MyConnector – Analysis of Context Cues to Predict Human Availability for Communication

Maria Danninger, Tobias Kluge, Rainer Stiefelhagen
InterAct Research, Interactive Systems Labs
Universität Karlsruhe, Am Fasanengarten 5, 76131 Karlsruhe
(maria, kluge, stiefel)@ira.uka.de

ABSTRACT

In this thriving world of mobile communications, the difficulty of communication is no longer contacting someone, but rather contacting people in a socially appropriate manner. Ideally, senders should have some understanding of a receiver's availability in order to make contact at the right time, in the right contexts, and with the optimal communication medium.

We describe the design and implementation of MyConnector, an adaptive and context-aware service designed to facilitate efficient and appropriate communication, based on each party's availability. One of the chief design questions of such a service is to produce technologies with sufficient contextual awareness to decide upon a person's availability for communication. We present results from a pilot study comparing a number of context cues and their predictive power for gauging one's availability.

Categories and Subject Descriptors

H.5.2 **Information interfaces and presentation**: User Interfaces.
H.5.1 **Models and principles**: User/Machine Systems.

General Terms

Design, Human Factors, Measurements.

Keywords

Context-aware communication, Computer-mediated communication, User models, Availability, Interruptibility.

1. INTRODUCTION

Should I call her? Should I email and hope she reads it? What was her schedule? I don't want to disturb her again in a meeting. If she was online right now, I could ask her. Similar questions arise too often when we are trying to figure out how to best reach someone.

Ideally, senders should have some understanding of a receiver's availability in order to make contact at the right time, in the right contexts, and with the optimal communication medium. To find out whether a system would be able to help, and how good it could become, we need to find out what information a system would need in order to be able to guess a person's availability for communication. Their personal calendar information? Current location? The active program on their PC? Keyboard events within the last ten minutes? Their engagement in the current activity? Or the presence of others? And many more.

ICMI'06, Nov 2–4, 2006, Banff, Canada.

1.1 Communication in mobile contexts

Modern communication technologies bring considerable advantages, as well as burdens, to both the sender and the receiver in a communication [17]. Despite the fundamentally social nature of communication, research and design of communication technologies disproportionately favors the initiators of communication, the sender, over the target of communication, the receiver. Therefore, the guesswork involved in making decisions about *how* and *when* to contact someone is placed in the hands of the sender. The sender calls when their situation is conducive to communication, but they do so with little knowledge of the receiver's situation. The problem is further exacerbated with the advent of mobile communication which decouples location from situation, thus decreasing the capacity for a sender to make informed decisions about the person they are calling. In the past, people were called at locations which reasonably described their current activity e.g. home, work, or school, but now that mobile phones are anywhere that people are, little contextual information can be inferred about the state of the receiver.

If there is no need to communicate in a synchronous way, this problem is much less apparent. Asynchronous communication, such as email, is reasonably convenient since the sender worries less about disturbing the receiving party. Instant messaging clients let the receiver set one's own online availability status. However, the growing use and constant attending to instant messages often becomes a distraction to users [1][6]. IM users are obviously aware of this pitfall as they very often use it to negotiate availability for a phone conversation [8].

1.2 MyConnector

Within the framework of the CHIL project - Computers in the Human Interaction Loop - we intend to develop context-aware, proactive computer services that assist people during daily interactions with others [4]. Rather than expecting people spend their time attending to technology, CHIL's goal is to develop computer services that are sensitive in attending to human activities, interactions, and intentions. In order to act in a proactive yet implicit way, services should be able to identify and possibly even understand human activities.

In this paper, we describe our ongoing research on a CHIL service called the Connector [5]. The Connector is designed to intelligently connect people at the right place, the right time, and with the best possible medium for socially appropriate communication. MyConnector is the personalized extension of the

Connector service. The goal of MyConnector is to eventually adapt to users and learn their availability. In order to inform the development of this technology, we have conducted a pilot study to understand which or which combination of a large set of context cues have a strong predictive power for gauging one's availability. Some of these context cues were already collected automatically others were manually updated by participants in our study.

The remainder of this paper is organized as follows: After an overview of related work in Chapter 2, Chapter 3 describes the implementation of the MyConnector prototype application and how it learns receiver availability and broadcasts updates to senders. Chapter 4 discusses the pilot study and results, followed by ideas about future work,

2. PREVIOUS WORK

Estimating human availability or interruptibility is known to be a very hard task [15]. Current computer and communication systems are mostly designed in a non-proactive way, passively waiting for the user to initiate interaction, or they need to be temporarily disabled by the users. Since non or all interruptions are disables, wanted interruptions, such as an important phone call, could be missed. As well people often forget to re-enable the system afterwards [7].

Different groups have addressed this issue by trying to sense in-the-moment interruptibility, mostly in office environments. Horvitz et al. have examined models based on calendar information, PC activity and audio and video streams [12]. Fogarty et al. have used built-in laptop microphones, motion sensors and computer activity information to learn interruptibility with statistical methods [14].

There has been a significant amount of effort placed on understanding and adding context to technology-mediated communications, such as instant messaging systems and mobile phones. Brown and Randell [3], in their essay on context sensitive telephony, discussed the possibility of an automated agent that blocks calls on the behalf of users. They concluded that a better solution would be to provide the receiver's context information to the caller to let the caller make a more informed decision about whether or not to initiate contact.

The designs of a number of mobile awareness systems align well with this approach. Context Phone [16] is a Smart phone application which enables users to share their context with others who use the same application. Both "Awarenex" [9] and "Live Addressbook" [7] are systems on mobile devices that allow users to see others' location and availability status with an interface similar to today's instant messaging buddy lists. The "Live Contacts" system [11] also provides preferences for communication channels. "Enhanced Telephony" [10] is a desktop-based design of an enhanced PC-phone. The "Lilsys" system has used ambient sensors in order to enhance an IM client [2].

In all of these systems, users must either manually update their availability state or context information is inferred automatically from sources such as login time, personal calendars, messenger status, idle time of computer input devices, and engagement in communication activities.

MyConnector is following in this direction and combines many of the features mentioned above. MyConnector integrates phone, instant messaging and email communication channels, and clients broadcasting others availability run on smartphones, mobile phones, or as web service. Our pilot study covers a broad set of contextual cues collected from four subjects over a period of one week, and we will compare them to prior findings. In contrast to most of the prior work, our goal was to include as many context cues as possible in our analysis, not limited to existing technology. We used technology to track PC activity and calendar entries, while other cues were self-reported by participants.

3. MyCONNECTOR FUNCTIONALITY

MyConnector is an extension of the Connector service [5], designed to model contextual knowledge about the user and to infer the user's availability for communication. It broadcasts receiver's availability to potential contact persons.

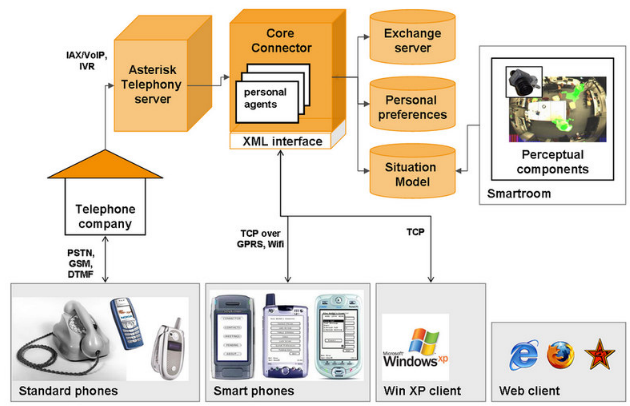

Figure 1. MyConnector: Overall system architecture. Frontend client communicate to server-side agents.

The overall system architecture is illustrated in Figure 1 and shows how various clients are integrated and communicate to the core Connector module. All the logic is placed on the server side of the system. The core Connector module is responsible for collecting contextual information and learning the users' availability model. It tracks PC activity and calendar entries. Data such as user preferences and settings are stored in a database. Calendar information is hosted by an Exchange server. The client-server communication is XML-based over TCP or GPRS.

Speech or graphical user interfaces run on a variety of client platforms, such as smartphones, laptops, and traditional telephones. MyConnector clients running on WinXP or as web service integrate phone, instant messaging and email communication channels. Users can choose between a variety of communication channels depending on available devices and communication networks. Their main purpose is to broadcast receiver availability to senders to enable more informed decisions on when and how to contact somebody.

3.1 Communication channels

Discussing all features of the four Connector clients goes beyond the scope of this paper. In the following, we will concentrate on how each of the clients broadcasts receiver availability to potential contact persons.

3.1.1 Standard phones

In order to allow people to easily call the MyConnector service from any phone, we have set up a server running Asterisk. Asterisk is an open source software voice over IP telephone private branch exchange (PBX). By calling a person's (toll-free) Connector number, the call is routed through our telephone server. As the caller, once you identify yourself and the person you want to contact, the Connector service will inform you about the receiver's current availability for phone communication; and then proceed to route or block the call, accordingly. MyConnector can as well support calling a team, or group of person's. When a group is called, Connector offers connections to those group members who are currently available.

3.1.2 Smart phones

Connector smart phones run a custom-built graphical Connector user interface, visually indicating current receiver availability directly in the address book. Currently supported platforms include Sony Ericsson P900 Symbian phone and Windows CE devices. When calls come in, the smart phones establish a GPRS or Wifi connection to the Connector server to determine how to respond to the calls or messages. Smartphones can as well block inappropriate calls, or adjust their notification behavior to the user's situation.

3.1.3 WinXP client

Figure 2 shows a screenshot of the MyConnector PC application, running primarily on WinXP. Along with phone communication, it lets the user send emails, send instant messages, and allows conference calls (via the Skype API).

Figure 2. Screenshot of the MyConnector Windows XP client. Symbols in the contact list show how someone can be contacted and initiate contact on click.

In the contact list, various symbols are displayed showing the availability of the contact person for communication media such as Skype IM, Skype call, email, office phone, home phone and cell phone. The WinXP client is able to gather PC activity in the background, and can feed this information to the MyConnector server to learn user availability.

3.1.4 Web client

User profiles and current availability are also viewable from web browsers, through the *myConnector.net* domain. Each user has a public profile accessible by anyone and different custom profiles which typically have more detailed information for selected individuals. Figure 3 demonstrates a public profile. We integrated the Google Maps service to display the current location of a user. Also, an overall availability level and details of the person's current location is displayed. Icons indicate availability for different communication media; some active icons may be clicked to contact the person. The level of information granularity displayed is user-defined in the owner's privacy settings.

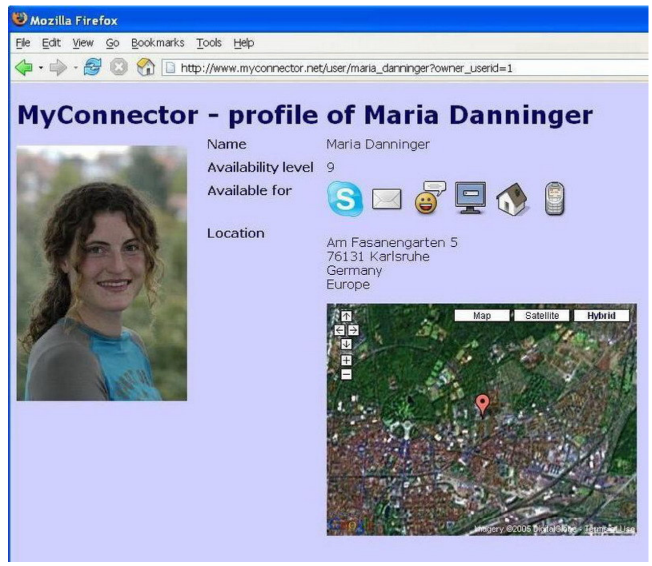

Figure 3. Web interface showing a public profile.

3.2 Related privacy issues

Whenever personal data such as this is broadcasted, privacy immediately becomes an extremely important issue to the user. This becomes obvious, as most people do not want their detailed location being shown in a Google map on the web. MyConnector provides the opportunity to specify *who* should be able to see *what* information *when*. E.g. *I want all my colleagues to see the building I am in, but only during working hours, but my family can always see where I am. The default should be only specifying what world continent I am on (as opposed to what country, city, street, building, or room).*

We implemented hierarchical privacy rules in a rule based system. Each rule specifies when it will fire depending on the time of day (free time or work time) and the location of the user. Such privacy rules can be created for users or groups in the address book; the default setting is used for unknown persons.

According to previous research, it is necessary to provide appropriate default settings when it comes to privacy related data. We ran an online survey with 43 people to find appropriate default privacy settings for our service. In this survey people were asked which details about their location and current activity they would like to broadcast to their wife/husband, family, friends, acquaintances, coworkers and their boss, during work time and free time. Results were showed that the time of day seemed to be only relevant for work-related persons (co-workers, boss), who should not get the same information during free time. As expected, less known persons (such as acquaintances) were less trusted than people in more proximate social circles (such as family and friends).

3.3 Learning availability in MyConnector

MyConnector uses machine-learning techniques to model contextual knowledge about the user and to infer the user's availability for communication. Input comes from the following context cues**,** which are automatically detected and uploaded to the MyConnector server.

3.3.1 Contextual information used by MyConnector

Personal calendar information is collected via a Microsoft Exchange server. Most users manage their appointments with the web interface, and the WebDAV interface allows to programmatically access this information.

PC activity data, such as the *number of mouse clicks* and *keyboard events*, *windows switching frequency* and *active programs*, is collected within the MyConnector WinXP application. This information is only accessible if a person is working at the computer, with the MyConnector application running.

Skype activity is tracked by the MyConnector WinXP application. We detect the following information: *Skype is running*, ongoing *Skype instant messaging conversation*, ongoing *Skype call or conference,* the *number of participants* in a conversation or call, the *number of messages* being sent and received.

3.3.2 Bayesian learning approach

Our system uses Bayesian networks to learn a person's availability. Bayesian network models are used to compute cumulative distributions over events of interest. This approach promised to discover generalizations and to provide a means for fusing multiple distinctions about the various context cues. Bayesian learning also provide a principled method for addressing potential sparse data in the early collection of data. A similar approach can be found in [13].

Supervised learning was applied in order to create a predictive model (that is gathering data along with labels that represent ground truth about the data). In our case, the ground truth was the person's self-reported availability. A drawback of such an approach is that it is very time-consuming and thus hard to get large amounts of data. In order to train the classifier, users of the system specify their availability for communication.

3.3.3 Availability as ground truth

When asking people about their availability for communication, it is hard to get a simple answer. When gathering data to train our Bayesian learning classifier, we asked people to provide us with the following information. We asked for a *general availability level from 1-4*, indicating how available someone is for communication, 1 meaning that a person is not available at all, and 4 meaning very available for communication. However, this level is independent of physical access to any communication media or devices. Additionally, we asked people to indicate their availability for different *communication media*, indicating whether they have physical access to their cell phone, office phone, home phone, email and Skype. Last, users specified the *type of conversation* they would currently be available for: for a very short question, a short discussion or for a longer (five minutes plus) conversation.

4. PILOT STUDY: WHAT ARE POWERFUL CONTEXT CUES?

Many more context cues then the ones currently collected by the MyConnector system may be used to determine a person's availability for communication. We conducted a pilot study in order to investigate the predictive power of context information currently used by MyConnector, as well as a number of possible future measures, that were self-reported by our subjects in this study.

4.1 Study design

In order to detect the best context cues to predict people's availability, we ran a pilot study with four participants from our research lab in Karlsruhe over a period of one week. A total of 1279 self-reported data points have been collected, not including large amounts of automatically collected data, such as PC activity. Each of the participants installed the MyConnector WinXP application on their laptop computer. Participants were asked to report their availability at work and also in their free time (we will also refer to this as "pinging"). However, only two of the participants provided data in their free time. Online connection was not needed. The system was able to store pinging results and send updates to the server when connected. Participants could as well fill out missed pings later on.

4.2 Data collection

We used an experience sampling technique, and pinged subjects about their current availability and current activity during their normal daily activities. A popup window as can be seen in Figure 4 appeared on their screen every 20 minutes. By simultaneously collecting sensor data we can run our learning algorithm offline and examine which of the following factors would have produced the best estimates of one's availability.

- The *time of day*
- *Personal calendar information*
- *PC activity*
- *Skype activity*
- the *current location*
- *collocation* with others (alone, dyads, small groups (3-7) or large groups (8 and up))
- *interaction* with others (alone, dyads, small groups (3-7) or large groups (8 and up))
- the *current activity* (out of basic-, intellectual-, interpersonal, personal- and transportation needs)
- *mental engagement* while doing the current activity (high, medium, low)
- *physical engagement* while doing the current activity (high, medium, low)
- *the importance* of the current activity (high, medium, low)
- *the urgency* of the current activity (high, medium, low)
- the *point in the lifespan* of the current activity (begin, middle, end).
- Ground truth was a self-reported availability level between 1 and 4. 1 meaning *not available at all* (e.g. sleeping, swimming), 2 meaning *basically not available, but*

exceptions possible (e.g. meeting, driving a car), 3 meaning *busy but can be disturbed* (e.g. internet browsing, preparing slides) and 4 meaning *idle, communication encouraged* (e.g. oing public transportation, waiting for an appointment).

For the offline data analysis, we used an iterative learning approach to get comparable results to an online classifier. Data entries were sorted by timestamps, and for each data entry t the classifier has been trained on data entries 1 to t-1. For the final result, the classification results for each item were counted.

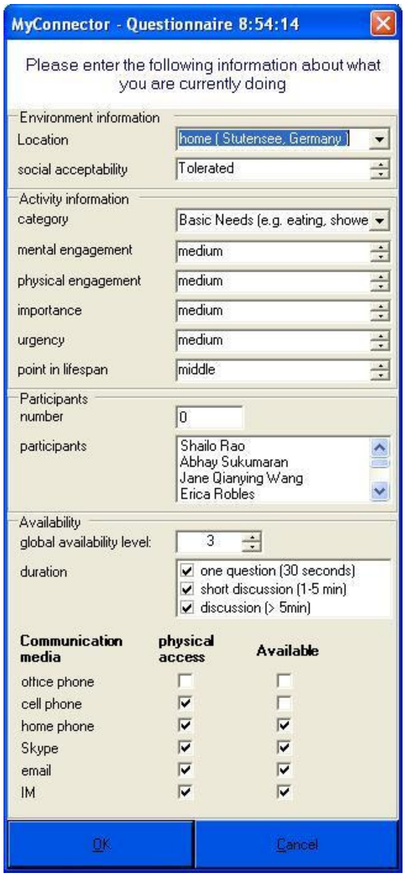

Figure 4. Participants provided information about their current activity in this popup window.

4.3 Results

Results represent the average of the Baye's classifier's performances for each user.

The impact of time and location on availability

In a first analysis, we assumed that location and time would be very good predictors for people's availability. Overall, the classifier could predict the person's self-reported availability level with an accuracy of 58.0%. Looking at different time information, the combination of the hour and day of the week performed best (54.3%) (Table 1).

The overall number hides the fact that there is a difference between two groups of users. The reason for this is that some users had heavily changing daily schedules, while others have had regular office hours, and thus a much stronger relation between location, time, and availability. Therefore, other factors besides time and location seem to be much more important for those mobile people with heavily changing schedules.

Table 1. Results for predicting availability from time and location data.

Attributes	Classifier accuracy rate
Time (hour, weekday)	54.3%
Location	*51.6%*
Time – Location	58.0%

The impact of PC activity on availability

PC activity such as mouse and keyboard events and the windows switching frequency were not very good predictors for a person's availability (28 – 30%) (Table 2).

Figure 5 is an example showing how PC activity data changed while the availability level stayed the same over a period of about 100 minutes. The number of keyboard, mouse and window switches change heavily. PC activity data could only be collected when subjects had their computer running.

Table 2 shows our results combining PC activity and Skype activity information. High overall PC activity does not seem to be related to lower availability, or the other way around. Only the active program, the window in the foreground, seems to influence one's availability for communication. As well looking at PC activity over an extended time period of time (up to the last 10 minutes), did not change this observation a difference.

This observation could be due to the fact that people do a lot of multitasking, especially while working with their notebook: browsing the internet, writing an email, having open IM conversations, talking at the phone, all at the same time. This working style probably outnumbers the time spent focused on one single activity, such as coding, and not being available for conversation. That could explain why the active program was the best predictor.

It looks like users are indeed more available when they are actually engaged in a Skype communication. But unfortunately, the number of the data points on Skype activity is not large enough to give that observation statistical significance.

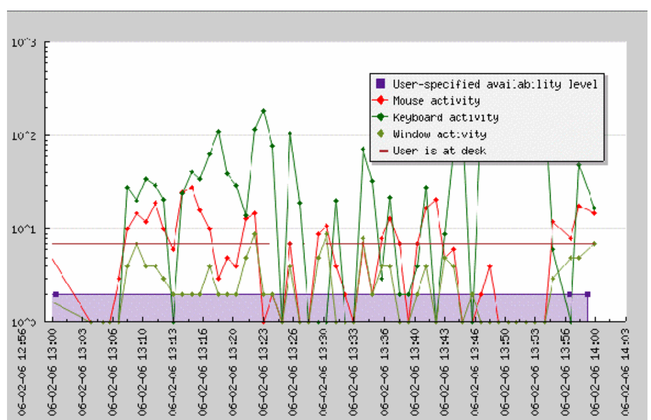

Figure 5. PC activity information and a person's self-reported availability level do not show a string correlation in this example period of 1h.

Table 2. Classification results on PC and Skype activity information

Attributes	Classifier accuracy rate
Active program	*48.4%*
Keyboard activity	*28.5%*
Mouse activity	*29.3%*
Window switching	*28.7%*
Online connection	*46.9%*
Skype	*32.3%*
Active Program & Online Connection	*49.1%*
All together	*26.7%*

Whether or not someone had online connection is an interesting predictor for participants' availability. Participants were more available for communication when they were as well having online connection. A reason for this observation could be that people communicate a lot via email, IM, or Skype, where internet connection is required. As well people are online a lot of the time. In case they are not, it could be that they are in meetings, or have no physical access to communication media (e.g. sports practice, transit), and are less likely to be available for a communication.

The impact of calendar information on availability

Classifier results from using personal calendar entries to learn people's availability is shown in Table 3. Overall, people are less available if they have an event scheduled in their calendar. We still believe that for many persons their planned availability as scheduled in a calendar is very different from their situated, in-the-moment availability [18]. Many people have calendar items that they do not really attend, and many meetings are informal and happening spontaneously. We asked participants in our study to keep an updated calendar for the duration of the study. The overall results are nevertheless promising,

Table 3. Were people busy if their schedule said they should be?

Attribute	Classifier accuracy rate
Calendar events	*58%*

The impact of social engagement on availability

It is known that the social situation a person is engaged in definitely plays an important role on their availability. People engaged in a meeting or in a discussion with others, either in person or remotely, are less available for outside communications. We differentiate the collocation with others as the number of people present in their immediate environment, compared to the interaction with others, which can be directly or remotely (e.g. via telephone). This is because one can be with others in the same space, but working by oneself, and thus being collocated with others but interacting with no one. Or one can be alone but interacting with others in a teleconference. Table 4 shows the predictive power of these two factors when estimating a person's availability level.

A more detailed analysis showed that collocation or interaction with others is a very good predictor for availability, but only when participants were not by themselves. Being alone did not relate to a person's availability. We detected three group types: dyads, small groups (3-7) and large groups (8 and up). We found that people are less available in large groups.

It would be interesting to study a larger data set and to investigate additional information about the situation, e.g. if a group meeting was planned or spontaneous, if a large group is structured (e.g. lecture) or unstructured (shopping mall).

Table 4. Information on a person's social engagement as measured by collocation or interaction with others helped to predict their availability correctly in 49% of all cases.

Attributes	Classifier accuracy rate
Collocation with others	*48.0%*
Interaction with others	*49.2%*
All together	*49.1%*

The impact of current activity on availability

The current activity which participants were engaged in at the time of the ping seemed to be a promising measure. We asked participants to report about their current *activity category*, as chosen from these five categories with guiding examples in parentheses: Basic (e.g. eating, showering, sleeping, bathroom), Transportation (driving, using public transport, cycling, walking), Required (doing homework/ research, at job, at meeting, in class, at sports practice), Alone/Personal (Internet browsing, Entertainment Media, leisure reading), and Social (socializing with friends, partying, dining out, smooching).

Based upon existing findings that focus on the concept of "flow" and how interruptions can break these highly engaged mental states, we collected the degree of m*ental engagement* required by the current activity during the time of the ping. Physical involvement in activities is commonly thought to hinder one's ability to communicate. We collected the degree of *physical engagement* required by the activity.

The willingness to communicate may as well depend upon the *importance* and *urgency* of the current activity. As well people are maybe more available at the beginning or towards the end of an activity. We therefore collected data addressing the *point in the lifespan* of the current activity.

Table 5 shows that the predictive power of single factors varied slightly. All together, activity measured could predict a person's availability with an accuracy of 51.5%.

A more detailed analysis of activity categories revealed some interesting insights. Numbers in parenthesis indicate the mean availability level, as rated between 1 and 4. Users are generally least available when they reported to be engaged in *interpersonal needs* (1.61) or *basic needs* (1.72). During *communication* (2.61) and *intellectual needs* (2.49) the availability level is significantly higher. The availability during *transportation* (2.3) lies in between. We could not collect enough data points to get significant numbers for the other categories. Moreover it was often hard to tell which of the categories apply, e.g. while having dinner with friends.

Table 5 shows that the urgency and importance of the current activity seem to be the best predictors for one's availability. Participants were more available when in activities perceived as not important or urgent. As well one's mental engagement looks promising. Even though the point in the activity's lifespan variable (begin, middle or end) was not a very good predictor, we found that participants were more ready for communication when their activities approached the end.

Table 5. The current activity influences a person's availability for communication.

Attributes	Classifier accuracy rate
Activity importance	47.3%
Activity urgency	46.1%
Activity mental engagement	45.0%
Activity category	42.8%
Activity physical engagement	38.7%
Activity point in lifespan	37.7%
All together	51.5%

4.4 Summary and discussion

Learning a person's availability is a very hard task. This may be due to the fact that availability is a highly personal characteristic that must take into account the individuals involved. Moreover, a person's 'stated' or 'planned' availability as e.g. scheduled in a calendar, does not always correspond to their 'demonstrated' or 'in-the-moment' availability. On the other hand, if an event is planned, interruptions are probably much more awkward then in a spontaneous meeting.

The time of day was especially powerful in combination with location information, in particular for people with a structured day and regular office hours. The predictive power of personal calendar information was promising, even though the existence of an appointment is not always a good indicator for a lower availability.

Results from PC activity information were lower then expected, even though the active program showed to be the best indicator. This was probably due to the fact that a number of participants used multiple computers throughout the day. People were more interruptible if engaged in Skype communication and in general, if they had connection to the internet. The reason for this could be that a lot of our communication takes place via the internet (email, IM, VOIP), and we are online whenever we can.

Looking at a person's activity information, the urgency and importance of the current activity seemed to both be extremely valuable context cues, but as well the mental engagement (being in a "flow") had its impact. This may be good news, since urgency and importance could be extracted from email communication or calendars entries. Our participants were more interruptible towards the end of an activity then at its beginning.

Especially promising was someone's social engagement, as measured by presence and interaction with others, either in person or remotely. This holds true as long as people are not by themselves, in which case we could not infer a higher or low availability. This could be correlated to Fogarty's findings showing that it is possible to very accurately detect availability from sensing nearby speech from laptop microphones [14].

The best overall result was 58% accuracy in detecting the correct out of four availability levels. Even though this number would be higher if mapped to a binary decision (available or not available), we question whether this system would be good enough to judge a person's availability and automatically route or block communications. Especially since communications are highly important and personal to most people.

We see two different approaches a context-aware communication system could follow, depending on where to put the intelligence and decision making. The first approach assumes that people's availability is too complex and difficult to be automatically learned and sensed. Such systems would concentrate on making communication transparent, and broadcast relevant context information to senders, assuming that senders can decide best whether it is appropriate to contact the receiver. The second approach puts all the intelligence into the system. The system uses relevant context information to infer receiver availability, and judges on behalf of the receiver whether to route or block a call.

We believe that with current technologies context-ware communication systems as MyConnector should focus on broadcasting high level contextual information such as people's location and social activities, maybe give suggestions, but leave the final decision in the hands of the people.

5. FUTURE WORK

The results presented in this paper will inform our ongoing research within the project CHIL, where a large number of audio-visual perception technologies are developed to identify and understand human activities and interactions. These technologies will have to be improved and tuned to detect context cues most significant for each service.

Since social activities, as well as location, showed to have a significant impact on people's availability for communication, we will integrate perception technologies that can sense and track user's location and in-the-moment social situation, such as presence and interaction with others. Our team has started to equip offices with cameras and omni-directional microphones in order to audio-visually detect activities inside offices [21].

A larger study with more participants would be necessary to strengthen some of our observations. We plan to run a much larger field study investigating the relation between people's planned and in-the-moment availability, related to their psychological profiles, by comparing calendar entries to actual responsiveness to real phone calls.

In order to take some burden from users, we plan to switch to an unsupervised learning approach, in which the system learns directly from user *reactions* to the system rather then self-reported feedback on availability.

It would be interesting to study additional factors related to *each* call or message. An example would be the social relationship to the caller, who could be a family member, friend, colleague, subordinate or boss. But as well the modality chosen by the sender will have an impact on availability, since one can be available for a text message but not for a phone conversation. Knowing such factors would provide more thorough insights in how people decide when to engage in an interaction.

6. CONCLUSIONS

We have presented MyConnector, a service aiming at empowering both the sender and the receiver to establish communication in a contextually appropriate way based on each party's availability. We have described how the MyConnector prototype uses a Bayesian approach to learn user availability and how availability information is broadcasted to potential senders via a variety of communication channels and clients. We discussed related privacy settings.

In order to design a proactive context-aware communication service, we need contextual information from sensors. In a pilot study we collected a large number of context cues and investigated their predictive power in gauging one's availability for communication. Some cues, such as calendar entries and PC activity, were collected automatically. Since we wanted to measure the impact of other potentially important context cues and not limit ourselves to already existing technologies, we additionally used direct user feed-back to collect data. We discuss our results in respect to where we see ourselves in the process of proactively mediating communication between people.

7. ACKNOWLEDGMENTS

This work has been funded by the European Commission under Project CHIL (http://chil.server.de, contract #506909).

The authors thank QianYing Wang from Stanford University for her help with the analysis.

8. REFERENCES

[1] D. Avrahami & S. E. Hudson, QnA: Augmenting an instant messaging client to balance user responsiveness and performance, *Proceedings of ACM Conference on Computer Supported Cooperative Work (CSCW'04)*, New York: ACM Press, 515-518.

[2] J. Begole, N. E. Matsakis & J. C. Tang (2004) Lilsys: Sensing unavailability, in: *Proceedings of ACM Conference on Computer Supported Cooperative Work (CSCW'04)*, New York: ACM Press, 511-514.

[3] B. Brown, and R. Randell. Building a context sensitive telephone: some hopes and pitfalls for context sensitive computing. In *CSCW Journal, special edition on context aware computing*, 13, 3 (2004), 329-345.

[4] http://chil.server.de/

[5] M. Danninger, G. Flaherty, K. Bernardin, H. K. Ekenel, T. Köhler, R. Malkin, R. Stiefelhagen, A. Waibel, The Connector - Facilitating Context-aware Communication, *Proc. of the Int. Conf. on Multimodal Interfaces (ICMI'05)*, Trento, Italy, 2005.

[6] E. Isaacs, A. Walendowski, S. Whittaker, D. J. Schiano and C. Kamm. The Character, Functions, and Styles of Instant Messaging in the Workplace. *Proceedings of ACM Conference on Computer Supported Cooperative Work (CSCW'02)*, NY: ACM Press, 11-20. 2002.

[7] A. E. Milewski, T. M. Smith, Providing Presence Cues to Telephone Users, *Proceedings of ACM Conference on Computer Supported Cooperative Work (CSCW '00)*, NY: ACM Press, 2000.

[8] B. Nardi, S. Whittaker and E. Bradner. Interaction and Outeraction: Instant Messaging in Action. In Proc. of the Conf. on Computer-Supported Cooperative Work (CSCW) 2000. NY: ACM Press, p. 79-88. 2000.

[9] J.C. Tang, N. Yankelovich, J. Begole, M. Van Kleek, F. Li and J. Bhalodia, ConNexus to Awarenex: Extending awareness to mobile users. In *Proc. of the Conf. on Computer Human Interaction (CHI)*, New York, 2001.

[10] J.J. Cadiz, A. Narin, G. Jancke, A. Gupta, M. Boyle, Exploring PC-telephone convergence with the enhanced telephony prototype. *Proc. of the Conf. on Computer Human Interaction (CHI)*, New York, USA, 2004.

[11] G. Henri ter Hofte, Raymond A.A. Otte, Hans C.J. Kruse, Martin Snijders, Context-aware communication with Live Contacts, *Proc. of the Conf. on Computer-Supported Cooperative Work (CSCW)*, Chicago, Nov 2004.

[12] E. Horvitz & J. Apacible (2003) Learning and reasoning about interruption, in: *Proceedings of the 5th International Conference on Multimodal Interfaces (ICMI'03)*. New York: ACM Press, 20-27

[13] E. Horvitz, P. Koch, C. M. Kadie & A. Jacobs (2002) Coordinate: Probabilistic forecasting of presence and availability, in: J. Breese & D. Koller (Eds.), *Proceedings of the 18th Conference in Uncertainty in Artificial Intelligence (UAI'02)*, Morgan Kaufmann Publishers, 224-233

[14] J. Fogarty, S. E. Hudson and J. Lai (2004) Examining the robustness of sensor-based statistical models of human interruptibility, in: *Human Factors in Computing Systems: Proceedings of CHI'04*, New York: ACM Press, 207-214

[15] J. Fogarty, S. E. Hudson, C. G. Atkeson G., D. Avrahami, J. Forlizzi, S. Kiesler, J. C. Lee & J. Yang (2005) Predicting human interruptibility with sensors, *ACM Transactions on Computer-Human Interaction*, 12 (1), 119-146

[16] M. Raento, A. Oulasvirta, R. Petit, H. Toivonen. ContextPhone - A prototyping platform for context-aware mobile applications. In *Proc. of IEEE Pervasive Computing*, 4 (2): p. 51-59, Munich, Germany, 2005.

[17] C. Shannon and W. Weaver. The mathematical theory of communication. Urbana, IL: University of Illinois Press, 1962.

[18] L. Suchman. Plans and situated actions: The problem of human-machine communication. Cambridge: Cambridge University Press, 1987.

[19] G. S. Pingali, C. Pinhanez, R. Kjledsen, A. Levas, M. Podlaseck. User-Following Displays. *IEEE International Conference on Multimedia and Expo (ICME 2002)*, 2002.

[20] M. Weiser. The computer for the twenty-first century, *Scientific American* (1991), 94-1

[21] C. Wojek, K. Nickel, R. Stiefelhagen. Activity Recognition and Room-Level Tracking in an Office Environment. *IEEE Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI'06)*, September 2006, Heidelberg, Germany.