Designing for Loose Coupling in Mobile Groups

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ABSTRACT

Loose coupling is a common way of organizing collaboration in work groups, but it has not been studied extensively in CSCW. In this paper, we consider the patterns of work that are seen in mobile groups that adopt a loosely coupled collaboration style. We report findings from interviews and fieldwork with teams of workers who deliver home healthcare services. In these teams, workers are mobile, widely dispersed, and autonomous, and team members communicate with each other only intermittently. Based on these findings, we identify and discuss four work patterns that occur in loosely coupled mobility: discretionary collaboration and effort thresholds, implicitly shared information, asynchronous communication and coordination, and barriers to synchrony. We consider the implications of these findings for the design of CSCW technologies.

Categories and Subject Descriptors

H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces, Evaluation/methodology.

General Terms

Design, Human Factors

Keywords

Mobility, Loose coupling, Loosely coupled mobility, Groupware design.

1. INTRODUCTION

As wireless networks and handheld computing platforms improve, and with recent shifts toward increased mobility in the Western workforce [7], mobile collaboration has increasingly become an important issue in CSCW. However, efforts to understand the implications that mobile work and mobile collaboration have for the design of technology are still in the early stages. Mobile groups are highly varied in the ways they organize work (e.g. [35]), in the physical dispersion of mobile workers (e.g. [27,3]), and in the styles of collaboration that take place between workers (e.g. [23]). To help make sense of this diversity, recent efforts have been made to describe and classify these variations by focusing on specific types of mobility [21], types of physical distributions that occur in mobile groups [23], and levels of coupling between mobile collaborators [6].

These categorizations of mobile work allow us to articulate some of the major differences between various mobile groups. In this study we follow up these general categorizations with details about how these characteristics shape collaborative work (and CSCW design) in a specific situation. In particular, we examine how one characteristic of mobile work – loose coupling – shapes patterns of work and collaboration. Loose coupling is common in mobile groups [6], where workers are autonomous and collaborate infrequently, but still must manage interdependencies. Most groups use combinations of loose coupling and tight coupling when carrying out work [2]. However, in this study we consider the case where loosely coupled mobility is the major means of carrying out work. This style of work shapes the patterns of individual and collaborative work that are carried out by workers, and by studying these patterns, we can draw conclusions about how CSCW technologies can be designed to meet the needs of mobile, loosely coupled workers.

Our study examines collaboration in home care teams in Saskatoon District Health (SDH), a health district in Saskatchewan, Canada. In SDH, teams of community-based healthcare workers provide patients with services in their homes, and they carry out their work in a loosely coupled fashion. In SDH—unlike many other mobile settings (e.g. [11,4,27])—work is not arranged to facilitate regular synchrony. Workers do not have regular meetings, and do not see each other face-to-face very often. There is a high degree of variability in schedules and locations within a team, and because of this, communication is difficult, and workers often carry out their work autonomously without regular input from others.

We carried out a series of interviews and field observations with SDH home care clinicians, and considered issues of autonomy, coordination, awareness, and communication in our analysis. Our findings emphasize the patterns of work that emerge when mobile workers must manage interdependencies with other team members, but without having their work arranged to facilitate collaboration. While we find that these work patterns introduce a range of collaborative difficulties, we also find that loose coupling is beneficial since workers operate in an unpredictable work environment and must often revise their work plans to deal with local circumstances. Loosely coupled work patterns provide them with the flexibility to handle unpredictability without the need for ongoing negotiation with others, which can be both difficult and time consuming.

In this paper, we present four major findings about loosely coupled mobility that have not been previously reported:

- When workers are autonomous and when communication is difficult, workers carefully consider the effort required to share information. Explicit communication of information is generally limited to urgent issues, and workers try to select methods with low effort and overhead.

- Shared artifacts and work locations capture evidence or "traces" of others' activities, and this is preferred as a method for learning about others since evidence is often "stored" implicitly, and it is easy to retrieve.

- When explicit communication and information sharing is needed, workers show a preference for asynchronous communication and coordination techniques since it allows them to deal with schedule and location variability.

- The mobility and autonomy of workers makes it difficult for them to achieve synchrony, so synchronous collaboration is limited. This leads to limited back-and-forth discussions and necessitates a prioritization of the information that is shared.

In the following sections we review related work and describe the setting in which we carried out our observations. We then report on our major findings, and discuss their implications for the design of mobile CSCW systems.

2. RELATED WORK

Mobile collaboration is highly diverse. Kristoffersen et al. [22] note that mobile groups may use either centralized or decentralized information resources, may be technologically connected or disconnected, and may be engaged in cooperative or individual work. This wide variance in ways that mobile collaboration can be organized makes it necessary to begin looking at specific groups to determine how their characteristics influence the CSCW needs of workers [7].

In this paper, we investigate loose coupling as the primary means of organization in a mobile group. Coupling is the extent to which people work together [31]. Gutwin [16] describes coupling as "the amount of work that one person can do before they require discussion, instruction, action, information, or consultation with another." All groups do not necessarily favor a specific coupling style and may move back and forth between a tightly coupled and loosely coupled style of work (e.g. [18,12,8]). However, specific work settings may require one coupling style more strongly than others. For example, Kindberg et al. [19] show that clinicians in the UK who work at different fixed sites and share the care of a particular diabetic patient tend to work together in a loosely coupled fashion. In this case, the style of collaboration is adopted largely because of organizational constraints and physical distributions.

Grinter et al. [13] describe loose coupling as work that occurs relatively independently of others, and that requires a reduced level of communication. Olson and Teasley [26] further elaborate on this idea (p. 422): "loosely coupled work is work in which people need to be aware of others' activity and decisions, but without the need for immediate clarification or negotiation. The work can proceed in parallel." Loose coupling then is a style of collaboration that occurs in groups, and that implies that workers can function in a somewhat autonomous fashion without reliance on ongoing interaction with others. As described by Olson and Teasley [26], workers still need to stay aware of others' activities in order to manage group interdependencies. Baker [2] suggests that staying aware of others' activities is important so that workers can identify when tighter coupling (i.e. more collaboration) is appropriate.

We are interested in loose coupling that occurs in mobile groups. This has not been widely explored, but in one notable exception Churchill and Wakeford [6] suggest that the level of coupling in

mobile groups can be used as a design dimension for technologies to support mobile collaborators. They describe two coupling styles for mobile workers: tight mobility and loose mobility. In tight mobility, mobile collaborators need real-time synchrony with others in order to communicate and coordinate work. In loose mobility, mobile workers asynchronously access documents or information – while they still co-operate with others, the collaborative requirements are reduced. Loose mobility, then, represents a form of loosely coupled interaction specific to mobile groups. It implies that workers are not regularly synchronized with others, and that asynchrony serves an important role in information sharing between workers.

Loose coupling often occurs when it is difficult for workers to communicate directly, and a common reason for this is the physical distribution of workers across a wide distance [26]. Luff and Heath [23] consider the question of physical dispersion of workers in mobile settings, and they identified three types of mobile distributions: micro-mobility, local mobility, and remote mobility. Micro-mobility is described as the way an artifact can be moved and manipulated in a relatively circumscribed, "at hand" domain, but it is also suggested that it includes "ways of providing and receiving information whilst co-present with others." Local mobility describes mobility around a single worksite. For example, an individual might move between different rooms or floors in a building. Remote mobility describes individuals who move around different locations or worksites. When considering the findings of Olson and Teasley [26], we can reasonably expect that workers who are more widely dispersed, as is the case in remote mobility, are more likely to utilize loose coupling since they are less likely to be co-located.

Collaboration in groups that employ remote mobility has many of the same problems that are encountered in situated distributed groups (e.g. [24,15]), but mobility introduces additional complexities. Since physical location becomes a changing dimension in mobility, it is difficult for workers to stay aware of others' locations and availabilities [10,3], and this introduces a range of communication and coordination difficulties [3]. In mobile groups, workers may have more opportunities to see each other face-to-face since they do not work out of distributed fixed locations. However, the variability in time and location seen in remote mobility can make it difficult to establish any type of intentional synchrony, even when technologies are utilized [5].

3. STUDY SETTING

We have been working with clinicians and administrators in the Home Care department of Saskatoon District Health (SDH) for the past three years as a part of an ongoing project to develop group support technologies for home care clinicians. The functional unit for managing a community-based patient's care in SDH is a treatment team—a group of multidisciplinary workers who separately travel to a patient's home and deliver a range of services to that patient. Our focus in this research has been to develop an understanding of home care teams and the patterns of work and collaboration that take place in those teams.

3.1 Treatment Teams

Patients who receive home care services in SDH are treated in their homes by clinicians from several disciplines. The set of community-based workers who share a common patient are called a home care treatment team. Since each worker treats multiple patients during a workday (usually 6-15 depending on the discipline), and since teams

are formed around patients, each worker is a member of multiple teams.

Each team member serves in a well-understood role in the treatment team, that role being defined by the expertise of the discipline of that worker. Because of this, potential collaborators know whom they should contact to address specific issues. We summarize the focus of each community-based home care discipline below:

- Occupational therapists (OT's) work toward improving a patient's level of function in activities of daily living, such as dressing, cooking, or writing, through retraining and exercise.
- Physical therapists (PT's) focus on improving a patient's gait and strength through exercise and gait training.
- Social workers provide patients with counseling services.
- Registered nurses (RN's) and Licensed practical nurses (LPN's) deliver a range of nursing services such as wound care and medication management.
- Case managers evaluate patients and make referrals for other services. They try to keep tabs on the patient as time goes by to determine if new services are needed.
- Home health aides provide patients with a range of support services – they prepare meals, do laundry, and help patients get dressed in the morning.

3.2 Initiating Home Care Services

When an individual is flagged as a potential home care patient (usually this occurs during a hospital stay), a case manager visits and evaluates them to determine their appropriateness for home care services. If the case manager decides that home care services are needed, they create a care plan document that specifies the clinical disciplines that are needed to address the individual's needs, the expected treatment duration for each discipline, and the interventions that they recommend that each discipline provide. This care plan defines the treatment team for that individual. The case manager faxes the care plan to the supervisor for each community-based discipline, who then assigns the patient to a specific worker.

Once a professional discipline begins treating a patient, the worker from that discipline determines their level of involvement in the patient's care and the course their services will take. The recommendations of the case manager are best guesses, but the discipline (OT, PT, SW, RN) can change the content of treatments, treatment frequency, duration of services, and appointment times. All professional disciplines, then, are self-dispatched and self-directed once they receive the initial referral (in the form of the care plan) from the case manager. This self-direction is a function of professional boundaries—workers from a given discipline are considered experts in their treatment domain, and because of this, are considered the ones best able to direct their own treatment activities.

Unlike the professional disciplines, home health aides are more tightly supervised, and do not have the same level of autonomy seen in other community-based workers. They are centrally scheduled using a computer-based scheduling system, and they pick up their printed schedules from the office twice a week. Similarly, they are not free to revise the services they deliver without discussing revisions first with an office-based supervisor.

3.3 The Work of Home Care Delivery

The majority of a home care worker's time is spent providing services to patients in their homes and driving between appointments. Workers deliver treatments individually, and provide services within the scope of their professional expertise.

Workers also spend a significant amount of time filling out paper-based forms to document their interactions with patients. While many workers try to do their paperwork in patients' homes or in their cars, most workers (with the exception of home health aides, who do not have desks and do not spend time in the office) end up spending time in the office each day completing paperwork from previous days. In SDH, workers are responsible for maintaining their own paperwork, and they carry it with them throughout the day. Since the documents are mobile with the workers, they are not shared with other team members. In addition to documenting treatments, workers also fill out forms that indicate the treatments they plan to deliver to each patient, and fill out a daily schedule that is used to help them plan their workday (again, excluding home health aides who do not set their own schedules).

Workers have few technologies to assist them in their work activities. SDH does not provide workers with mobile phones, but some workers use their personal phones while working. Workers have voicemail access, and nurses and home health aides carry one-way numeric pagers.

3.4 Office Sites

Workers' offices are divided between two separate buildings across the city from each other. A worker's office is assigned based on their discipline, with nursing and case management having offices at one location, and OT, PT, and social work having offices at the other. With the exception of home health aides, each worker has a desk in a large room with other members of their discipline (see Figure 1). Management for each discipline is handled separately, and managers for each discipline have offices at the respective office sites. Managers for home health aides have offices at the downtown office site, but home health aides do not spend time in the office other than to attend training sessions and to pick up schedules and supplies. Each site has a separate set of support staff that supplies administrative support to the workers with offices at that location.
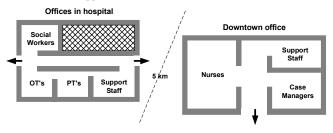

Figure 1. Physical distribution of office sites

4. METHOD

A primary goal in this research was to develop an understanding of collaboration patterns in order to inform the design of mobile groupware for community based clinicians in the health district. We were interested in how clinicians interact with support staff and with other more situated departments and individuals in the health district, but we did not conduct a separate analysis of these. Rather, we learned about these areas by investigating the clinicians themselves to determine how these interactions occur. We utilized two major methods of inquiry: interviews and field observations.

We conducted three rounds of interviews. Each round consisted of seven interviews, one with a member of each clinical home care

discipline. Participants for interviews, and for field observations, were selected by health district administrators, and participants varied across interviews rounds in order to give a range of perspectives from each discipline. Each interview lasted from 1 to 1½ hours. Interviews with case managers, social workers, occupational therapists, and physical therapists were conducted at that person's desk; interviews with nurses (RN's and LPN's) and home health aides were conducted in a private meeting room at the home care office.

The first round of interviews was informal and exploratory in nature, and we attempted to develop a general understanding of organizational issues and basic work patterns. In the second round, we attempted to identify current information utilization practices in home care, including documentation, team collaboration, and communication practices. During the third round of interviews, we were able to follow up on the findings from the first two rounds, and to discuss complex issues in further detail.

In addition to the interviews, we spent approximately 60 hours carrying out field observations to develop a detailed understanding of workers' day-to-day work activities. Since we were interested in work and collaboration, we focused the observations around individuals rather than on specific locations. A full workday was spent with a member of each clinical discipline, for a total of seven workers who were observed. The clinicians were observed while they carried out their daily work activities, with observations taking place in the office, in workers' car, and in patients' homes.

The field notes from the observations and the audiotapes from the interviews were then transcribed. We analyzed these transcriptions to identify interesting work and collaboration patterns.

5. FINDINGS

In this section, we will present the findings of the study. In our analysis, we focused on patterns of communication and coordination that occur within multidisciplinary teams of workers who treat a given patient. Our focus here is on clinicians—community based workers who provide services to patients, and while we were aware of office-based support staff, in the following sections we do not consider them part of the "team" since they are generally not privy to clinical information about patients, but instead support those who are. We begin by presenting an overview of loose coupling in home care teams. We then discuss four characteristics of our study groups that relate to loose coupling and remote mobility: discretionary collaboration and effort thresholds, implicitly shared information, asynchronous communication and coordination, and barriers to synchrony.

5.1 Overview of Loose Coupling in SDH

Mobile work in SDH is characterized by worker autonomy, remote mobility, and intermittent communication. Workers are generally autonomous—they determine their level of participation in patients' care, establish their own schedules and plans, and carry out the majority of their work activities individually. Their office hours are not known to others, and they do not have regularly scheduled team meetings, so face-to-face meetings do not often take place. Workers spend much of their time carrying out tasks that are not easily interrupted for communication, such as driving and delivering treatments, and it is difficult to maintain an awareness of others' locations, availabilities, and schedules. Collaboration can therefore be difficult, and workers usually communicate with each other intermittently, and often only when they believe the necessity of communication outweighs the effort required to communicate.

In spite of the intermittent nature of collaboration, workers are still interested in others' activities, and attempt to maintain an awareness of them. However, current work practices make this difficult, and this understanding is usually incomplete. For example, the documents (schedules, treatment plans, and medical documentation) each worker maintains during the work day contain information about each worker's activities. However, even though access to these documents could potentially improve coordination, they are maintained as separate and unshared "information buffers" [20] since each worker needs access to their documents at the site where the work is carried out.

Even though collaboration and information sharing can be difficult, the reduced interdependencies seen in home care have some benefits. For example, the mobile work environment seen in home care is unpredictable—workers may be delayed while driving between patients' homes or while delivering treatments. Loose coupling gives workers the flexibility that they need to handle this uncertainty, since they do not need to consult others when plans and schedules need to be revised.

5.2 Discretionary Collaboration

The autonomy of the individual workers seen in loosely coupled mobility means that collaboration with others is (in most cases) not strictly required; instead, workers engage in collaboration when they decide that it is valuable to do so. The fact that collaboration is for the most part discretionary implies that in each instance of potential engagement the worker must assess the tradeoff between the effort required to collaborate and the benefit that could be realized either for the worker or for the shared work focus. Therefore, there is now a threshold of effort under which mobile workers may decide not to collaborate – since they can get by without sharing information or seeking consultation, there will be situations where working together is not worth the overhead costs. This is particularly true given that work is not organized to promote collaboration, but to facilitate autonomy since it affords flexibility in dealing with unpredictable work settings [1,28,33].

In the case of SDH, interdependencies generally arise from goals that, although important, are not the main focus in the provision of care. That is, collaborating with other workers does not make the difference between being able to give or not give treatments, but it does make a difference to the overall quality of care and efficiency of delivery, in the much longer term. In the short term, however, home care workers can usually get by without extensive contact with other disciplines, and this is a necessary characteristic given the difficulty of contact.

This style of collaboration means that workers will know more about their own activities relative to shared work foci than is actually passed on to others. Even when information has been physically recorded in the form of plans, schedules, and patient records, this information is inaccessible to others, and is not available as a group resource. Even though this information is not shared, it does not mean that it is irrelevant to others or that others are not interested. Again, the barrier to this sharing is the level of effort required to explicitly communicate information to others, and information that is seemingly mundane is typically not shared. In the case of SDH, workers usually know a great deal more about the patient, their situation, and the services they provide to the patient

(e.g. why, how, when, etc.) than they communicate to others. While much of this information may be relevant to others, in many cases the person who holds that information may not know how relevant it is due to his/her lack of knowledge about others' work situations. In the following example, J points out the differences between information that gets communicated, and information that would be useful for a worker to access:

J, a PT: "We do a lot of messaging back and forth on voice mail. Here is my question—call me back with the answer. You know, that type of thing. Communicating with the nurses wouldn't be something that we do on a really regular basis, but when we need to do it, it is really important."

"A lot of times too it may not be something that we would even call the nurse about, but, gee, I would like to know what this guy's diabetes is doing right now just because that might explain this or that. It is not something important enough to track down the nurse to find out today anything new on the client [i.e. patient], but if we were able to sort of read what was happening with nursing and sort of the client's response to the nurse's visits and that, it would certainly complete the picture better for us. But because communication is difficult and always a challenge in the community, we pick and choose what we communicate about. But if we had better access, we would know a lot more about our client."

As seen in this example, communication usually occurs with other team members when "it is really important", but it is also usually restricted to those workers whose participation is necessary to see an issue through to successful resolution. In the examples that we will present in the next sections, the collaboration that does occur takes place between pairs of workers. This is done as a means of minimizing effort, since collaboration becomes more time consuming as the number of individuals involved increases. However, it also means that in many cases, some team members are unaware of problems that are considered urgent by others, but that are not communicated to them.

In the next sections, we examine three situations that reflect this relationship between effort and the collaboration practices of loosely coupled mobile groups. These situations are arranged in order of increasing collaboration effort, and are valuable for discussions about technology design because they highlight the value of lower-effort mechanisms for collaboration and awareness that could otherwise be overlooked. In the first section, we consider the problem of how mobile workers maintain peripheral awareness of others' activities. We then examine communication patterns for mobile home care workers, and discuss the value of asynchronous communication in mobile groups. Third, we look at the effort required to arrange synchronous communication.

5.3 Implicitly Shared Information

Managing and coordinating activities relative to shared locations and to shared work artifacts is a common aspect of working in a group. However, in loosely coupled mobility, since workers are not regularly co-present in shared locations, and since shared artifacts are often accessed asynchronously, and due to a range of communication and information sharing issues (we will discuss this in the next two sections), it is often difficult for workers to coordinate their activities relative to these interdependencies. However, our findings suggest that in loose coupling, the shared location and artifacts serve not just as an interdependency that must be managed; they also serve as an information space where awareness information about other workers' activities can be gathered.

When people interact with an environment, they often leave traces of their activity that others can pick up later (e.g. [17,30,14]). These traces can be obvious (e.g. creation of new objects, large changes to existing objects) or subtle (e.g. gradual wearing of a path). The kinds of information that can be gathered include information about presence (someone was here), specific information about particular activities (e.g. an opened window means that someone opened it) or information about patterns of use (e.g. where do people usually walk).

The idea of shared locations and artifacts as awareness resources is particularly germane for understanding loosely coupled collaboration in home care. By sharing a common patient and work site (i.e. the patient's home), collaborators who rarely meet face-to-face and who work from different offices can gather information about each other. Information shared is left implicitly—that is, workers do not have to expend effort in many cases to leave information about their activities. Additionally, the form of the information is such that it can be retrieved very easily by others, which is of crucial importance in discretionary-collaboration situations – where autonomous collaborators are unwilling to expend much effort to find out about others.

In SDH, workers gather information by observing physical evidence of others' activities in the patient's home. For example, OT's and PT's usually leave printed handouts that describe exercise programs, and nurses often leave supplies in the patients' homes for the next visit. These clues provide evidence that a visit has occurred recently, and some indication of the type of treatment that was given. E, a nurse, discusses how she is able to utilize clues in the patient's home to learn about others' activities:

E, a nurse, expresses that it is difficult "to know who's involved [in a patient's care] and when they [other team members] generally see them [any given patient] or how often they generally see them or what they are working on. For example, OT's, what kind of equipment they [the OT] may be looking into getting for that person [the patient]. We never know that kind of thing until it appears or the client [i.e. patient] says the OT has been here and I am going to be getting this or that."

In this example, E points out that it is difficult to maintain a basic awareness of the makeup of the treatment team, and the level of participation that others have in a patient's care. This is largely due to the autonomy of workers and their ability to determine their own level of involvement. This has implications for more explicit forms of communication since it may be difficult to know who should be involved when communicating about or coordinating work activities relative to a given patient.

E points out two sources of awareness information: the physical evidence in the patient's home and information that is provided by the patient. The patient represents the single shared resource that receives the focus of the team's efforts, so the patient is aware (assuming that they are not cognitively impaired, as is sometimes the case) of all interactions they have had with members of the treatment team. Because of this, workers regularly talk with the patient and attempt to learn about others' activities and levels of participation. Additionally, patients often volunteer information to workers when they feel it is relevant:

[D, a PT, is in patient Y's living room and is instructing Y through an exercise program] Patient Y states that she becomes very fatigued when D and the OT both visit her on the same day, and that D and the OT both ask her to do upper body exercises. D states that she was unaware of the treatment overlap and that she will begin focusing on lower body and trunk exercises in the future, and will allow the OT to handle the upper body.

In this case, D was not aware that there was an overlap in treatments with the OT (i.e. both were carrying out upper body exercises). The patient informed her of this, and she adjusted her treatments to accommodate this new information.

As we can see in SDH, even though the shared patient and the shared work location can provide workers with access to information about others' activities, this type of information does not provide a full account of others' activities. Since workers usually leave physical evidence unintentionally, they do not usually attempt to make sure the information is complete. Even when obvious evidence has been left, the patient or their caregivers may clean the home, and remove the evidence. Additionally, problems arise with using the patient as an information source. At times, patients do not understand the treatment activities provided by workers, and they may have difficulties explaining the treatment to others in a way that is understandable.

5.4 Asynchronous Collaboration

Asynchronous communication does not allow for the efficiency seen in the rapid back and forth that occurs when people are synchronous, but in loosely coupled mobility it is favored over synchrony since it allows team members to deal with their lack of awareness of others' locations, availabilities, and schedules. Messages that are left asynchronously persist, and can be retrieved by the recipient when they are able to read or listen to them. Unlike other types of mobile groups (e.g. [5]), our observations in SDH showed that asynchronous communication is not used primarily as a means of shifting to synchrony, but rather to help workers coordinate activities, and to selectively push and pull information within the group.

Asynchronous messaging is used extensively in SDH in part because of the nature of mobile service work—many workers state that it is unprofessional to talk on the phone in front of a patient. In addition to this, many treatments cannot be easily interrupted to become synchronous. Time in patients' homes, along with time spent driving, account for the majority of the hours in a worker's day. So, in this case, the nature of the work strongly favors asynchrony since each worker can find the best time in their schedule to retrieve and deal with messages.

In SDH, most asynchronous messages are passed on using voice mail, handwritten notes, and messages passed through the office staff. The flexibility of asynchrony and its ability to accommodate each individual worker's schedule and availability can be seen in the daily activities of P, an OT:

P leaves the office and spends the morning in the community treating patients. Around noon, P stops at a café to have lunch. After finishing lunch, P uses the pay phone in the café to phone in to check her voice mail messages. She writes down the important points from the messages [in this case, the messages convey information about the changing statuses of specific patients, passed on by other clinicians who treat them], and then files the written

messages into the folders that hold the documentation for the relevant patients. P looks up the voice mail number for L, the PT that treats one of her patients. She phones L's voice mail number, and leaves a message telling her that the patient's wife reported that he has fallen twice in the past week [mobility and falls are one of PT's primary concerns].

In this example, we can see how P uses downtime in her schedule to retrieve her messages. From our observations, the strategy used in this example is typical—workers seek out a quiet place where they can take notes and return calls before checking their messages. SDH does not provide workers with mobile phones (although workers report that a modest number of SDH home care employees carry their personal mobile phones with them, none of the workers we observed had a phone), and most workers do this from the office, gas stations, or restaurants. This strategy is flexible, and it accommodates the autonomous nature of loosely coupled collaboration—workers check and respond to messages when they are able. This example also shows the typical use of asynchrony to address specific issues rather than to pass on routine information. In this case, the repeated falls of the patient were worrisome to P, so she phoned the PT, who is the expert on mobility issues, and is the most qualified to address the problem.

The intent behind asynchronous messages is usually to resolve a specific issue—to pass on information, to get a pressing question answered, or to coordinate activities. So, these asynchronous interactions are typically shaped by need, and with a specific goal. This asynchronous, need-driven interaction style limits the range of information that workers can access. Unlike the mobile workers discussed by Perry et al. [29] who regularly become synchronous with mobile phones to check up on projects and developments in the office, the asynchrony seen in loosely coupled mobility often precludes the type of rapid back and forth that is required to pass on often seemingly inconsequential information that is needed to maintain an awareness of others.

5.5 Barriers to Synchrony

Even though asynchrony is favored in loose coupling, some work situations require full synchrony. However, when synchrony is required, workers must overcome the barriers that make synchrony less frequent in the first place. The difficulty of becoming synchronous is primarily the result of two factors. First, in loose coupling, work is not organized to facilitate regular synchrony with others. For example, in SDH, workers do not spend part of the day in the office to "catch up" with other team members. Second, as we have previously mentioned, limited awareness of others' locations, availabilities, and schedules makes it difficult to initiate synchrony face-to-face or using the phone.

From our work in SDH, we generally see a higher level of effort required for initiating intentional synchrony with others (i.e. synchrony that requires negotiation to set up) than in asynchrony, and therefore, the level of urgency required for initiating synchrony tends to be higher. Synchrony is usually only sought out when back-and-forth discussion is needed to resolve an issue, which, in our observations, generally indicates a more complex work situation. So, for example, in SDH synchronous communication may occur because of changes in a patient's needs, unexpected events involving a patient, or a need to coordinate treatments more closely. In one case, a nurse and an occupational therapist used synchronous

communication to coordinate their treatments for a patient with a somewhat urgent condition:

E, a nurse, visits a patient in the afternoon [The patient has a longstanding history of skin breakdown over the sacrum as the result of sensory loss and poor positioning when sitting in his wheelchair]. She changes the dressing that covers the wound on the tissues overlying the patient's sacrum. After changing the dressing, she tells the patient that the wound has worsened. When she returns to the office later that afternoon, she phones the OT who also treats the patient, and leaves a voicemail message telling the OT about the condition of the wound and recommending that the OT may want to revisit the patient's sitting schedule [i.e. the amount of time he sits, lies down during the day] and the positioning devices he uses when he sits in the wheelchair. The nurse asks the OT to call her back at the office. The OT calls back approximately 45 minutes later, and they discuss the situation and jointly develop a new sitting schedule, and the OT agrees to investigate new positioning devices for the patient.

In this case, synchronous communication was necessary to coordinate activities in order to resolve the patient's needs, needs which required the joint expertise of both disciplines. In most instances, when we observed synchronous communication used as a means of coordinating work as is seen in the example, workers attempted to minimize the need for ongoing synchrony as much as possible by developing plans for future action so that further negotiation would not be needed.

This example also illustrates how shifts are typically made to synchronous communication. In most cases, we observed workers using asynchronous communication to facilitate these shifts, usually in the form of messages such as, "Call me in the office—I will be in from 2:00 to 3:00." This strategy, however, is not always very effective, and some workers report that it is not unusual for it to take a few days before they are able to talk with another team member on the phone. This delay is often the result of delays in receiving and responding to asynchronous messages. Due to the autonomy of workers in loosely coupled mobile groups, it is possible that workers may not have an opportunity to retrieve and respond to asynchronous messages until hours after the message was actually sent. Therefore, there is a delay in the response time, so the message sender may not be available for synchrony when the recipient tries to reach them. These difficulties, and the difficulties that arise from a lack of information about others' locations, availabilities, and schedules can be seen in comments from J, a physiotherapist:

J, a PT: "We can actually call the nurse directly [nurses have phones at their desks], but they are tough to get a hold of. They are in very early—in and out usually before we are even in. And then at the end of the day they may be in but we are usually out, and do not come in at the end of the day. And it is hard to call a nurse from a client's home and discuss another client over the phone, so sometimes we have to make a point of coming back in here so that we can call a nurse, you know, that type of thing. And sometimes the nurse can get a message to call us, and they may be able to find a place to call us during the middle of the day, but will we be at our desk? I don't know."

In addition to phone-based communication, SDH workers occasionally utilize face-to-face meetings to exchange information with others. These meetings may occur in an opportunistic fashion where workers see each other without a mutual plan to meet.

However, the physical separation between workers' office sites makes meetings between workers from certain disciplines rare (see figure 1). Even when workers have offices in the same site, the schedule variability between workers reduces opportunities for these meetings to occur, as described by J below:

Interviewer: "You share the same office site with social work and occupational therapy. How does this affect your communication with members of those disciplines?"

J, a PT: "It isn't always as easy as that because everybody is always coming and going at different times. You are certainly more apt to bump into them than you would, say, nursing because they are not on site here, but we still do leave a lot of voice mail messages for each other and that kind of thing. Normally we are mostly in for the first couple of hours in the morning and we don't usually return at the end of the day—some people will, but that is not our usual pattern. Usually the OT's and the social workers are in the office in the morning, but we don't have set rules about that. So you might want to talk to an OT and they have gone out on an early a.m. dressing kind of visit and they are back in and you are gone, so it's not a set thing."

This example illustrates a more general principle in loosely coupled mobile groups: work is not organized to facilitate synchrony, and when synchrony is needed, this lack of organization makes it difficult. The work group is not centralized, and a common hub is not regularly utilized to facilitate co-present meetings. As we have suggested in other sections, this lack of opportunity for regular face-to-face, agenda-free and casual conversations prevents explicit communication from being used to regularly convey mundane information about others' work activities. The result of this, as is regularly reported in SDH, is that workers are forced to make decisions and carry out work without access to a full range of potentially relevant information.

6. IMPLICATIONS FOR DESIGN

In the next sections we discuss the implications of our findings for the design of CSCW tools that support loosely coupled mobile groups. We discuss the need to maintain flexibility, to consolidate workers' information buffers, to support loose coordination, to augment physical spaces, and to support loose communication channels.

6.1 Preserve Flexibility

Our findings from SDH show that while a loosely coupled group structure causes difficulties in communicating and coordinating work, it also provides workers with the flexibility they need to function effectively in an uncertain mobile work environment. The home care work setting is unpredictable—workers can get caught in traffic, and they often have little control over events in patients' homes that can force revisions in their daily plans. Workers need the flexibility to revise their plans without consulting others.

Literature from organizational research suggests that loose coupling is an adaptive way for organizations to structure work when work environments (i.e. factors that influence work but are external to the group or organization) are unpredictable. Scott [33] argues that (p. 603) "loosely joined structural elements are seen as highly adaptive to systems confronting heterogeneous, conflicting, and changing environments." Similarly, Orton and Weick [28] see a fragmented external environment as a cause of loose coupling, and adaptability,

which they describe as assimilation and accommodation of change, as one of the direct effects of loose coupling. Loose coupling is seen as affording more adaptability and flexibility in changing environments because individual subunits are more autonomous and are free to rapidly adjust to changes in their specific circumstances [1], presumably without consulting others.

The flexibility seen in loose coupling is one of the central issues that must be considered when designing CSCW applications, particularly when workers are mobile and must contend with associated environmental uncertainties. While loose coupling may seem to be a problem that needs to be solved through the addition of tools that facilitate tighter communication and coordination channels, this is not necessarily the case, since this increases interdependencies and sacrifices strategic flexibility that is needed to carry out work activities. We argue that CSCW technologies can have a positive impact when supporting loosely coupled mobile groups, but that designs should not force tighter coupling, should not increase interdependencies, and should allow workers to maintain flexible work practices. In the next sections, we will cover four possible strategies for accomplishing this.

6.2 Consolidate Information Buffers

As pointed out by Kmetz [20], loosely coupled work can cause fragmentation of the information needed to support work activities across the locations where the work is carried out. This is particularly true in mobile work, where workers work out of different locations and need adequate information on hand to support their work. These information buffers are not accessible by others: for example, SDH workers maintain clinical notes, schedules, treatments plans, and other miscellanea such as phone numbers in paper folders that are not shared with other disciplines.

Since maintaining information buffers is part of work patterns seen in loose coupling, CSCW systems can have a role in supporting these practices. These information maintenance practices provide a design opportunity to consolidate information that is fragmented across multiple locations, and to make it visible to other team members. Shifting from locally maintained information buffers to a merged group repository has the potential to improve awareness and coordination within teams. However, this approach has some obvious risks.

One of the advantages to information buffers is that (p. 272) "they are used at the discretion of those having access to them, and their very existence can be denied, if necessary" [20]. This discretionary access to information buffers raises the question of privacy and permissions when moving to a shared computer-supported information repository. This can be seen in our study as well, since some workers are unwilling to share certain types of information that they maintain locally because they feel the information is sensitive and is given to them in confidence by patients or their family members. These concerns with discretion, and the relative autonomy of workers, means that when developing shared information repositories to support this type of loosely coupled work, workers should be able to protect private information from others, and that a strict form of information sharing is not practical.

Merging information buffers also has the potential to threaten the autonomy and flexibility of loose coupling if the design, policies, or expectations associated with a CSCW system require workers to provide information within given timeframes or to provide information in excess of what they are normally accustomed. This approach has the potential to introduce additional interdependencies, rather than accommodating current work practices.

6.3 Support Loose Coordination

Since regular communication channels are not usually present in loosely coupled mobile groups, and since workers have limited awareness of others, coordinating work can be difficult. While the general autonomy of workers means tight coordination is not usually necessary, interdependencies may make it necessary for group members to coordinate their activities at times. For example, in SDH workers are autonomous and can usually make decisions about their own activities without worrying about how they impact others. However, at times a lack of insight into others' activities can lead to undesirable outcomes such as schedule collisions, service replication, or to the delivery of contraindicated services.

When considering the role CSCW technologies can play in facilitating coordination in loosely coupled mobile work groups, the tradeoff between coordination mechanisms and worker flexibility must be carefully evaluated. Heavyweight coordination mechanisms that require strict commitments by workers and ongoing negotiation can be detrimental since this approach can decrease workers' autonomy and flexibility, and can require ongoing communication which is effortful. Given the uncertainty of mobile work settings, workers may have difficulties meeting to strict timelines due to unexpected events and delays, so lightweight and low cost coordination mechanisms seem to be a better fit.

Lightweight coordination mechanisms for loosely coupled mobility ideally would facilitate mutual adjustments to others' activities without the need for negotiation, an outcome that requires significant awareness of others' activities. Scott [32] suggests that one way of achieving this type of low overhead coordination is through the use of schedules and plans, since they generally do not require the ongoing involvement of workers once they are established. However, in mobile and loosely coupled work settings, workers may operate according to individual, autonomously established plans and schedules rather than adhering to a group plan or a group schedule. This approach allows workers to adapt to the uncertainty of a mobile work environment, but does not facilitate coordination within the group. However, sharing the information that is available in these individual plans and schedules within a group (and organizing and representing it in a meaningful way) can still achieve the same result – workers know what actions others are carrying out relative to shared work resources and foci, and they know when they plan to carry them out, so that they can make appropriate adjustments to their own work activities. In preliminary field trials of a CSCW system in SDH, we made workers' individual plans and schedules visible to other group members, and our initial results suggest that this approach improves coordination without sacrificing autonomy and flexibility.

6.4 Augment Shared Physical Spaces

In loosely coupled mobility, workers are not often in the same place at the same time. However, common spaces, such as offices or other worksites, may be shared asynchronously (i.e. same place, different time), and any common space that does exist can play an important role as an awareness resource for the workers. For example, in SDH team members asynchronously share the patient's home as a common work site, and make use of information that is available in that space to maintain an awareness of others' activities.

These common spaces provide access to information that cannot be found through other means, and require very little effort both for the person who leaves the information and for the person who gathers it. However, common workspaces for mobile groups may be public or belong to someone else, and they do not always provide sufficient information for workers to maintain reasonable awareness. It is possible that the information-holding capacity of these real-world shared spaces themselves could be augmented to overcome some of the limitations observed in our study, and to allow workers to be more aware of others' activities and more able to share information.

For example, GeoNotes [9] allows users to place virtual notes that are attached to real world locations. The notes can be accessed at that location with mobile phones and PDAs, and workers can be alerted when they come into close physical proximity with a note. While this technique seems to be a promising way of contextualizing messages by attaching them to a site, the need to explicitly compose and attach messages limits this technique to intentional communication only. However, an approach like GeoNotes that implicitly gathers and shares information such as who has recently visited a location, when, and the duration of time in location could improve awareness and enrich information access in the real world common space.

6.5 Support Loose Communication Channels

One of the side effects of loose coupling and mobility is that workers have few opportunities for informal face to face communication, and purposeful explicit communication can be difficult to initiate. The decreased incidence of communication is not necessarily a problem for workers given the need maintain flexibility through reduced interdependencies. However, the level of effort required to initiate communication when it is needed is problematic, since workers must deal with uncertainty about others' locations, availabilities, and schedules. Therefore, when designing CSCW systems the goal should not necessarily be to increase the amount of communication that occurs in loosely coupled mobile groups, but to lower the amount of effort that is required to initiate communication when it is needed.

In our findings, we see that asynchronous communication is often preferred, since it accommodates workers' need for flexibility and does not force them to interrupt current work activities to retrieve messages. Instead, the recipient has the flexibility to retrieve messages whenever it best suits their work schedule, and the sender does not have to worry about recipients' availabilities. This level of communication can be achieved with many current technologies such as text messaging, voice mail, mobile phones, and alphanumeric pagers. However, while these technologies are useful communication tools, limited awareness of others' can make it difficult to utilize these technologies effectively.

Common communication technologies (e.g. mobile phones, pagers) provide workers with a communication channel, but they do not necessarily provide them with the range of information that is needed to support the effective initiation of communication. Since loosely coupled workers work with limited contact with others, they may be unaware of changing group membership and variable levels of participation, so it can be difficult to determine who relevant parties are when communicating with others. Communication technologies for loosely coupled mobility should allow workers to easily determine who needs to be involved in communications, and to target specific subsets of the group. Additionally, on occasions

when more synchronous forms of communication are needed, workers should be able to coordinate synchrony with others with little effort. As we discussed previously, information about others' schedules and plans has the potential to assist with this, as do emerging technologies to help ascertain workers' availabilities (e.g. [34,25]).

7. CONCLUSION

In this paper, we presented results from interviews and fieldwork with home care teams, and considered how the loosely coupled characteristics of collaboration shape workers' activities and patterns of collaboration. Our findings suggest that loosely coupled work patterns allow workers to deal with the uncertainty of mobile work environments. Since collaboration and interdependencies are minimized, workers usually have the flexibility to deal with the unpredictability of the work setting without consulting others. In cases where collaboration is required, workers use discretion when initiating contact with others, and attempt to do so in ways that minimize the effort required. Workers make use of awareness information available through shared work locations and common artifacts as the lowest cost means of collecting information about others. When more direct communication is needed, workers prefer asynchrony to synchrony since it allows them to overcome uncertainty about others' schedules, locations, and availabilities.

Our findings have several implications for the design of CSCW technologies for loosely coupled mobile groups. Designers must carefully consider the impact CSCW technologies will have on the flexibility that is provided by worker autonomy and limited interdependencies within the group. We considered how CSCW tools can help facilitate collaboration while preserving this strategic flexibility. We considered how fragmented information buffers can be merged to improve information access and awareness, how loose coordination can be facilitated by providing low cost mechanisms that do not require ongoing negotiation, how physical spaces that are shared asynchronously can be augmented to further promote awareness and explicit communication, and how loose communication channels can be facilitated by improving access to information about group membership and levels of participation.

We are currently carrying out field trials in SDH with a mobile CSCW system that we have designed based on our findings.

8. ACKNOWLEDGMENTS

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