. Participants judged whether their use of each feature, client, or communication method decreased, increased or did not change during the past year. In addition, they were asked to provide a few words or phrases that described the strengths and weaknesses of each communication method.

The survey was administered in a two-week period. A total of 32 people completed the survey, of which 27 had participated in the first survey. Participants included 21 researchers, 4 programmers, 4 managers, and 3 administrative employees. Twenty-eight percent of the participants were female.

Interviews

We conducted 23 interviews several months after the second survey. Sixteen of the interviewees were male; 18 had taken both surveys. The interviews covered communication behaviors of the participants, and lasted approximately one hour.

RESULTS

The results of our surveys and interviews are divided into three parts: an analysis of usage trends in communication behavior, an analysis of patterns of behavior across users, and an exploration of the strengths and weaknesses attributed to the tools and how that impacts their use. In our examination of the communication trends, we restricted the analysis to the 27 people who completed both surveys.

Use and Trends in Communication Behavior

The availability of new communication methods does not guarantee that people will use them. To determine adoption of new options and their impact on the more traditional communication methods, we examined the first and second survey to identify usage trends.

We did not expect a significant reduction in the use of traditional communications channels, such as face-to-face, telephone, physical notes, and email. As expected, no differences were observed for these methods over the year (see Figure 1). Use of phone, email and face-to-face
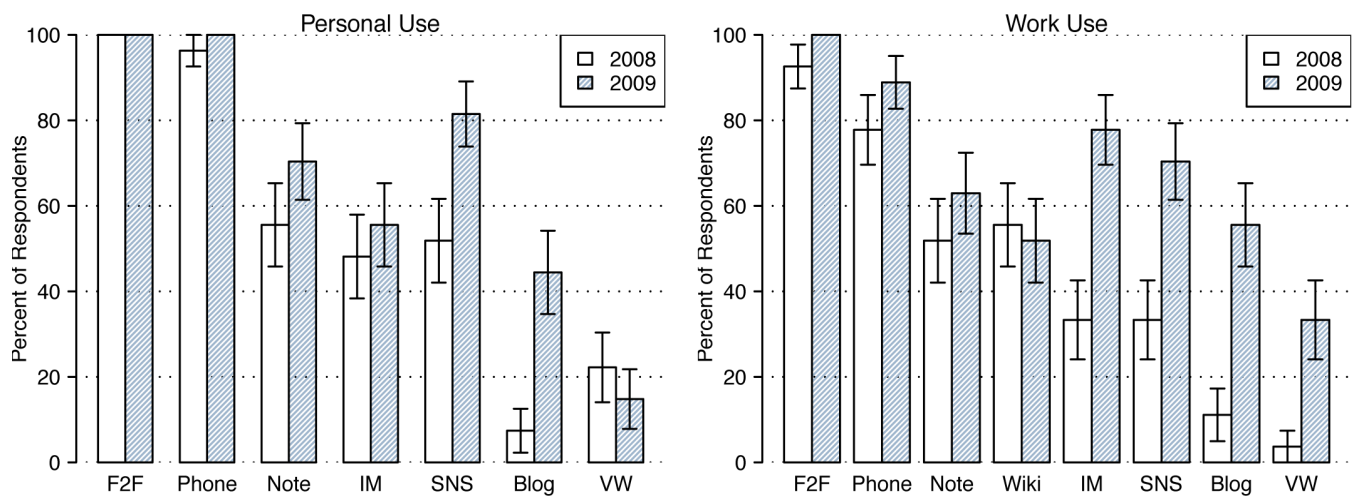
Figure 1. Percentage of respondents reporting the use of each method for personal and work use in 2008 and 2009. All respondents used email for work and personal use, so it has been excluded from the graph.

communication for both personal and work purposes was nearly universal, although phones were used more for personal than for work communication ($F(1, 26) = 8.08$, $p<0.01$). Physical notes were used for communication by about to 78% of respondents, with no difference between the surveys or the aspect of life in which they were used.

With regard to newer communication technologies, more people reported that they used IM ($F(1, 26) = 14.81$, $p<0.001$), SNS ($F(1, 26) = 19.50$, $p<0.001$), blogging ($F(1, 26) = 33.12$, $p<0.001$), and VW ($F(1, 26) = 5.20$, $p<0.05$) in 2009 than had in 2008 (Figure 1). In addition, more people used IM ($F(1, 26) = 7.83$, $p<0.01$) and VW applications ($F(1, 26) = 11.61$, $p<0.01$) at work than in their personal life. The use of wikis did not change over the course of the year.

Respondents indicated how frequently they used each method, ranging from Never to Daily (see Table 1 for frequency of methods). Somewhat surprisingly, people reported more frequent face-to-face communications in 2009 than in 2008. The reported frequency of other traditional communication methods did not increase over this period. Use of IM clients, especially the text chat function, increased dramatically over the year from a median of less than once a month to weekly use. Voice chat and video chat increased as well, but less so, from a median of Never to Less than once a month.

The 2009 survey added questions about IM. Three-fourths of respondents had used IM on their internal IM server with a median frequency of Weekly, but only 15% used it on a daily basis. Eighty percent used IM status for people on their buddy list to be aware of who was on-line, but less than half did so on a daily basis. Two-thirds had set a customized status message at least once. However, more than half did so infrequently, less than once a month.

In both year, people reported making contributions to wikis less than once a month. For those who used wikis in 2009, they read them (median = monthly) more frequently than they contributed to them (median = less than once a month).

Method	Mean (Median) 2008	Mean (Median) 2009	F-ratio
Face to Face	4.5 (Daily)	5.0 (Daily)	8.68 ***
Phone	4.4 (Daily)	4.7 (Daily)	3.11 ^
Physical Note	2.5 (Monthly)	2.9 (Weekly)	ns
Wiki Contribution	1.6 (< Monthly)	1.2 (< Monthly)	ns
Any IM Client	2.6 (< Monthly)	3.6 (Weekly)	13.0 ***
IM F: Text Chat	1.9 (< Monthly)	3.6 (Weekly)	17.9 ***
IM F: File Sharing	0.9 (Never)	1.3 (< Yearly)	3.21 ^
IM F: Voice Chat	1.1 (Never)	1.8 (< Monthly)	6.24 *
IM F: Video Chat	1.0 (Never)	1.6 (< Monthly)	4.64 *
SNS	2.0 (< Monthly)	3.7 (Weekly)	21.7 ***
Twitter	0.9 (Never)	3.0 (Weekly)	15.1 ***
Blog	0.9 (Never)	3.0 (Weekly)	24.3 ***
Second Life	0.3 (Never)	0.6 (Never)	ns

Table 1. Comparison of Frequency of Use of Selected Communication Methods and Clients for 2009 and 2009. Email is excluded, since its frequency was 5 (Daily) for all cases. IM F:IM Feature.
^ indicates p-values <0.1, * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

The survey responses highlighted the trend of keeping up with colleagues, friends and family on social network sites and microblogs. Use of SNS applications rose from less than once a month to weekly over the year. Microblogs, like Twitter, also showed a dramatic increase from a median frequency of Never in 2008 to Weekly in 2009.

From additional question asked in 2009, we found that most people who posted status updates on social networking sites (51%) reported that they posted monthly or weekly, with one person posting daily updates. Close to half of the 2009 respondents use Twitter, with one reporting reading statuses hourly, and five daily. People post status updates much less frequently, however. A quarter of those reading posts had never written one themselves. The median frequency of posting on a microblog was between monthly and weekly.
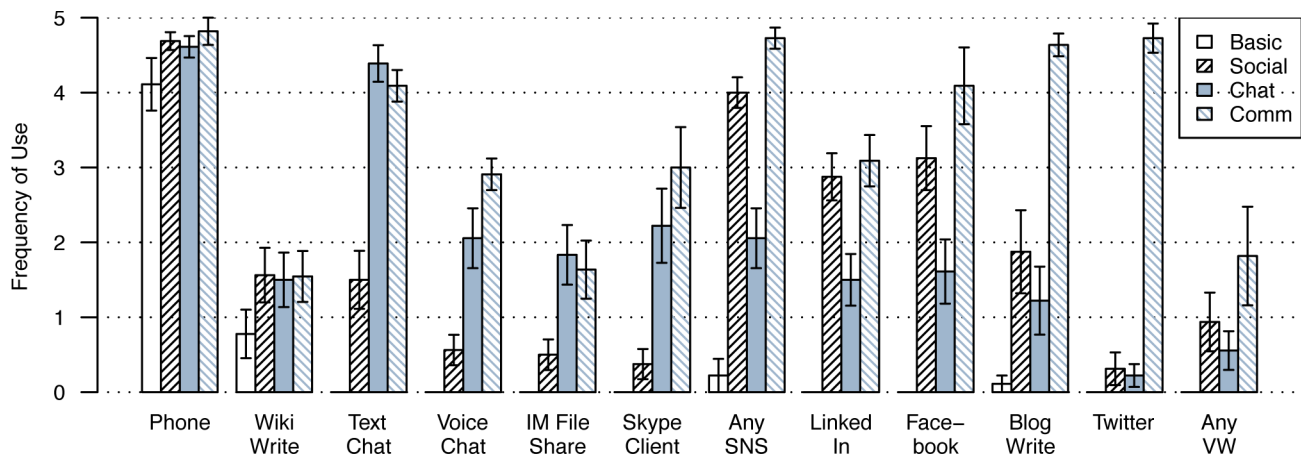
Figure 2. Groups of participants identified by hierarchical cluster analysis show different mixes of communication methods.
0 = Never, 1 = Not in Last Year, 2 = Less than Once a Month, 3 = Monthly, 4 = Weekly, 5 = Daily.

In 2009, nearly 70% of respondents read blogs, generally on a daily or weekly basis. Writing blog entries was less frequent. Only half reported having ever written a blog post on a work-related topic and 37% for personal postings. Work posts were more frequent (median = monthly) than personal ones (median = Less than once a month).

We found no differences in the use of communication methods during the period studied for persons with different roles in the organization or for those with different demographics. Within a small organization, there are fewer instances of certain roles. Although our respondents play a range of roles with varied demographics, some categories have insufficient persons in them to be able to find any meaningful differences, if such differences were to exist.
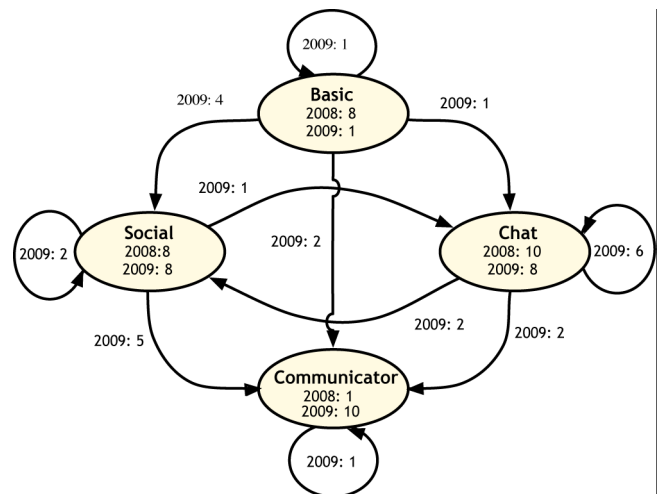
Clusters of Communication Behavior

To examine in more detail how people adopt new communication technologies, we performed a hierarchical cluster analysis using *pvclust* in R [25] on a subset of twenty representative variables common to both surveys. These consisted of the frequency of use for the following: face-to-face communication, telephone, physical notes, wikis, blogs, IM, voice chat, video chat, file sharing using an IM client, SNS, and VW, as well as the use of the following clients or sites: AIM, Google Talk, Skype, LinkedIn, Facebook, Twitter, Second Life, and World of Warcraft. These variables capture the overall use of the different communication tools for an individual as well as their frequency of use. We clustered each user's responses by year, allowing us to analyze how behavior changed over time. We only included data from those who participated in both surveys (n=27). The resulting analysis produced four clusters with good separation. Examining the mix of communication methods used within each cluster (see Figure 2), we can identify the following groups:

- *Basic*. Tends to use face-to-face, email and, to a lesser extent, the telephone, for communication.

- *Social*. Basic plus use of SNSs on a regular basis. May use text chat infrequently.

- *Chat*. Basic plus use of instant messaging on a regular basis. Occasionally uses voice or video chat, SNS.

- *Communicator*. Uses most channels at least monthly, but many weekly or daily, including blogs and microblogs.

Over the year measured in the surveys, we noticed a large movement among the groups (see Figure 3). In 2008, there were eight people in the Basic and Social groups, 10 in Chat and only one in Communicator. One year later, only one person remained in the Basic group. There were now eight each in Social and Chat, and 10 in Communicator. Few people stayed in the same group over the year. People in Basic migrated to Social although a few moved to Chat or directly to Communicator. Those in Social generally moved to Communicator. Chatters were most likely to stay in the same group, but if they changed, they became Communicators. No one moved from Social, Chat or Communicator back to Basic.

All groups contained people with different roles. The Chat group, for instance, contained two programmers, two

Figure 3. Groups of participants identified by hierarchical cluster analysis show different mixes of communication methods and migration paths over time.

researchers and one manager. The distribution of roles over the four groups did not differ significantly ($\chi^2(9)=9.18$, ns.). Hence, the adoption of communication tools does not appear to be related to a person's role in the organization.

To gain further insights about how people in the different groups viewed communication tools, we examined the strengths and weaknesses (data collected in 2009 only) for communication methods by group, excluding the 2009 Basic group since it contained only one person. Communicators used the full set of tools available, and hence they had opportunity to give thought to the applicability conditions for each communication tool. This was reflected in their responses, which were varied, and focused more on nuances and details of the technology than responses from the other groups. As a result, they often did not mention the more basic issues reported by other groups. This effect is often observed in expert-novice studies, where novices spend time explaining the stated problem, while experts don't even mention the obvious information [18].

The insights people had about the characteristics and possibilities of media seemed to differ between the groups. An example of differences between groups can be seen in the reported weaknesses of face-to-face communication. Many in the Basic, Social and Chat groups mentioned as a weakness that people had to be physically co-located for face-to-face communication. Most people in the Social group and a few in the Chat group considered it a weakness that face-to-face communication often took more time. Communicators also brought up the time issue, but did not comment on the co-location problem. We conjecture that this omission was because they thought this problem was so obvious that it did not bear mentioning. Instead, the weaknesses they uniquely considered were scheduling problems, the lack of a conversation record, how differences in social skills affect the quality of the communication, and that it was socially inappropriate to multitask. The comments show that Communicators not only communicated more frequently using a larger set of tools than the other groups, they actively evolved their skills, or (in terms of the Channel Expansion Theory [3]) engaged in a knowledge-building experience, to a higher degree than the other groups.

The Chat group spent as much time using instant messaging as the Communicator group. However, their comments about the weaknesses of IM concentrate on its deficiency for detailed conversations, especially technical ones. On the other hand, the Communicators were concerned with the unreliability of the status information and the amount of typing required. A few people from all groups mentioned the intrusiveness of IM.

The Social group was similar to the Communicator group in their SNS activity. Both groups expressed concern for privacy on these sites. Several people in the Communicator group were concerned about the open, unfiltered atmosphere and the need for privacy settings. People in the Social group commented that there are too many social networking sites and too much information on them. One person in this group commented, "99.7% of the people are definitely NOT my friends." The Chat group had little to say about SNS, other than reporting their unwillingness to share personal information.

These differences among groups with respect to strengths and weaknesses of various methods suggest that the cluster analysis identified useful groupings. Communicators appear to be masters of their communication ecology, choosing an appropriate method based on differentiating features as opposed to choosing the one that is at hand. The migration of people from the Basic group to other categories strongly suggests a progression toward more sophisticated use of the ecology of communication tools over time.

Different Tools for Different Communication Needs

In our direct comparison of the reported frequency of use between the 2008 and 2009 for respondents who completed both surveys, few methods decreased in use, although many increased. To better understand how people assembled their communication ecologies and why new methods were added to their communication toolbox, we performed a qualitative analysis on the strengths and weaknesses collected in the 2009 survey and people's responses to interview questions on their preferred communication method and the considerations they took into account when choosing a communication method.

Summary of Strengths and Weaknesses

Survey responses were coded into five categories: Function, Immediacy, Productiveness-Efficiency, Side Effect and Social Aspect. The category *Function* includes responses about existence of functions. *Immediacy* includes phrases about the speed of response. The *Productiveness-Efficiency* category includes responses that describe effectiveness, efficiency, quality of message and other aspects influencing the usefulness of communication tools. The category *Side Effect* includes responses describing unintended usage or effects of the communication tools, such as "acts as to-do list" for email. Finally, the *Social Aspects* category includes responses that describe social or emotional effects on interpersonal and social relationships attributed to the use of communication tools. All categories except *Side Effect* were subdivided further:

- *Function*: signal range, signal capture/transfer; signal ability, requirement, record, structure;

- *Immediacy*: synchronicity, immediacy, availability;

- *Productiveness-Efficiency*: establishing common ground, quality of message, efficiency, effectiveness, expressiveness, ease-of-use, characteristics, cost, distance matters;

- *Social Aspects*: social characteristics, emotional affect, social affect, preference, privacy.

Categories and subcategories were designed to cover the strengths and weaknesses found in our material. In all, 704 words and phrases were coded, representing 345 strengths and 359 weaknesses. The top sub-categories of every communication channel are shown in Table 2. This table provides insight into the judgments people make when selecting a tool for their needs.

Tool	Strength	Weakness
Face to face	*F: Signal capture* (10): Non-verbal communication, context and nuances *PE: Establishing common ground* (9): easy to check understanding, to create a mutual understanding *I: Immediacy* (7): immediate	*PE: Efficiency* (11): Time consuming *PE: Distance matters* (8): need to be in the same place at the same time
Phone	*I: Immediacy* (14): immediate clarification, feedback and confirmation	*SA: Social affect* (16): causes interruption *F: Signal capture* (9): no non-verbal feedback
Physical Notes	*PE: Easy to use* (7): easy *F: Signal ability/exchange* (6): visually salient shared artifact *F: Record (6):* persistent tangible record *PE: Effectiveness* (6): Good reminder, fallback when other means don't work	*PE: Effectiveness* (17): limited bandwidth, can be missed, easy to lose
Email	*F: Record* (10): Persistent record *I: Synchronicity* (10): asynchronous *PE: Efficiency* (10): fast, efficient *PE: Effectiveness* (8): Carefully compose precise message *SA: Social affect* (7): Non-intrusive, don't cause interruption *I: Immediacy* (6): no need to respond immediately, can delay	*I: Immediacy* (10): long delay, no tight-looped discussion
IM	*I: Immediacy* (9): immediate, instant response *Cost* (7): lightweight	*PE: Establishing common ground* (7): poor awareness, hard to coordinate discussion *PE: Effectiveness* (6): not good for detailed information or large volumes *SA: Social affect* (6): disruptive, intrusive, distracting
Social Network	*PE: Effectiveness* (11): Good method for broadcasting, passive observation of friends' activities *F: Signal ability* (8): connect and keep up with distant friends and family	*SA: Privacy* (7): weak support for managing privacy
Wiki	*F: Record* (7): central shared repository *F: Signal ability* (6): shared open authoring	*PE: Ease of use* (9): hard to edit, difficult formatting language *PE: Effectiveness* (7): disorganized, unused information *SA: Social affect* (7): no one take responsibility for information update
Virtual Worlds	*F: Signal ability* (6): models the physical world	*PE: Ease of use* (10): hard to navigate
Blog	*PE: Effectiveness* (20): find interesting, useful information, trends, niche information	*PE: Quality of message* (10): unreliable, inaccurate, low quality *PE: Effectiveness* (6): too many

Table 2. The top sub-categories of strengths and weaknesses for each communication tool, with the number of words or phrases coed in the category in parentheses. For each sub-category the top category is labelled with the following acronyms: F: Function, I: Immediacy, PE: Productiveness-Efficiency, SE: Side Effect and SA: Social Aspect.

Email, Phone, Wikis and Virtual Worlds showed the largest differences in the number of strengths and weaknesses reported. Participants identified more strengths than weaknesses for Email, but fewer for Phone, Wikis and Virtual Worlds. Phone and email were used daily (Phone: 90% of respondents in 2009, Email: 100%), while Wikis and Virtual Worlds were used much less frequently. In 2009, Virtual Worlds were used by 28% in their work, and wikis were used by 47%. The number of coded weaknesses reflects an overall negative attitude towards these communication media, which was confirmed in the subsequent interviews. Interestingly, both Wikis and Virtual Worlds had many comments on the difficulty of using them (see Table 2). The telephone, on the other hand, is a well-established and well-known communication tool; hence, users were not tempted to report weaknesses in terms of ease-of-use.

Media Choice

From the interviews we found that face-to-face is a preferred communication channel in the studied organization. This is not surprising, as all media selection theories predict a preference for face-to-face. Respondents commented that face-to-face communications is good for relationship building, ideation, problem solving, and for keeping some issues "off the record." These comments resemble findings from other research [24]. A recurrent comment in both the survey and in the interviews was the immediacy of establishing a face-to-face communication: "It's a very small office and I just walk over and talk to somebody, because that is immediate."

Although people use the phone frequently for both private life (2009: 100% of respondents) and work (2009: 90%), many people seemed to dislike using it, as suggested by the large number of weaknesses for this communication tool. In both the survey and the interviews, respondents said

explicitly that they preferred to use other communication channels, such as face-to-face or email. In particular, people resented telephones since they cause interruptions for the recipient, and because the phone lacks non-verbal feedback. In one interview, Alex[1] said, "I feel bad interrupting people, and I don't like being interrupted." Helene elaborated on the intrusions phones cause: "I guess they [the recipients] can *not* take the call, but still they generally do, and it isn't as positive as face-to-face. You have no feedback as to what they're in the middle of."

The quote from Helene indicates something interesting about communication initiation at a smaller organization. The phone is viewed as an intrusive communication channel. People want to be considerate to their communication partners and do not want to interrupt them unnecessarily. When the cost of walking to a person's office and peeking in to gauge a person's interruptability is low, people opt for the walk even for a short simple question. Julia gives an example of this behavior:

> I can look in their office, and if they look busy and if I'm not desperate to talk to them, I'll walk by. I'll come back later. Or maybe I go to my office and write an email, realizing that this is a bad time. So I don't really have that with the telephone. The phone is the phone. I have already interrupted them. Whereas walking by, I haven't interrupted them until I really interrupt them.

The consideration of the state of the communication partner when choosing communication media is not well explained by current media selection theories. However, consideration of the partner's availability was a common theme in the interviews. Some choose to use email as a non-intrusive communication method, in particular for recipients not working on the same project. Others, such as Julia, above and Earl, below, described methods for gauging people's state before initiating a face-to-face communication.

> I got the sense at some point that people use their door in their office to indicate [openness for interruptions]. There's several stages. It's wide open, right, fair game. You know your door's open. If it's half open, then it's like, "bug me if you have to, but if you can find a way not to bug me, that's cool, too." Or it it's closed but not shut, it means "I really don't want you to bug me, but what can I do?" And if it's shut, it means "I'm having a private conversation with my lawyer and don't under any circumstances open the door."

In a smaller organization, the cost in gauging people's availability is low. People are collocated, the walk is not long, and it gives a break from sitting in front of the computer. Perhaps the low cost makes people more apt to check and more sensitive to when it is a good time to interrupt.

Email is a preferred method of communication within the studied organization, competing with face-to-face for popularity. It had the highest ratio of strengths to weaknesses and the largest number of categories and subcategories for coded strengths (Table 2). Several reported email strengths are noteworthy. One is that the

process of composing an email allows writers to sort out their thinking, resulting in a more precise and clear message. This process may take some time, causing delays in communication, but, as viewed by our respondents, that is a valuable aspect of email for knowledge workers. This observation was confirmed in the interviews, as described by Nate: "I've found that sometimes it's easier to really nail down an idea and explain it when I can compose it in a couple of sentences that have the solidity of text." This finding supports the cognitive-based model of media selection [26], where deeper processing sometimes adds benefits to written communication not found in face-to-face communication.

We also found evidence in both the surveys and in the interviews that email supports reviewability [4]. In the interviews, most respondents noted that they used email when they wanted a written record of the communication. For instance, Walter said, "[Email] provides a written record of what we were talking about so I can go back and make sure I said what I thought I said." Zeke said "[Email] is the most precise way of communication in terms of keeping track of the history and the facts I communicated."

According to our survey respondents, another strength of email is that there is no need to reply to email immediately because of social conventions established at this organization. On the other hand, respondents acknowledge that one weakness with email is that there can be long delays in getting a response, often prompting a face-to-face communication when responses were not speedy enough.

Another interesting strength of email reported in the survey responses is that email does not cause interruptions. This view contradicts the cost of email interruptions found in previous research [17]. It is possible that this is an artifact of the environment of the respondents, due to relatively low e-mail volume and the ability to walk to someone's office to have a direct discussion if an immediate response is desired.

Different circles and purposes of communication

In the interviews, we found that new communications channels such as blogs, microblogs, and SNSs did not replace current communication channels. Instead they complemented them. This was particularly evident for blogs. Several respondents were active bloggers, some for personal use only, while at least two blogged for professional purposes. As Nate put it, "In my professional life, I communicate ideas through responses to blog posts." Blog comments can be on colleagues' blog posts, or more commonly, they are responses to persons outside the company.

SNSs also transcend organizations. Many of our respondents said they were using LinkedIn for maintaining professional contacts. But SNSs also give an outlet for more social interaction for colleagues with the company, or as Nate puts it, "I'm connected to professional contacts on Facebook, but the use is more social. It's lightweight and it's more for social grooming."

The new media expands professional communications beyond the organization. To some extent this is not new,

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[1] Participant names have been changed to protect their anonymity.

since newsgroups have existed for a long time, but blogs and micro-blogs have made these discussions more public and accessible. New media also add a social dimension to existing professional relationship building.

DISCUSSION

This paper describes an in-depth examination of the use of communication technologies in the workplace. We found that people's interaction with communication technology takes place within a communication ecology. People's choices are affected by both intrinsic and extrinsic factors, with the result that no single method may satisfy all their constraints. Our findings show definite trends in technology use, give new insights into how users value and choose among available technologies, and show how a person's technology use can define other behaviors. These insights have the potential to influence how future communication tools are designed and studied. Evidence from this study indicates that tools should be designed to be used in combination rather than in isolation.

Our results suggest that existing media selection theories do not cover all the complexities exhibited in the evolution of communication ecologies. Current media selection theories focus on the selection of one tool for one communication act (often validated by asking people to do the same communication act using different tools) without taking into account that tools exist within in a communication ecology, where the tools work in concert rather than alone. People move fluidly between tools to satisfy their communication needs. We identify aspects missing from current theories, including consideration of the state of the communication partner and insight into how people adopt new media. These can serve as foundational elements in the development of a new or revised theory of communication media choice.

While our research focused on a specific population, we believe our results are representative of smaller collocated organizations and are meaningful because the population that we studied exhibits many of the characteristics common in the modern information centric workplace. For instance, our research sampled across job type, age, educational background, and language skills. Further, our results were based on a study of employees in a small organization (as opposed to a large multi-national corporation), reflecting a different communications dynamic that should be studied separately.

In addition to the insight that communication choices should be studied within their communication ecology, the results of our research have several other important implications for the design of future computer-based communication tools. These include:

Communication channels are not getting replaced; users are just using more of them. Our study found that users are not adopting new technologies in place of existing technologies; rather, new technologies are being used alongside older ones. People find certain technologies effective for a particular type of communication, and choose to use technology that fits best. IM, for example, is not replacing email or face-to-face communication; it has found

a niche in support of a specific type of communication. Blogs and SNSs extend beyond the small organization and connect professionals to other information sources. Thus developers of new communication technologies should consider designing for co-existence rather than replacement.

Many implementations for the same job. In addition to the variety of technologies available, our research shows that users are adopting several different tools within the same category. For instance, many participants reported using several different IM clients and SNSs because no single implementation is used by all people with whom they need to communicate. This behavior stands in contrast to how most communication tools are built, that is to be the only instance within a specific class of technologies. Yet the most successful communications technologies, email and phone, allow interface innovation to co-exist within a well-defined communication channel. This creates opportunities for innovation while preserving interoperability. We expect that new communication channels will not prosper as monocultures; rather, a diverse set of interfaces appropriate to diverse user needs will increase the likelihood that a communication channel is adopted. The proliferation of Twitter clients, for example, is a good indicator of its long-term viability.

Basic functional support motivates initial adoption, but technological support for interpersonal connections drives continued use. Through analyzing the adoption trends and through our cluster analysis, we found that technologies were almost always adopted initially because they had an explicit purpose in support of a work task. For example, many participants took up instant messaging so they could better communicate with peers not currently in the office. However, our analysis showed that the sophistication of a particular tool's ability to support the complexity and nuances of interpersonal connections significantly influenced continued use. One participant commented that he finds the inability of the corporate IM client to support chat with people outside the company to be a significant weakness. As designers, we must focus not only on building technologies that support specific task requirements, but we must also foster long-term connections among users.

CONCLUSION AND FUTURE WORK

By examining the communication practices and attitudes in the workplace, we found that people's choices of and interactions with communication technology are governed by their communication ecologies, which support a diverse set of tools to meet user needs. Within the ecologies, we explored emerging trends in communication tool use, compared the relative strengths and weaknesses of several important communications technologies, and identified groups of users based on their communication preferences.

These studies represent the first steps in building a comprehensive understanding of the office communication ecology. Our next steps will consist of continuing to examine the workplace communication ecology through continued survey and interviews methods as well as exploring communication tool use on a more granular level. We intend to instrument participants' computers to capture a

trace of communication technology use over time. This analysis will complement the results of the work reported here, and will produce additional insights into how different tools are used to communicate in the workplace.

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