

# Communication Chains and Multitasking

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## ABSTRACT

There is a growing literature on managing multitasking and interruptions in the workplace. In an ethnographic study, we investigated the phenomenon of *communication chains*, the occurrence of interactions in quick succession. Focusing on chains enable us to better understand the role of communication in multitasking. Our results reveal that chains are prevalent in information workers and that attributes such as the number of links, the rate of media and organizational switching can be predicted from the first catalyzing link of the chain. When chains are triggered by external interruptions, they have more links, a trend for more media switches and more organizational switches. We also found that more switching of organizational contexts in communication is associated with higher levels of stress. We describe the role of communication chains as performing *alignment* in multitasking and discuss the implications of our results.

## Author Keywords

Communication, interaction, multitasking, workplace.

## ACM Classification Keywords

H5.3. [Information Interfaces and Presentation]: Group and Organizational Interfaces – *Computer-supported cooperative work, Asynchronous interaction, Synchronous interaction*

## INTRODUCTION

There has been recent interest in how information workers rely increasingly more on large networks of people irrespective of geographical location, e.g. [18]. These studies underscore how effective networking involves being skilled not only in the use of different media but also in more subtle practices which involve understanding which media best suits different types of interactions.

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We maintain that understanding communication practices of information workers must be viewed within a larger context of understanding the management of work. Lately there has been much interest in the CHI community on how people can manage multitasking and interruptions in the course of their work [1, 4, 5, 6, 8, 11, 12, 16, 13]. A recent study revealed that information workers manage on average 12 different projects [16]. Each project often involves a unique set of contacts (colleagues, managers, customers, vendors, etc.). Thus, information workers manage and switch among multiple projects throughout the workday, and at the same time they are managing a large social network of individuals associated with these different projects.

The hectic nature of work has long been documented, even before email and IM entered the workplace, for example dating back to Mintzberg's [17] study of managers. Yet in focusing on present-day work, we have more communication media available than in Mintzberg's era of information work. The documented high level of multitasking and interruptions leads to a currently unanswerable question: has the prevalence of communication media in the workplace created more opportunities for interaction, and consequently interruptions, or rather has the expanded number of projects that people are involved in created more need for communication and thus interruptions? Are these two phenomena inseparable?

## ALIGNMENT IN MULTITASKING

Multitasking is a combination of switching among different tasks and also switching between solitary work and communication with others. We are interested in understanding the behaviors involved in communication when people handle multiple projects.

Strauss [26] described work as a trajectory of multiple tasks. We consider the process of following such a work trajectory to be a process of alignment, involving both *self-alignment* in keeping track of one's own work but also *alignment with others* especially for collaborative work. Self-alignment can involve returning back to the point left off in a task when one was interrupted or to a new task, but it can also involve switching between local and global perspectives of one's different tasks in order to maintain an overview [7].

Aligning with others involves continual coordination and communication [8]. This communication activity serves multiple purposes with respect to helping manage multitasking: for example, providing awareness of others' actions and information about work, articulation of collaborative work, helping one prioritize projects, getting access to key information needed in work and coordinating with others. Continual alignment with others is especially critical when work is tightly-coupled [10].

Pickering & Garrod's model of interactive alignment [22] suggests that people strive in their communication to align themselves with others at different levels, for example by establishing communication routines. Communication is a joint activity; each partner cooperates so as to insure both achieve the same representation. Communication in the workplace may have many different functions [15, 1] but following [22], an important function is for people to align their work with others and in the organizational context.

In this paper we report on an ethnographic investigation of the workplace, focusing on the role of communication in multitasking. We noted continuously that communication acts that occur as breaks from solitary work are not single acts. Rather, they often follow one after another in quick succession as chains of communication acts. Thus, from our observations, people also switch communication partners in a similar way to how they switch among tasks in solitary work [8]. The concept of *communication chains* was first introduced by Reder & Schwab [23] who discovered that, as part of cooperative work, people need to insure that they are available to others and also at appropriate times they need to make an effort to contact others. We were interested in building upon this work to gain a better understanding of why people shifted from a solitary work mode, where they switched among multiple tasks, to a type of communication mode, where they showed patterns of switching among multiple communication partners with different media.

Chains of communication may at first glance seem random and disorderly. But in fact, they do have an order, a structure. Following Pickering & Garrod we propose that this structure is developed both as a strategy to accomplish alignment with others and also is shaped by certain factors. We were interested to understand more deeply what the structures of these communication chains are. Using Reder & Schwab's perspective of examining work as temporal activity, we set out to understand how communication chains are integrated (or not) into the solitary work pattern of multitasking. Guided by an ethnographic analysis, we hypothesized that the process of aligning with others through communication is affected by media, by the organizational context of the partners, and involves stress.

1) *Media-switching*. Several studies have focused on patterns of activity related to communication in multitasking such as resumption of tasks after conversations [12, 13]. Other studies have focused on patterns of media use with a single communication medium such as IM or

email [18, 28]. To our knowledge, no one has examined patterns of media switching for communication while multitasking. We expect that media choice is related to how people align with others. For example, because face-to-face communication acts are longer than communication with IM or email [24], we might expect different patterns of media switching that can reveal interesting information about alignment. Certain media sequences may be better suited for integrating with the multitasking of solitary work.

2) *Organizational context*. Information work often involves communicating with people in one's business unit or department but also with others outside of one's department or even organization [18]. Professional networks can span organizations. We expect that communication sequences might follow different patterns depending on what the communication partners' organizational context is. In fact, we expect that different media may be used depending on partners' organizational contexts.

3) *Stress*. Though there have been a lot of anecdotal reports that multitasking leads to stress (e.g. [8]) as yet this has not been empirically measured. We were interested to discover to what extent stress might be related in particular to the length and structure of communication chains.

## RESEARCH SETTING & METHODS

Our field site is a large corporation, the Loquor Corporation<sup>1</sup>, headquartered on the west coast of the U.S. with offices also distributed across the U.S. The corporation serves in an advisory role by providing expertise on scientific and technical issues for its customers.

Our data collection methods follow the ethnographic tradition. Our goal was to get a snapshot of a person's daily work life. To capture this egocentric viewpoint, it necessitates that one becomes fully entrenched in the informant's own cultural setting. Informal interactions, other social arrangements and nuanced practices that every worker has nurtured are an important part of work life that can only be seen by stepping into their shoes. As such, we felt that diary studies or surveys would be ill suited for a deep analysis of interaction in the workplace.

Observations were conducted through a shadowing method. Shadowing is an intense form of observation in which the researcher observes and follows the informant whenever possible. The researcher carried a paper notepad and recorded and time stamped the informant's activities. As much as possible, the researcher would sit directly behind the informant to fully observe the informant's focus of attention, e.g. a computer screen or papers on the desk. The key data points that were recorded were an activity's start/end times, artifacts utilized, person(s) (if any) interacted with, goal of the activity and relevant quotes. We made it clear that the informant could at anytime ask the

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<sup>1</sup> Pseudonyms are used in this paper. Loquor is Latin for 'speak.'

researcher to temporarily leave or stop taking notes whenever she felt uncomfortable with a certain event being recorded. Informants were asked to act as they normally would. Whenever something unclear would arise during the shadowing sessions, the observer would typically reserve questions until the end of the day.

In total, 19 informants were shadowed, resulting in approximately 13,000 separately recorded events representing over 550 hours of data over a period of about 18 months. Informants were recruited by email from an initial pool suggested by our contact at Loquor. An initial half-day shadowing session was done so that the informant would get used to having a shadow, and so that the observer would get acclimated to the informant's environment. At the end of this half-day, an interview was conducted to ascertain what regular interactions they participated in. Three full workdays of observations then commenced, followed by a post-interview to clarify and discuss the collected observational data. We recorded a mean time of 7 hr. 48 min. of data per day per informant.

After observations were complete, we measured job stress, with the Job Content Questionnaire (JCQ), an instrument which operationalizes “job strain” into job demand and job decision latitude [14]. Our version of the JCQ uses a 7-point Likert scale. The informants were in a wide range of professions: library manager, library staff, two general managers, two project leaders, business associate, business manager, two scientists, (semi-retired) engineer, technical staff director, knowledge management staff, two engineers, distinguished engineer, principal director, intern engineer and senior business director. All used information and communication technologies in their work.

### DATA CODING

All paper notes were transcribed into a spreadsheet. Each line of the spreadsheet represented an activity with its date, start time, end time, media used, people involved and general context of the activity. Communication media use was categorized into face-to-face (F2F), meeting, phone, instant messaging (IM) and email. Meetings were interactions planned at least half a day ahead and included teleconferences. Each recorded segment of data is based on “events,” as opposed to how Reder & Schwab defined “tasks”: “Tasks are accomplished by workers through ‘events,’ which we define as observable actions.” For example, someone working on a demo may prepare slides and then create a picture in a drawing program. While both events are part of the working sphere [8] of “demo”: for data analysis purposes, we consider them as two tasks. That is, the *immediate goal* of one is to edit a slide and the other is to create a picture. From hereon, we use the terms tasks and solitary work events interchangeably.

Solitary work, as opposed to communication acts, consisted of working alone using productivity software (word processors, spreadsheets, slides), browsers, specialty tools (e.g., for labs or software development) and paper.

### Communication Action Chains

We now operationally define communication chains. Chains are composed of communication acts that can be thought of as *links*. Each link represents a F2F, email, phone or IM communication act where there is a discernable target and source person(s). For example, an email *from* someone and the subsequent email reply *to* the person would represent two sequential links in a chain. A communication act need not be reciprocated to be considered a link in a chain. Email that is read without replying or phone calls that result in a voice message are both still valid links in a chain. The intent to communicate is the important factor for our analysis. While paper was sometimes used as a communication medium (e.g., leaving Post-It notes on someone’s desk), we found it difficult to discern in many cases whether paper usage was really a communication act (e.g., signing an equipment approval form). Thus, paper usage was classified as being part of solitary work. On average 36 min. per day were spent with paper work, yet only about 7% of such events could be considered communicative.

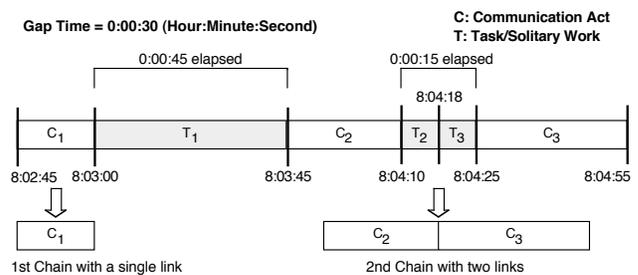


Figure 1. Two chains in a sequence of events.

We observed that while interactions often happened one after another, sometimes these interactions were interspersed with short tasks such as glancing at paper reports or searching the Internet. We thus define a *gap time* of 30 seconds to allow two communication acts with solitary work in between them to still be considered sequential links in a chain. This value of 30 seconds falls within a time scale that Naur [19] cites as the *specious present*: a moment in which our object of focus is still influenced by what we focused on a few seconds before. Between 20 to 40 seconds, we will begin to forget this “previous” focus. If tasks between two communication acts are less than the gap time, then the communication acts are still considered as if they were sequential. Fig. 1 illustrates how two chains are identified in a particular time segment.

For each chain, we counted the number of *media switches*. A media switch occurs when two consecutive links use different media. For example, a chain of [F2F→Email→Email→Phone] would have two media switches. A chain of length one has zero media switches.

**Table 1. Times per day per informant for tasks and communication acts. Sd's are in parentheses.**

| Context                    | Times (Hour:Minute:Second) |              |                      | % of All Comm Acts |
|----------------------------|----------------------------|--------------|----------------------|--------------------|
|                            | Avg. Event                 | Median Event | Avg. Total           |                    |
| Work Home <sup>1</sup>     | 0:02:46<br>(0:04:36)       | 0:01:00      | 1:04:36<br>(0:38:14) | 46.01%             |
| Company <sup>1</sup>       | 0:02:10<br>(0:03:14)       | 0:01:11      | 0:49:37<br>(0:31:20) | 36.14%             |
| Outside <sup>1</sup>       | 0:02:17<br>(0:02:41)       | 0:01:32      | 0:16:27<br>(0:15:52) | 12.08%             |
| All Comm Acts <sup>1</sup> | 0:02:18<br>(0:04:15)       | 0:00:56      | 2:18:31<br>(0:56:30) | 100%               |
| Solitary Work              | 0:02:31<br>(0:04:26)       | 0:01:00      | 3:01:34<br>(1:20:17) | --                 |

<sup>1</sup>Meetings, paper work and unknown events are excluded.

### Organizational Contexts

We were also interested in the organizational context in which chains occur. Nardi et al.'s [18] work on 'intensional' networks captures the notion that people are members of multiple social networks in the workplace that transgress beyond one's own department. Thus, each communication act was coarsely coded into one of three organizational contexts: *work home*, *company* and *outside*, depending on with *who* the person was communicating:

*Work Home*: These are organizationally determined contexts that reside within a person's business unit. For example, these include interactions with one's department or division.

*Company*: These are communications bounded by the company, but outside the person's business unit. For example, these include interactions with one's IT department (assuming the person does not belong in IT).

*Outside*: These are interactions with others that exist wholly outside the company. These would include interactions with customers, vendors, social clubs, professional societies or friends and family.

In cases where interactions involved more than one person, we typically chose the organizational context that best encompassed all participants. For example, meetings with people from the 'Work home' and 'Company' were coded as 'Company'. Group discussions involving outside participants were always coded as 'Outside' because most meetings with outside people were focused around them. These contexts represent a simplification of a previous schema we have used [27] to analyze interaction among multiple groups in the workplace. Analogous to media switches, we also examined the number of *organizational switches* within a chain.

### DESCRIPTIVE STATISTICS

Having described the nomenclature for our data segmentation scheme, we now report descriptive statistics.

#### Summary of Communication Acts & Solitary Work

Table 1 shows the average time spent per day for each informant on communication acts in the different organizational contexts and tasks. Informants averaged about 3 hr. on solitary work per day, while averaging 2 hr. 18 min. on communication acts per day. Table 1 does not include data on meetings (average of 1 hr. 46 min. per day per person), paper-based work or unknown events. Unknown events include activities the researcher was not permitted to observe (e.g., family conversations, bathroom breaks or lunches) or communication acts whose context was indiscernible due to the researchers inability to adequately record the event. The average duration of solitary work and average duration of communication acts is correlated across informants,  $r=0.58$ ,  $t(17)=2.97$ ,  $p<0.05$ .

Informants spent the majority of communication time with others in their 'Work home' context (46%), about a third of the time in their 'Company' context and about 12% of time in the 'Outside' context. We did not find significant differences in average communication event times between the interaction contexts. This suggests that organizational boundaries by themselves do not predict the length of communication act events.

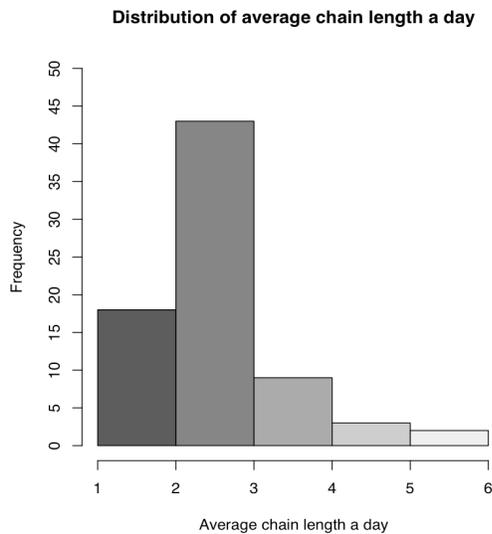
**Table 2. Averages per day per informant on various metrics of communication chains.**

| Measure                     | Avg. / day           | Median |
|-----------------------------|----------------------|--------|
| # of Chains                 | 27.36<br>(9.81)      | 30.21  |
| Chain Duration <sup>1</sup> | 0:05:17<br>(0:07:51) | 02:32  |
| Chain Length <sup>2</sup>   | 2.51<br>(2.24)       | 1.67   |
| Link Duration               | 0:02:27<br>(0:02:04) | 02:14  |
| Media Switches              | 0.44<br>(0.88)       | 0.026  |
| Org. Switches               | 0.57<br>(1.18)       | 0.053  |

<sup>1</sup>Sum of link durations in a chains. <sup>2</sup># of links in a chain.

#### Chain Attributes

Table 2 shows descriptive statistics of communication chain attributes. The data show that each person does not communicate in single acts; rather, most interactions occur in chains (averaging 2.5 links). The average chain link lasts 2 min. 27 sec. Chain duration, the average total time of all links in a chain is 5 min. 17 sec. On average for each chain, media switches are few (0.44), as are organizational switches (0.57).



**Figure 2. Histogram of observed chain lengths per day.**

Fig. 2 is a histogram of the average chain lengths per informant per day and shows that the chain length data is skewed to the right. More than 40 of the 76 (19 informants x 4 days) average chain lengths per day are 2-3 links long.

### Probability of switching media

What is the *expected* number of chain links when someone starts interacting with a particular communication media, e.g. email? To answer this question, we can model the data with Markov chains. While we will not delve into its theory, the “Markov property” defines the next state as depending solely on the current state [20]. This assumption has been used in a wide variety of observational studies and in practice is a good approximation to analysis of data that does not strictly follow the Markov property [2]. Below are the transition probabilities in matrix **M**:

|       | F2F   | Email | IM     | Phone | End  |       |       |
|-------|-------|-------|--------|-------|------|-------|-------|
| F2F   | 0.38  | 0.085 | 0.0087 | 0.057 | 0.47 | F2F   | 0.44  |
| Email | 0.075 | 0.54  | 0.0061 | 0.072 | 0.31 | Email | 0.36  |
| IM    | 0.097 | 0.097 | 0.26   | 0.030 | 0.51 | IM    | 0.032 |
| Phone | 0.15  | 0.17  | 0.011  | 0.24  | 0.44 | Phone | 0.18  |
| End   | 0     | 0     | 0      | 0     | 1    | End   | 0     |

For example, entry  $m_{12}$  states that the probability of switching to email given F2F is 0.085. Entry  $m_{25}$  states that the probability that the chain will end with an email is 0.31. “End” is the *absorbing state*, representing the end of a chain. A chain ends when a task/sequence of tasks exceeds the gap time (see Fig. 1).

The vector on the right of **M** defines the simple probability of starting a chain with a certain medium. For example, the highest probability of starting a communication chain is by F2F (0.44) and it is next most likely to expect that a chain is started with email (0.36). These probabilities (and those of **M**) are derived from frequency counts of the observed data.

We can derive the expected time to “absorption” via the above matrix’s *fundamental matrix* [9]. The expected number of transitions with various media as the first link is:

|       |             |
|-------|-------------|
| email | 2.93 links  |
| phone | 2.43 links  |
| F2F   | 2.28 links  |
| IM    | 2.14 links. |

Thus we see here that although F2F-started chains are the most probable, email and phone-initiated chains are longer, with IM-initiated chains having the shortest expected length.

We can use the simple and transition probabilities to calculate the *probability of a chain* (i.e., of a particular sequence of media usage). For example, the probability of a [F2F→Email→F2F] chain would be  $0.44 \times 0.085 \times 0.075 \times 0.47 \approx 0.0013$ . After identifying all chains in our dataset, we can summarize the average probability of chains across informants as 0.084 (sd=0.076). From our Markov analysis, we can also say, for example that a chain with many Email→IM transitions would be in general “less probable” than a chain with many F2F→F2F transitions.

### CATALYSTS FOR CHAINS

What types of events catalyze chains and how do these catalysts affect communication chains? In this section, we examine the effect that interruptions have as catalysts and also examine how media choice and organizational context affect a chain’s properties.

#### External Interruptions

As there has been much recent research showing the prevalence of interruptions in the workplace, we were interested to discover the effect that interruptions have on chain properties. By interruptions we refer to *external* interruptions. We might expect that chains begun as a result of interruptions, i.e. unplanned communication acts from others, might lead to longer chains. One reason is that once people are interrupted from a task they may take the opportunity to catch up with other communication needed to align their work with others. On the other hand, self-initiated chains (i.e., where the communication act is intentionally started by the informant) might be more purposeful and directed towards fewer people. Self-initiated chains also include communication acts that were (nearly) initiated mutually by both parties (e.g., running into people in the hallway).

A t-test<sup>2</sup> revealed that external interruptions (M=2.8, sd=2.8) did indeed lead to significantly more links in a chain compared to self-initiated communication (M=2.4, sd=2.4),  $t(1020)=2.46$ ,  $p<0.05$ . However, we found no significant difference in *chain duration* in externally triggered and self-initiated chains.

<sup>2</sup> All t-tests use Welch’s approximation for non-equal variances.

Yet though having more links, chains triggered by external interruptions ( $M=0.07$ ,  $sd=0.07$ ) had a significantly lower probability (lower than the norm chain probability, 0.084) than self-initiated chains ( $M=0.09$ ,  $sd=0.08$ ),  $t(1390)=-6.59$ ,  $p<0.001$ . In other words, externally-initiated chains had rarer media transitions than self-initiated chains. External interruptions may force people to try different and novel media combinations in order to accomplish the goals instigated by the initial, external communication act.

### Media Choice

We now examine the effect of certain communication media as the first link on the chain. Observations during our shadowing sessions seemed to indicate that F2F conversations often served as cues to others that informants were available for further interactions, leading to longer chains. We thus surmise that when F2F is the first communication act it will lead to the longest chains. In addition, synchronous F2F communication tends to last longer than asynchronous methods like email [24].

We tested whether F2F-initiated chains had the most links. An ANOVA showed that when conducting multiple comparisons<sup>3</sup> tests, the results showed significant differences among media ( $F(3,1925)=13.96$ ,  $p<0.001$ ) but did *not* entirely confirm our expectation. Email-initiated chains ( $M=3.03$ ,  $sd=2.96$ ) had significantly more links than F2F-initiated, ( $M=2.25$ ,  $sd=2.26$ ),  $p<0.001$ , phone-initiated, ( $M=2.32$ ,  $sd=2.19$ ),  $p<0.001$ , and IM-initiated chains, ( $M=2.07$ ,  $sd=2.34$ ),  $p<0.05$ . This actually conforms to estimates of chain length from our Markov analysis.

We also tested with multiple comparisons whether F2F-initiated chains would have the longest duration. We did find significant differences among media:  $F(3,1925)=5.72$ ,  $p<0.001$ . IM-initiated chains ( $M=0:01:44$ ,  $sd=0:02:43$ ) lasted significantly shorter than email ( $M=0:04:31$ ,  $sd=0:07:18$ ),  $p<0.05$ , F2F ( $M=0:05:30$ ,  $sd=0:09:31$ ),  $p<0.05$ , and phone ( $M=0:05:46$ ,  $sd=0:07:52$ ),  $p<0.05$ . Email-initiated chains showed a trend to be shorter in duration than chains initiated by F2F and phone,  $p<0.10$ , and there was no significant difference between F2F and phone in chain duration. Thus, chains initiated by synchronous events were of longer duration.

Following our idea that external interruptions might trigger people to catch up with their communication, we also expected that externally-initiated chains would have more media switches. A t-test shows this to be weakly significant,  $t(1110)=1.7$ ,  $p<0.10$ ; the mean media switches for externally-initiated chains ( $M=0.52$ ,  $sd=1.05$ ) was greater than for self-initiated chains ( $M=0.43$ ,  $sd=1.00$ ).

### Organizational Context

We were interested in how chain length might be related to the organizational context of the communication. Our field

observations indicated that ‘Outside’ context interactions varied widely (from quick chats to family, to longer discussions with customers), but ‘Company’ context interactions were longer and more consistent perhaps due to the amount of time needed to establish common ground (as opposed to the ‘Work home’ context).

We first tested whether chains initiated in a ‘Company’ context had more links. Results showed this to be the case:  $F(2,1771)=8.60$ ,  $p<0.001$ . A multiple comparisons test found ‘Company’-initiated chains ( $M=2.85$ ,  $sd=2.75$ ) had more links than chains initiated in the ‘Work home’ ( $M=2.31$ ,  $sd=2.44$ ),  $p<0.001$  and ‘Outside’ contexts ( $M=2.41$ ,  $sd=2.37$ ),  $p<0.05$ . No significant differences were found for chain duration.

Again, following our notion about external interruptions, we tested whether externally-initiated chains (which were shown to have more links) would also have more organizational switches. A t-test showed this to be the case:  $t(1023)=2.12$ ,  $p<0.05$ . Chains catalyzed by an external source had more organizational switches ( $M=0.69$ ,  $sd=1.47$ ) than self-initiated chains ( $M=0.54$ ,  $sd=1.28$ ).

When communicating in the ‘Outside’ contexts, we surmised that informants would use a greater variety of media channels in order to align to others’ media preferences. For example, if an informant is trying to track down a customer (an ‘Outside’ context), she might often have to switch from phone to email (0.17 probability in the Markov matrix), as opposed to interactions in the ‘Work home’ context, where many quick consecutive F2F interactions occur (0.38 probability). An ANOVA confirmed this:  $F(2,1771)=67.45$ ,  $p<0.001$ . Pairwise t-tests revealed ‘Outside’-initiated chains ( $M=0.05$ ,  $sd=0.05$ ), are less probable (have less common media transitions) than ‘Company’-initiated chains ( $M=0.07$ ,  $sd=0.07$ ) and ‘Work home’-initiated chains ( $M=0.10$ ,  $sd=0.09$ ). All pairwise contrasts here had statistically significant differences,  $p<0.05$ , in probability. Finally, note that ‘Outside’ and ‘Company’ initiated chains have probabilities less than the overall chain probability mean (0.084), while ‘Work home’ initiated chains have a greater probability.

We asked the question of which media triggered chains with more organizational switching. A multiple comparisons test ( $F(3,1925)=14.98$ ,  $p<0.001$ ) showed that chains begun with email ( $M=0.85$ ,  $sd=1.61$ ) had significantly more organizational switches than chains begun with phone ( $M=0.53$ ,  $sd=1.14$ ),  $p<0.001$ , and F2F ( $M=0.40$ ,  $sd=1.13$ ),  $p<0.001$ . Email had weakly significant differences with IM ( $M=0.46$ ,  $sd=1.27$ ),  $p<0.10$ .

We expected that more organizational switching should be correlated with more media switching as people might use a variety of media to reach others at a distance. Across informants, we found the correlation between the average number of organizational switches and average number of media switches per day to be significant:  $r=0.82$ ,  $t(17)=5.90$ ,  $p<0.001$ .

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<sup>3</sup> All pairwise t-tests from hereon use Holm’s correction.

## PREDICTING STRESS

We now examine the question of whether some types of communication chains might be more stressful than others. Using the JCQ instrument, we examined five variables to see which might predict job stress. We used a backwards stepwise regression with the Akaike Information Criterion (AIC) [3]. This avoids some of the deficiencies with traditional stepwise techniques that rely on p-values for variable removal.

**Table 3. Averages per informant on stress measures.**

| Instrument              | Average (sd)    | Instrument Range |
|-------------------------|-----------------|------------------|
| Job Strain <sup>1</sup> | 0.78<br>(0.25)  | 0.14-7           |
| Job Demands             | 55.9<br>(11.35) | 12-84            |
| Job Decision Latitude   | 148<br>(17.53)  | 24-168           |

<sup>1</sup>Job Strain=(Job Demands x 2) ÷ (Job Decision Latitude)

Table 3 shows the average measures of job strain (the composite measure of stress) and its two components: job demands and job decision latitude. Job decision latitude is made up of skill discretion (the degree to which you are allowed to learn and do creative things) and decision-making authority. Job demands (i.e., pressure) is positively related to job strain. Job decision latitude is *inversely* related to job strain, i.e. the higher the measure of job decision latitude the lower the job strain.

**Table 4. Models for Stress derived from AIC Stepwise Reg. The standard errors of coefficients are in the parenthesis.**

| Independent Variables           | Job Strain           | Job Demands       | Job Decision Latitude |
|---------------------------------|----------------------|-------------------|-----------------------|
| Intercept                       | -0.0018<br>(0.29)    | 30.19**<br>(9.54) | 153.78***<br>(3.48)   |
| Median Chain Duration (seconds) | --                   | 0.153*<br>(0.063) | --                    |
| Median Chain Length             | 0.31'<br>(0.16)      | --                | --                    |
| Median Link Duration (seconds)  | 0.0015*<br>(0.00055) | --                | --                    |
| Median Media Switches           | -1.64'<br>(0.80)     | --                | 133.96'<br>(66.07)    |
| Median Org. Switches            | 2.27**<br>(0.59)     | 43.21'<br>(22.35) | -182.82**<br>(48.86)  |
| <i>R</i> <sup>2</sup>           | 0.72                 | 0.47              | 0.49                  |

': 0.05 < p < 0.1, \*: p < 0.05, \*\*: p < 0.01, \*\*\*: p < 0.001

Table 4 shows the models predicting job strain, job demands and job decision latitude. We used median values due to the presence of outliers (e.g., rare, inordinately long chains skewed the dataset). Multicollinearity was measured by calculating the Variance Inflation Factors (VIF) for each

regression equation. Based on a cutoff value of VIF=10, we found no evidence of multicollinearity; the maximum VIF was 2.98.

The regression model shows that organizational switching in chains is the most predictive factor for job strain. If we break down the job strain measure into its components we find that this is due mostly to the job decision latitude component. We interpret this finding to indicate that switching across organizational boundaries is associated with stress due to less control in decisions and less influence that people have outside their work homes.

Median chain duration is predictive of job demands. This suggests chains spanning a lengthy time period lead to more stress, possibly leaving less time for solitary work. Finally, median link duration is predictive of overall job strain. This implies that longer communication acts lead to more stress.

There is a trend showing that as media switches increase job strain decreases. This is due mainly to job decision latitude. This might be explained by the notion that when media switches are frequent, people are choosing the appropriate media that can best fit in their multitasking practices, thus increasing their latitude in decision making.

Interestingly, job decision latitude increased with media switching but decreased with organizational switching. Our results might stem from the fact that informants who experience a lot of organizational switching have little control over groups outside their primary area of work (usually their work home, or department). The main result thus suggests that alignment work that involves switching organizational contexts is stressful.

## QUALITATIVE DATA

Our analysis characterized communication chains and how their properties are related to interruptions, media choice, organizational context and stress. We now triangulate our data with an analysis of informants' post-interviews.

### Managing Media Switching with Multitasking

We found that different media affected the number of communication acts (links) in a chain and its duration. From the interviews we discovered that informants switched media strategically in their process of alignment. Even if informants were aware of others' media preferences, their own media choice was influenced by how well the technology allowed them to manage different interaction contexts without disrupting the flow of their work. However, when an individual's preferences override another's preferences, opportunities for interactions can sometimes be lost. For example, a knowledge management staff member grudgingly admitted that she does not check her voice mails even though many in her 'Company' interaction context may not prefer phone calls:

*I have a tendency to email more than phone, and I know, like when I check my voicemail, I always have millions of messages because I never check my voicemail even though*

*it's the same people trying to contact me all the time. So it's just like preference of communication. I prefer emails, I prefer phone...It's a problem when the person prefers the phone to be contacted through phone because they know I just won't ever call them <laughs>. I'll just email them. I just never pick up the phone to call them....it takes longer probably than they would prefer because it's like through email instead.*

As a result, interactions with people in her 'Company' interaction context are potentially lost because her preference is to do email. As one of the younger employees at Loquor, this informant felt she had more control over her interactions when using email, e.g. she could control when she communicated. The next quote describes her hesitation to add yet another type of media with her boss in her 'Work home' context because it would intrude her personal life (once she got a BlackBerry, her boss did indeed contact her on weekends):

*Yeah, he asked me before and I'm like, mm...no. It was like a year after he got his [BlackBerry], that's when I got mine... I was just like, I didn't want it because I knew then that he could tap me in the weekends, you know, after work...*

Upon looking at his communication statistics, a general manager remarked that his biggest weakness was not making a better effort to use the phone in his 'Company' context:

*I think the weakest part of my performance is that I don't just pick up the phone and call my peers as often as I should. I just tend to blast an email to them....there's lots of people who much prefer phone chats to email. Fortunately my boss is not one of those people, so we just do email.*

Many people prefer email because it offers control (we found that email-initiated chains had more links and email communications tended to last shorter than F2F or phone). The business director of Loquor called her email checking her "down time":

*I don't find it stressful because I'm in control with it...on the phone, I've got to be thinking and my brain is listening and thinking at the same what it's going to say back...that kind of interaction, it's live and you've got to be on...it feels more like break time when I'm doing email."*

This control perhaps allows one to better integrate their communication into their multitasking worklife. This last excerpt suggests that strategic use of media might even help manage stress in the workplace.

### **Managing Organizational Context with Multitasking**

Informants also used media strategically and in patterns to manage interaction in different organizational contexts. Brenda, a business associate in a technical department often interacts with business associates in other departments on the opposite U.S. coast, exchanging information needed to compile reports. Her medium of choice is often IM:

*[My] IM [lasts] seconds. That's what I would expect, "Are you there?" "Did you get the file?" "I'll be sending this." "Check your email." You know, which makes sense. [I'll IM] our East Coast offices, I'll say, "Are you there?" If they're online, I'll be sending you this or this invoice. I think it'll take longer to call the number, put in my authorization code, wait for the phone to ring.*

Indeed here Brenda knows that she'll have to either phone and then email or IM and then email. For her, email is the main medium of communication; the use of IM or phone is used to get others to check their email. Because the phone call must go to another company division, an authorization code is necessary (while technically still part of Loquor, it is a long distance phone call). To Brenda, shaving off those few seconds of inputting a simple authorization call is valuable amidst her multitasking, especially when all she needs to do is get someone's attention to check their email.

Some informants expressed frustration that others would use ineffective media patterns. Here, a scientist expresses her predicament over her new "phoners" in the 'Outside' and 'Company' context:

*At the time I was working with you, I got to spend more time just sitting and working on something. I say things have degraded simply because I've lost time to do that kind of thing...Now I have people that are "phoners" <laughs>. They'll send me emails, and then they'll phone. They just go do both. And then they'll tell me everything that's in their email. It's very redundant...of course, it's hard to leave the phone ringing.*

This is an example of how certain media patterns can be inefficient. It also illustrates a mismatch in expectations when aligning with others especially across organizational contexts.

The interviews revealed that the informants tried to use their limited work time efficiently for communication. One example of this occurred when an informant felt it worthwhile to communicate F2F with others in the 'Company' context even though it took more time to physically reach the other. Loquor's campus is spread over several blocks. A business manager relates why he invests more time in F2F with others in his 'Company' context:

*Well, that's because we're stuck out here in Building 8. If I want to go to anybody else other than the other organizations that are in Building 8, I have to walk all the way over there...so I'm going to spend a little bit more time in there because after walking all that distance you know. Cause you see I obviously spend less time on the phone but if I'm going to take the hike, I'm going to spend a little bit more time talking to them face-to-face.*

The business manager described that the 'Company' context is more stressful for interaction because of his lack of authority there; he chooses F2F interaction to get more "buy-in" when he needs something to accomplish his work.

Throughout our observations we noted that people valued interactions in the ‘Company’ context. It gives the informant a quick snapshot of the company as a whole, something that would otherwise be difficult to get solely in the ‘Work home’ context. The general manager noted the general lack of ad-hoc F2F interactions with the ‘Company’ context. He explained that he must purposefully seek these people out.

*My social group at [Loquor], I don’t really bump into them very often. And, I know them well enough that I will either pick up the phone or just blast them an email...They don’t need to see me at all, so that makes sense.*

This is an example of a concerted effort by the informant to touch base with his ‘Company’ context. This could explain why ‘Company’ context communication chains have more links: people try to maintain communication with others company-wide to get a broader picture of the organization.

## DISCUSSION AND CONCLUSIONS

Our study suggests that a significant part of multitasking involves not only switching among tasks but also switching communication partners, involving the use of different media in different organizational contexts. We argue that communication chains are a consequence of how people strategically use communication and media in conjunction with their multitasking work styles to align their work with others.

Our quantitative and qualitative data suggest several reasons why people communicate in “chains” as opposed to single communication acts. First, perhaps once people are interrupted from solitary work it may be more efficient to conduct a series of communication acts to reduce the cost of multiple reorientations to an interrupted task [16]. Our interview data suggest that some people develop communication sequences or patterns as ways to improve the chances of reaching others. Another reason is that when people multitask in solitary work they may store up information needs and then interact with others in chains to get the information they need in order to continue with solitary work. There may also be social reasons for communication chains that some of our informants described and that need to be further explored. Some chains may occur because one communication act begets another.

We found differences depending on which media initiated communication chains. Email-initiated chains had longer links on average but were of shorter duration than chains initiated by synchronous communication (IM-initiated chains were even shorter). This suggests that in a multitasking environment, when people are under time pressure, asynchronous communication may be best suited for multitasking.

Though recent work has identified how interruptions affect a task such as in reorientation and timing (e.g. [1, 4, 16]) our data shows the consequence of interruptions on communication patterns. When chains are triggered by

external interruptions, they have more links, a trend for more media switches, rarer media transitions and more organizational switches. Both chain length and organizational switches are associated with job strain. This has implications for the design of systems to support people in handling interruptions which we discuss shortly.

We return again to Reder & Schwab’s work and examine their recommendation on dealing with channel (media) switching: “*the multimedia approach to workstation design is definitely the right development model.*” However, examining this more closely, we see that simply providing a range of media choice for communication may not be sufficient for managing multitasking.

Our study suggests that the design of so-called interruption management systems must take a multifaceted approach in how to *transform* interruptions so that they are less stressful. Much of the work people do is alignment with different people—this is very difficult work and causes stress; however, the freedom to navigate between different people in different organizational contexts with choice of media may allow one to cope better with this stress. Thus while the interruptions we observed usually caused *more* alignment work on the organizational level to occur, future systems might be able to determine which interruptions are *likely* to result in long chains requiring multiple parties to be contacted. Systems that could filter out interruptions that are likely to have many links of longer duration may help facilitate users in conducting solitary, creative multitasking work.

Hence, simply providing more media choices for the user for interaction also exposes one to more interruptions and longer chains. Rather, media should be strategically provided when the current situation is less likely to invoke chains that lead to higher stress.

## Limitations and Future Work

Our coarse-grained separation of communication acts by organizational context provides only a rough idea of the *content* and *context* of the event. We plan to address this concern by coding our data into *working spheres*, thematically connected events. By examining the content of interactions, we hope to unpack the relation between projects and interactions. Another area we wish to investigate is the difference between single-link chains and multiple-linked chains. Why do some chains end abruptly with a single interaction whereas others continue?

Because of our focus on informal interactions, our data excluded meetings. However, meetings often serve as a hub for communication acts. Spontaneous communication occurs before and after the meeting. While studies often cite meetings as a primary annoyance for workers, the effects of meetings may be even more pronounced when one considers them as catalysts for chains.

As with all studies focusing on a single site, the issue of generalizability can be problematic. While the number of

people we observed (19) is greater than other such studies, e.g. by [21] and [25], we nevertheless cannot claim that our sample is broadly representative. We did observe a wide variety of people which we believe provided a good mix of what an “information worker” is. Despite this, cross-organizational studies are needed to investigate the prevalence and effects of communication chains in the workplace.

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#### REFERENCES

1. Bailey, B. and Konstan, J. On the need for attention-aware systems: Measuring effects of interruption on task performance, error, and affective state. *Computers in Human Behavior* 22, 4 (2006), 685-708.
2. Bakeman, R. and Gottman, J. M. *Observing Interaction*. Cambridge University Press, Cambridge, UK, 1997.
3. Burnham, K. P. and Anderson, D. R. *Model Selection and Inference: A Practical Information-Theoretical Approach*. Springer, New York, NY, USA, 1998.
4. Czerwinski, M., Horvitz, E. and Wilhite, S. A Diary Study of Task Switching and Interruptions. In *Proc. of CHI'04*, ACM Press (2004), 175-182.
5. Dabbish, L. and Kraut, R. E. Controlling interruptions: awareness displays and social motivation for coordination. In *Proc. of CSCW'04*, ACM Press (2004), 182-191.
6. Fogarty, J., Hudson and Lai, J. Examining the robustness of sensor-based statistical models of human interruptibility. In *Proc. of CHI'04*, ACM Press (2004), 207-214.
7. González, V. M. and Mark, G. Managing currents of work: Multitasking among multiple collaborations. In *Proc. of ECSCW'05*, Springer (2005), 143-162.
8. González, V. M. and Mark, G. “Constant, Constant, Multitasking Crazy”: Managing Multiple Working Spheres. In *Proc. of CHI'04*, ACM Press (2004), 113-120.
9. Grinstead, C. M. and Snell, J. L. *Introduction to Probability*. American Mathematical Society, Providence, RI, USA, 1997.
10. Hollan, J., Hutchins, E. and Kirsh, D. Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research. *ACM TOCHI* 7, 2 (2000), 174-196.
11. Hudson, J.M., Christensen, J., Kellogg, W.A. and Erickson, T. “I’d be overwhelmed, but it’s just one more thing to do.” Availability and interruption in research management. In *Proc. of CHI'02*, (2002), 97-104.
12. Iqbal, S. T. and Horvitz, E. Disruption and Recovery of Computing Tasks: Field Study, Analysis and Directions. In *Proc. of CHI'07*, ACM Press (2007), 677-686.
13. Iqbal, S.T. and Horvitz, E. Conversations Admire Computing: A Study of Interruptions and Recovery of Task Activity. In *Proc. of User Modeling '07*, Springer (2007), 360-364.
14. Karasek, R. A. Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Administrative Science Quarterly* 24, 2 (1979), 285-308.
15. Kraut, R. E., Egidio, C. and Galegher, J. Patterns of Contact and Communication in Scientific Research Collaborations. In *Proc. of CSCW'88*, ACM Press (1988), 1-12.
16. Mark, G., González, V. and Harris, J. No Task Left Behind? Examining the Nature of Fragmented Work. In *Proc. of CHI'05*, ACM Press (2005), 321-330.
17. Mintzberg, H. *The Nature of Managerial Work*. Harper & Row, New York, NY, USA, 1973.
18. Nardi, B. A., Whittaker, S. Whittaker and Schwarz, H. NetWORKers and their Activity in Intensional Networks. *CSCW* 11, 1/2 (2002), 205-242.
19. Naur, P. Computing Versus Human Thinking. *Communications of the ACM* 50, 1 (2007), 85-94.
20. Nelson, B. L. *Stochastic Modeling: Analysis & Simulation*. McGraw-Hill, New York, NY, USA, 1995.
21. Perlow, L. A. The Time Famine: Toward a Sociology of Work Time. *Administrative Science Quarterly* 44, 1 (1999), 57-81.
22. Pickering, M. and Garrod, S. Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences* 27, 2 (2004), 169-226.
23. Reder, S. and Schwab, R. G. The Temporal Structure of Cooperative Activity. In *Proc. of CSCW'90*, ACM Press (1990), 303-316.
24. Sanderson, P. M. and Fisher, C. Exploratory Sequential Data Analysis: Foundations. *Human-Computer Interaction* 9, 3/4 (1994), 251-317.
25. Sproull, L. and Kiesler, S. *Connections*. The MIT Press, Cambridge, MA, USA, 1991.
26. Strauss, A. Work and the division of labor. *The Sociological Quarterly* 26, 1 (1985), 1-19.
27. Su, N. M., Mark, G. and Sutton, S. A. Workplace Connectors as Facilitators for Work. In *Proc. of Communities and Technologies '07*, Springer (2007), 171-190.
28. Venolia, G. D. and Neustaedter, C. Understanding Sequence and Reply Relationships with Email Conversations: A Mixed-Model Visualization. In *Proc. of CHI'03*, ACM Press (2003), 361-368.
29. Whittaker, S., Frohlich, D. and Daly-Jones, O. (1994). Informal workplace communication: what is it like and how might we support it? In *Proc. of CHI'94*, ACM Press (1994), 131-137.