MOBILEESSENCE: A MOBILE NON-INVASIVE PLATFORM FOR MEETING NOTES CAPTURE

By
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B.S. Computer Science, MIT, 2001

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning,
In Partial Fulfillment of the Requirements for the Degree of Master of Science in Media Arts & Science
At the Massachusetts Institute of Technology
May, 2007

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ABSTRACT

*MobileEssence provides a light-weight, ubiquitous meeting capture tool which affords the user the ability to capture all important information, including recording what **was** just said, **who** said it, and what **is** being said at the moment. Traditional methods and tools for meeting information recording have often focused on the meeting-room as the nexus for useful information exchange. Instead, MobileEssence uses the mobile phone as a ubiquitous interface allowing notes to be captured anytime, anywhere while not requiring the user to change their focus. MobileEssence allows users to only record the important information and annotate this in real-time, instead of only allowing post-processing. We show that MobileEssence produces more effective meetings and post-meeting collaborations: User studies showed that users are not distracted by MobileEssence during meetings when compared to pen and pencil, and that they are better able to recollect events which were discussed during meetings.*

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1. Introduction

Meetings are fundamental elements of most organizational structures, providing a central mechanism for coordination and information sharing. The meeting, however, has been characterized by a problem of persistence after the fact – the information is often lost once the meeting is over. As a result of this problem, a number of projects have attempted to provide tools to record and transcribe the events in meetings. Most of the research in the field of *Computer Mediated Communication Systems* has not focused on the mobile device. There is, however, a renewed interest in the intersection of collaboration tools with ubiquitous computing, in large part due to the advent of the Smartphone[1].

This project leverages the full capabilities of the Smartphone platform[1] to capture information in a continuous, non-obtrusive, and seamless manner.

Meeting systems such as Xerox CoLab give computers to each person in a meeting and use a large shared display to view this information. This use of such a display provides benefits for collaboration[37]. Other systems have focused on different environments, such as classrooms[3,4,5], offices[6,7], conferences[8] or other formal environments[9,10]. Most of the work that has taken place with mobile devices has focused on remote collaboration, with the underlying assumption that mobile devices should only be used when larger systems are not available. MobileEssence denies this

[1] By Smartphone, we refer to any device which is fully programmable and fully-connected to the Internet, and has enough processing power and memory to sustain collaborative tools such as MobileEssence.

assumption, and uses the mobile phone as a platform for normal face to face meeting recording. More details on the history of this category of tool are discussed in section 2.

The Smartphone is a platform ideally suited for the implementation of this type of face to face interaction and recording. These systems are small, always on, and provide an ideal platform to create applications which move and record with the users' normal daily interaction. These system, however, have not been actively used in real-time personal interaction when parties are co-located, except in a passive form for co-location detection in such systems as Serendipity [38]. MobileEssence focuses on using the mobile phone as a mechanism to extend the notion of note-taking as a basis for the capturing and meta-tagging of contextual information such as sounds, location, topics and people.

1.1 Scenarios

The following are a sequence of scenarios which are afforded by the MobileEssence platform:

1.1.1 Meeting Room Capture

This scenario involves a group of meeting participants all sitting down in a meeting room. Each user has his/her own phone which runs the MobileEssence client.

As each member of the meeting enters the discussion or meeting room, they can be added to the list of active meeting participants. This membership information is available to all other members immediately, and might be displayed on a central computer screen or projected interface.

Each individual member is then able to demarcate relevant parts of the meeting by simply pushing a single button. The previous 15 seconds and the subsequent 5 seconds of the meetings are then annotated as being of interest to that particular user. This might be done for the same temporal segment by several

different users. Potentially, the current speaker at any one time is given this real-time information about how interested his/her audience. User data showed that this is often too long, and more research into how far back to record would be valuable, which is discussed in section 6.

During the meeting, users are able to add information through either a mobile interface or a standard computer interface, although it is assumed that users are more likely to simply participate in the meeting.

After the meeting, the users are able to access the collective summarization of the meeting. They may add additional information about the meeting, such as links to further details or particular sections, or can substitute textual replacements for recorded voice sections.

1.1.2 Post-Meeting Collaboration and expansion

One of the most problematic aspects of small-group meetings is the permanent recording of information, and the follow-up with information that is recorded during these meetings. As a result of this lack of notations, commitments made during meetings are often forgotten or lost soon after the meeting has been completed. The recording of notes is covered in scenario 1.2.1, but here we explore how MobileEssence provides a means by which responsibility for material can be easily followed up on.

In this scenario, the users hold a normal meeting, during which time some users make commitments – an agreement or pledge to do something in the future. These commitments are made throughout the proceedings of the meeting, and by various members of the meeting. As a result, the members of that meeting are quite likely to forget the commitments made during the meeting. MobileEssence, however, allows the users to demarcate certain sections of speech as being a commitment. When reviewing the meeting notes after collaborating, participants may now flag the necessary audio bits as commitments and invite other users to second, confirm or discuss the commitment, as discussed in scenario 1.2.4.

1.1.3 AdHoc Hallway Meetings

The use of multiple recording devices in the MobileEssence system provides the ability for users to take the notion of real-time meeting capture to a mobile environment. We have talked about the notion of remote conference called users, but this mobility extends to the frequent ad-hoc meetings which occur in less official environments. This scenario is a modification of the original scenario 1.2.1.

In this scenario, two members of a team, Bill and Ted, meet while walking past one another on the way out of the building, or perhaps in a corridor. The sight of Bill triggers a memory in Ted, who initiates a conversation that extends beyond a simple greeting. At this point, the system has not recorded an official meeting, since nothing of interest or value has been marked as important.

During the conversation, Ted's comment intrigues Bill. They do not have time to continue the conversation now, but do not wish to leave this forgotten. In order to make sure that they keep a recording of the information, one or both of the users inform MobileEssence that the last comment was important; MobileEssence then determines who the members of the conversation were, and records this.

By the end of the day, both Bill and Ted have forgotten the conversation and do not send one another follow-up emails, as they had promised during their ad-hoc hallway meeting. Later that day, however, the reminder system detailed in scenario 1.2.6 sends both of the users email, prompting an email dialog following up on the information generated during the ad-hoc meeting.

1.1.4 Conference Call Meetings

In the previous scenario, all of the members of the meeting were co-located. In this scenario, the manner in which it is used changes slightly, but the inherent utility of the application is not reduced by remote collaboration, as is described in more detail here.

This scenario is an extension of the scenario 1.2.1. In this case, however, one or more persons attempting to join and participate in the meeting are located remotely. Using MobileEssence, the user is able to phone into the meeting through a normal conference call system, and skim through previous entries in the system. The user is able to ask questions and see notes or photos of previous notes in the system. Finally, once they have started participating in the main meeting, they are able, through a mobile device or the web interface, to add notes to the discussion in the same manner as everyone else in the meeting.

1.1.5 In-Situ Voting for Real-time feedback

An increasingly common technique in modern organizations is the use of voting as a mechanism for conflict resolution, or more commonly information gathering. Specifically, while voting is considered to be ineffective as a conflict-resolution tool [26], it is considered effective as a mechanism for the resolution of personal conflict and information sharing [33]. MobileEssence provides a generic mechanism for in-situ voting, which affords users the ability to setup votes when necessary without any additional software.

In this scenario, we describe voting done in a manner called "voting-before-discussion" [33]. In this particular use of voting, members in the meeting vote many times during the course of a discussion. The users, about to address a topic, vote on the question to determine potential problems and find out more about how the rest of the group views this topic. The results using the MobileEssence system are instantaneous, and as such can be done many times during the meeting. Since the MobileEssence software is running concurrently for all members of the meeting, including those physically separate from the main group, the voting system can give remote users a non-verbal presence in the rest of the group.

1.1.6 Backchannel Communication during Meetings

Backchannel communication has been the topic of recent study [28, 30, 31] as a tool which provides a potentially useful additional communication channel. We take our definition of backchannel as being:

The virtual backchannel is a private and unofficial channel of communication used for a wide variety of communications that cannot or should not be made in public: private discussions with friends; tangential

or completely off-topic exchanges; assistance with rhetorical strategies, the meeting software, or group etiquette; phatic[2] exchanges, and so on. [28, p.4]

While the uses of a backchannel are wide in scope and have been taxonomized in some detail [28], we use a simple example here to illustrate the point:

In the middle of scenario 1.2.1, a set of users are listening to a speech by a high-up manager. A new employee hears a reference to a web-site that he has not previously seen. He is not able to whisper to his colleague because they are across the table, so he simply sends her a backchannel message asking about this website. She responds with enough information for the new employee to listen to the rest of

[2] In linguistics, a **phatic** expression is one whose only function is to perform a social task, as opposed to conveying information. (c.f. http://en.wikipedia.org/wiki/Phatic)

the meeting without misunderstanding the rest of the presentation as a result of not being able to ask a simple question.

2. Background

Collaboration tools have traditionally been hampered by several problems. These consist of physical issues such as where system can run, as well as issues with user adoption of technology. In particular, users feel that technology is invasive in meetings (c.f. section 5), that the use of technology is somewhat unnatural, that it interrupts the flow of meetings, and that it is an impersonal encroachment into the meeting arena. In addition to creating a user experience that is at least as useful as that of traditional pen and paper, the primary design goals of MobileEssence are to be:

- **Unobtrusive**: ***Extracting the essence of a meeting through the ears of the member s***– previous work has often focused on capturing all information. This means that, while a system may be unobtrusive during recording, it is more difficult when retrieving the information as a result of the abundance of data. By leveraging the members' interpretation of the meeting up front, MobileEssence can reduce the obtrusive nature of too much data in later stages.
- **Natural***: **Differentiation of tools for different purposes*** – tools have focused on providing a single interface for both the capturing and evolution of collaboration notes. Differentiation of tools for different purposes allows the system to act on what is most natural to the user.
- **Non-invasive**: ***Ubiquity*** – tools have not been as transparent and portable as mobile phones. A number of systems have provided large workspaces, which while feature-complete is also invasive. By using a mobile phone platform, MobileEssence can become non-invasive.

MobileEssence addresses each of these limitations by attempting a multi-modal minimalist design.

Meetings have traditionally been recorded either in their entirety, or by taking meeting notes that only capture the salient points of a meeting. Complete recording of meetings has been assisted by providing tools which allow users to quickly navigate through the entirety of the recorded data for a meeting (cf. discussion of Xerox CoLab).

Meeting notes, on the other hand, have been shown to be more effective in being accessible after the initial meeting, and for providing a better summary for later perusal. Unfortunately, meeting notes need to be taken by a member of the meeting, who often contributes less to the meeting than those that are not taking notes. As a result, in a small meeting, taking notes can produce a significant loss of contribution compared to discussions where no one takes notes. In addition, due to the unique view point of the author, the notes may have a limited, biased or perhaps simply erroneous view of the meeting's contents.

In order to address these issues, MobileEssence provides a mechanism where data entry is very simple, allowing for an increase in active participation and collaborative, and thus resulting in a set of meetings notes that gives a shared perspective of the meeting.

By leveraging the limited screen real-estate and input flexibility, we are able to create a client interface that encourages minimal but effective use. This screen area may be expanded by providing a shared display –projecting the web-based page on an overhead projector. The advantages of having a shared display of collaborative work in a face-to-face meeting have been extensively demonstrated [34,37, 42].

Ultimately, we consider the mobile-phone to be an ideal tool for collaboration: it is already widely used for collaborative task through text messages, conference calls, and regular phone calls, but has not been targeted as a platform for collaboration in the same way as computer have been .

2.1 Collaboration Tools

Computer-Supported Cooperative Work tools have a rich and diverse history, spanning over the last several decade starting in 1963 with Englebart and English work at the Augmentation Research Center. Their work with NLS (oN Line System) aimed at augmenting and supporting teamwork, such as sharing documents, navigating through information, filtering information and shared screen displays. This section provides an overview of the research which is relevant to the design of MobileEssence. These include an overview of the taxonomy of CSCW systems, computers and their use in classrooms, shared displayed tools and memory prostheses.

2.1.1 Taxonomy of CSCW systems

CSCW systems can be classified by a common time-space matrix, application domains or the so-called 3C model. In addition, there is a quantitative, an organizational and a social taxonomy. Table 1 shows the time-space matrix. A more comprehensive breakdown of CSCW systems can be found in Borghoff and Schlickter[20].

Space/Time	***Same time(synchronous)***	***Different times (asynchronous)***	
		predictable	***unpredictable***
Same Place	Face-to-face meeting*	Shift-work	Blackboard
Different places (predictable)	Video conferencing*	email	Joint editing of documents
Different places (unpredictable)	Mobile phone conference*	Non-real-time computer conference	Workflow management

Table 1 – Time-Space Matrix (* indicates a meeting supported by MobileEssence)

MobileEssence provides augmentation tools for synchronous interactions both when these are predictable, non-predictable and when in the same place.

2.2 Computers and uses in Classrooms

Experts in the field concede that Computer Supported Collaborative Learning (CSCL) is important for the "social facilitation in the learning process. Factors that contribute to this process in the classroom include face-to-face interaction, negotiation of tasks and coordination of activities and mobility" [58]. However, technology to this end is still in its relative infancy. Closely related to the MobileEssence project is the Classroom 2000 Project, a system developed to store teacher activity at the blackboard and then render it accessible to students via websites. According to Lopez-Cozar et al, "all the teacher's activity was stored by a ubiquitous system together with timestamps, and then was made available for students, who thus could concentrate better on the teaching activity itself as they did not need to take class notes" [56]. Indeed, Lopez-Cozar's team is currently attempting to take this notion of ubiquitous mobile computing in the academy to the next level: they envision a hand-held note taking system available to individual students and linked to a central web server which, in turn, has satellite components at various outposts in the educational environment. Aspects of this technology are not dissimilar to MobileEssence.

A 1992 study of 30 Chinese students in Hong Kong enrolled in a four-year degree program in TESL provides information that, while technically addressing lecture note-taking in a foreign language, is germane to lecture comprehension of students in any language [57]. The study employed observation, questionnaires, diaries and interviews to ascertain students' ability to capture and comprehend information, the problems and obstacles they encountered in doing so, and the strategies they employed to overcome these issues. The researchers found that the primary problems encountered by students were threefold: the speed of delivery of the lecture, the new terminology and concepts presented, and

students' difficulties in concentrating. Regarding the fast pace and high pressure of the situation, one student remarks, "If the lecturer explains something too fast – especially theories which are rather abstract - then I need to have some time to think about it" [57]. Regarding new and unfamiliar vocabulary, another student says, "I am still unable to comprehend the whole lecture. This is because some terms he talked about are quite technical, abstract and new to me" [57]. When asked how they dealt with these comprehension issues, students were markedly reluctant to take written notes. In answer to the question, "Do you take notes?", students replied, "No, because he [the lecturer] is speaking too fast. I can't mark down anything," and "I think active listening is more important than copying down things" [57]. Indeed, two of the primary obstacles cited by students – speed of delivery and unfamiliar concepts and vocabulary – are a direct target of the MobileEssence technology. MobileEssence attempts to obviate the difficulty and distraction of handwriting notes by simply pressing a button and allowing for auditory review later.

2.3 Shared Meeting GUIs

Some of the earliest CSCW work focused on the use of special-purpose hardware or specially-constructed meeting rooms. This includes systems such as Xerox CoLab and the University of Arizona's GroupSystem [33], which used specially build hardware/furniture combinations for each individual. These projects augmented large rooms or workspace with hardware to provide a complete immersive environment in which to work.

The Xerox ParcTab[57] project investigated the use of mobile devices in combination with the Xerox CoLab system. It provided a touch-sensitive screen, some hardware buttons, and a gesture alphabet. It provided a mechanism to allow users to vote in a manner similar to the one in MobileEssence, although

their system did not work well with multiple people in the room due to the use of IR as a communication system.

Brad Myers and al. created a system which used PDA to communicate with a central display. They all connected to a single PC, allowing users to in turn, take charge of the input system as if they had control of the computer's mouse and keyboard. In addition, they created a drawing program which allowed users to simultaneously draw onto a shared space.

One piece of work which is an parent of MobileEssence is the work done on creating an Collaborative table-based interface[16]. This work examined the use of a single *commit* button to allow users to capture sections of a conversation that were relevant and post them on a web-space. In addition, it provide a surface to allow users to write notes, and a camera which could be used to capture information on the table. This research, however, was not used much beyond the prototype stage, and as such there is not a great deal of user-studies to allow an understanding of how it would have been used.

2.4 Memory Prostheses

2.4.1 Complete Environment Capture Systems

As computers have become more portable and more closely tied to our everyday work life, the idea that they should be able to provide a mechanism for assisting our memory has become quite prevalent. Here, several different approaches which are more focused on the individual's recall of information are presented as background for the MobileEssence platform.

One of the most catholic approaches to augmenting memory has been Gordon Bell's work on My Life Bits[54]. This is an ongoing, long-term research project whose goal is described as: "MyLifeBits is a lifetime store of ***everything***. It is the fulfillment of Vannevar Bush's 1945 Memex vision including full-

text search, text & audio annotations, and hyperlinks. There are two parts to MyLifeBits: an experiment in lifetime storage, and a software research effort."

A second, related research platform is the Rhodes' Remembrance Agent. It has similar goals to the My Life Bits, which is to provide tools to access all of the information available through the internet and through our computers in a continuous way. This means that it tries to give users information that is relevant to their current context, whether it is a set of emails with the person with whom you are talking, or a set of relevant papers when writing a paper. It is based on a mobile computing platform which is able to provide its wearer with a visual and auditory display at all time.

2.4.2 Audio Memory Prosthesis Devices

In the purely auditory domain, Hindus and Schmandt's Ubiquitous Audio[10] platform explored way of marking up audio during phone calls in such a way as to provide semi-structured metadata about the given audio stream.

Mitsubishi Electric Research Laboratories has devised a platform which allows mobile phones to back-track a few seconds so that users are able to re-listen to parts of a conversation which they might have missed[52]. It is activated either through the handset, or when the user's ear stop and remakes contact with the mobile phone.

In a similar vein, the Personal Audio Loop is a continuous audio-recording mechanism running on a mobile phone. It has a copy of the last 15 minutes of audio, and allows people to scan through this audio if they wish the listen to a part of a conversation or audio again. One of the primary differences is that PAL was not collaborative, since the information was only retained by the individual.

3. Design Considerations

Certain assumptions are made in the design of the system. We will outline these, and then proceed to go into more depth on each one:

- The user should not have to look at the device for a large percentage of use.
- Since the cost of input on a mobile phone for complex information is higher than when using a PC, we need to optimize this limitation.
- The cost of reading data is equally uneven, meaning that we should only be using a mobile device to display a large amount of information when there is no other option.
- Since the cost of input of data is so high on a mobile phone, we need to assist the user by reducing possible options presented by using any environmental or contextual knowledge that we have.
- The user should have access to evidence of the actual meeting rather than only individuals' interpretation of events of the meeting.

3.1.1 Active vs. Passive Device Usage

One of the key design factors in designing the MobileEssence application and usage scenarios was that the majority of users (89%, c.f. section 5) feel that mobile phones are somewhat or very a negative presence in meetings, and disrupt productivity. Not only do users feel that mobile phones are destructive to meeting progress, but furthermore they believe that technology is generally a negative influence in meetings (78%, c.f. section 5).

We hypothesize that there are two primary reasons for this. The first is simply that computer technology has in general provided tools intended for more individual use, such as email, IM, web browsing and

other work. This means that users quite naturally see it as a means to excuse themselves from active participation in the meeting.

The avoidance, however, is often much more perceived than real due to the lack of eye-contact. When a person is working on a laptop, while they may be listening to others but are often not making eye-contact, their actions are perceived as being rude and dismissive.

In order to address this strong feeling against technology in meetings, we attempt to provide a tool which limits the user's ability to do work outside of the primary meeting. In addition, by providing some functionality which can be used easily and without looking at the device, we are able to add technology with both takes in active input from users, while maintaining a stream of discussion and much needed eye-contact.

3.1.2 Post-meeting Collaboration difficulties

Most of the people that take notes at the end of a meeting do not share these notes with others in the group. This leads to two significant problems, which we attempt to address in the design of the system. The first problem is the limited view point which each person is likely to take of the meeting, due to the only record of the meeting's contents being their own. The second is that as a result of only having their own notes, they do not have any real sense of what others in the meeting considered important. Together the problems can be called the False Consensus Phenomenon [47], whereby members of groups view other's ideas as being the same as their own unless explicitly shown otherwise.

3.1.3 Multi-Modal Impedance and Affordance

We view the difference in impedance of information input and output on the mobile phone and PC as a key to creating software which is easy to use, portable, and still fully functional.

3.1.3.1 Mobile Input

Mobile input is a clear problem when trying to create software for end-users. While people have learnt to write SMS messages very effectively, it is still something which has two separate and problematic elements. First, there is a generation problem whereby the different age groups tend to have different levels of comfort using SMS[43] and secondly, that people are not able to input data into the mobile phone without looking at the screen. While this is true for computer, it is aggravated by mobile phones due to the use of T9.

3.1.3.2 Mobile Output

Mobile Output is an area that is currently being actively developed, both in the hardware available and the uses to which it is being put. It is, at this point in time, unclear as to best use of mobile output. For some, it is reasonable to read a book on a PDA, while for others it is an unacceptably small screen and non-tactile experience. The assumption made in this design is that the mobile screen should only be used when there is little other option, but, if possible should be avoided as the primary display device for use-cases.

3.1.3.3 PC Input and Output

Personal Computers, or any device which provides similar characteristics in terms of keyboard input and screen size is very well understand when compared to mobile phones. It is generally acknowledge that within limits, the PC is a good device for entering textual information, and reviewing multimedia information that is structured. As such, in the MobileEssence platform, it is used as the primary place for complex data manipulation, rather than leaving this task to the rather limited mobile device's interface.

4. Technical Overview

4.1 Platform design and structure

MobileEssence is based on a client-server architecture. The various clients communicate with the central server, which maintains information about which meetings are currently in progress, as well as what was recorded. The client is written in JavaME.

The server is implemented in Java using Tomcat as a web-server, and MySql as a database. It is designed using "best-of-breed" java enterprise techniques, including n-tiered architecture and web-services using the Spring Framework and Hibernate. As such, it is designed to be able to handle a large amount of incoming traffic, and will not need to be substantially modified for large scale deployment. Using java has resulted in longer development time, but has given us the advantage of good audio processing libraries, and a proven architecture.

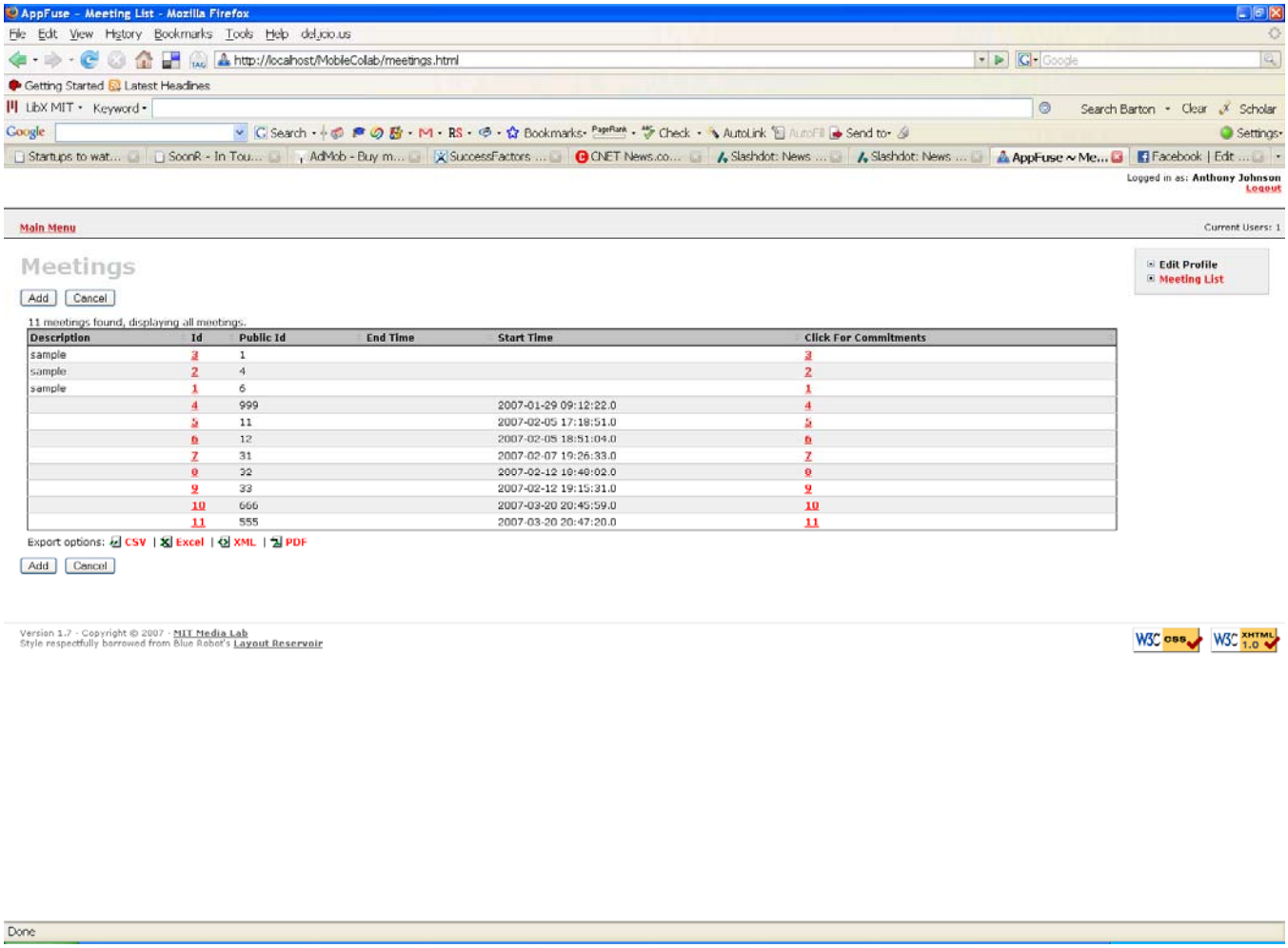


Figure 1 – List of users meetings

4.2 Mobile Client

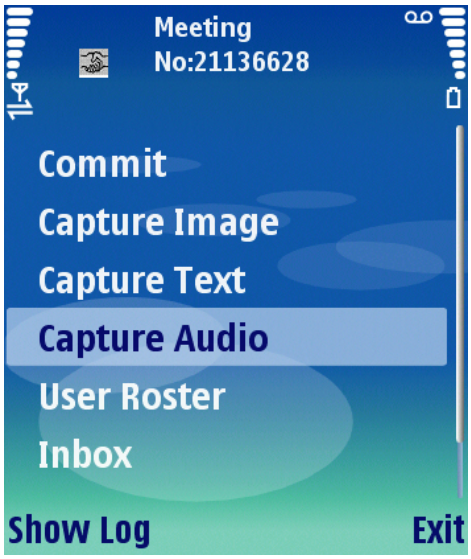


Figure 2 – Primary Mobile Client UI

4.2.1 Post-facto recording functionality

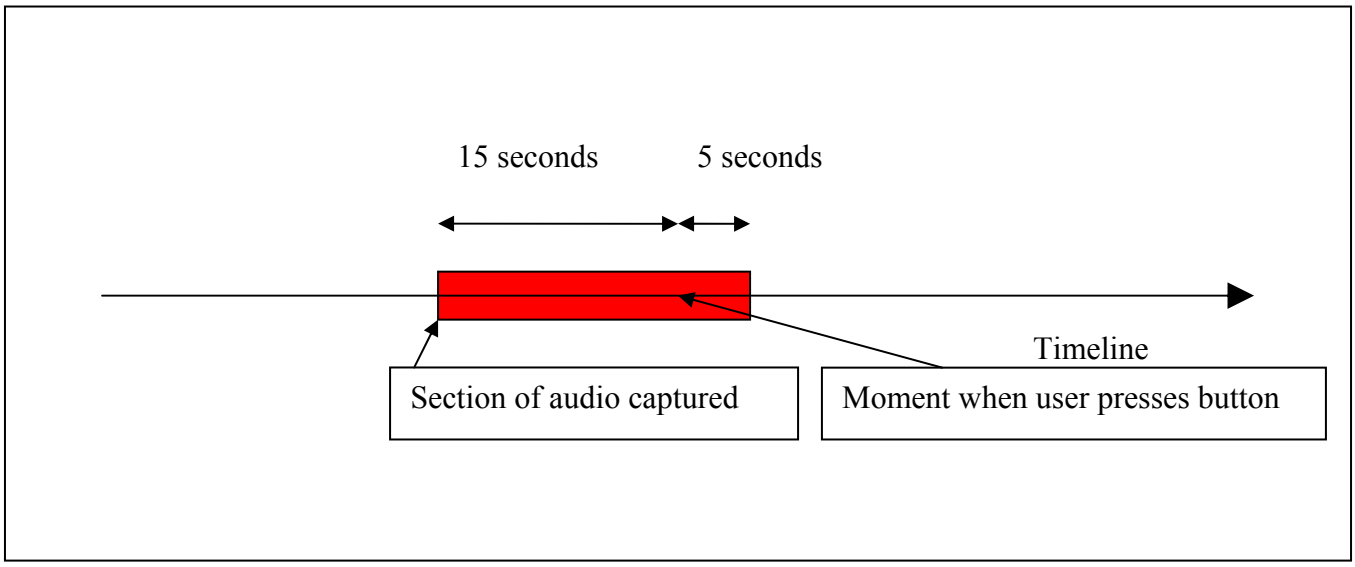
4.2.1.1 User Perspective

MobileEssence continuously record audio. It does not store this audio permanently, but discards it after 15 seconds. This means that when a user identifies a portion of the conversation as being important, they are able to push a button and get a retrospective recording. This concept is illustrated in Illustration 2.

4.2.1.2 Technical Details

Pushing the button sends a copy of the current buffer back to the central server after a 5 second delay. This sequence is shown in Figure 3. This results a 20 second audio section – 15 seconds before and 5 seconds after the user initiates the recording. In addition, it signals to the other phones to perform the same action. This is done through a message server that runs on the central server using a polling

architecture.[3]



[3] although this could be implemented using SIP or other point to point networking protocols

Illustration 1 – Retrospective Recording

These files are then stored on the central server in combination with a basic synchronization (c.f.2.2.2) mechanism. Once the audio data are received, a simple speech detection algorithm is run across the files, and the phone with the highest energy for the duration of the last speech section is determined to be the last/current speaker (c.f. 4.2.5).

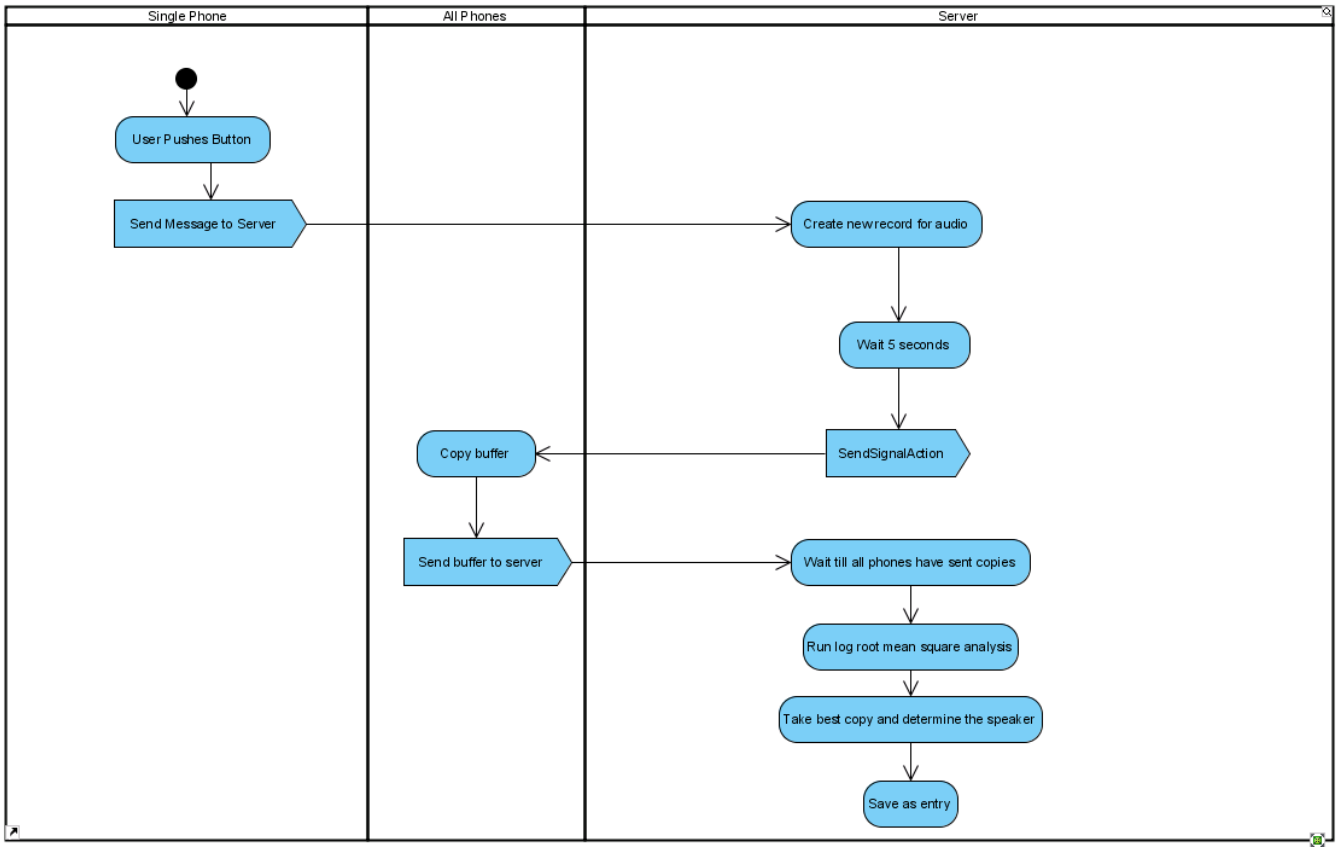


Figure 3 – Activity Diagram for Retrospective Audio Capture

4.2.2 Client Synchronization

Since the mobile client only polls every 5 seconds, the server synchronizes all the phones on the first phone to join the meeting. Every time a client requests a list of currently logged in users, a timer correction value is sent back, which is used by the client to align itself with the master phone. While this does not provide perfect synchronization, it is adequate for the purpose of detecting the last speaker.

4.2.3 Recording audio/photos

Since it is easy to incorporate other multimedia information into the conversation, the system allows the easy upload of photos or audio recordings along with a textual description of the material if so desired. For audio, this is done in a straight-forward manner, allowing the user to start a recording and sending it over when the recording is finished. For photos, the user is able to take a photograph, examine a preview and then append a textual description to the photograph before sending it over.

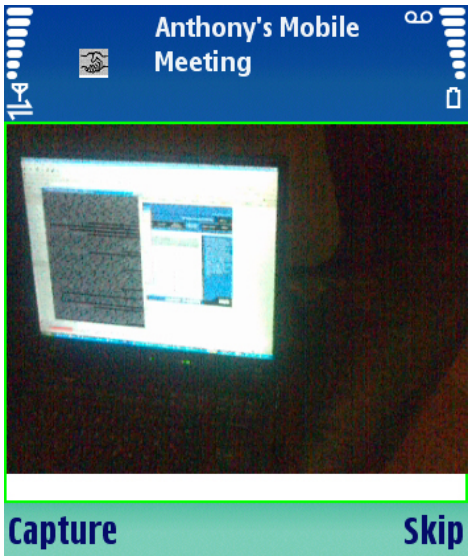


Figure 4 – Image Capture Screen

Figure 5 – Image Preview Screen

4.2.4 Text

Pure textual entries can be entered using the same interface as used for entering comments with audio or photos.

4.2.5 Speaker Determination

Speaker determination is done by a multistage process detailed below(also see Figure 6). The process is initiated by a primary controller. This sends a message to the central server, which then tells the mobile phones in the meeting to send a copy of their audio buffers over to the central server.

Speaker determination is done once copies of the audio files arrive at the server. The system calculates the log root mean square of the different samples starting for 5 seconds before the user clicked on the record button. The audio stream with the highest log root mean square is considered to be the "best" copy of the audio.

This can result in false calculations being made, if multiple people are speaking simultaneously. In practice, however, this was not encountered, or was at least not mentioned by test subjects.

4.2.6 Bluetooth meeting setup and SMS invitation

In order to facilitate meeting setup, two different approaches were tried. The first method used was similar to how current conference call systems work using a shared number which is entered by all participants. The primary advantage of this was that the users are very familiar with the system, but the disadvantage is that it does not take into account any of the additional information provide by the mobile phone. The second was an attempt to remedy this by using Bluetooth as a system to detect a list of possible meeting members(Figure 6).

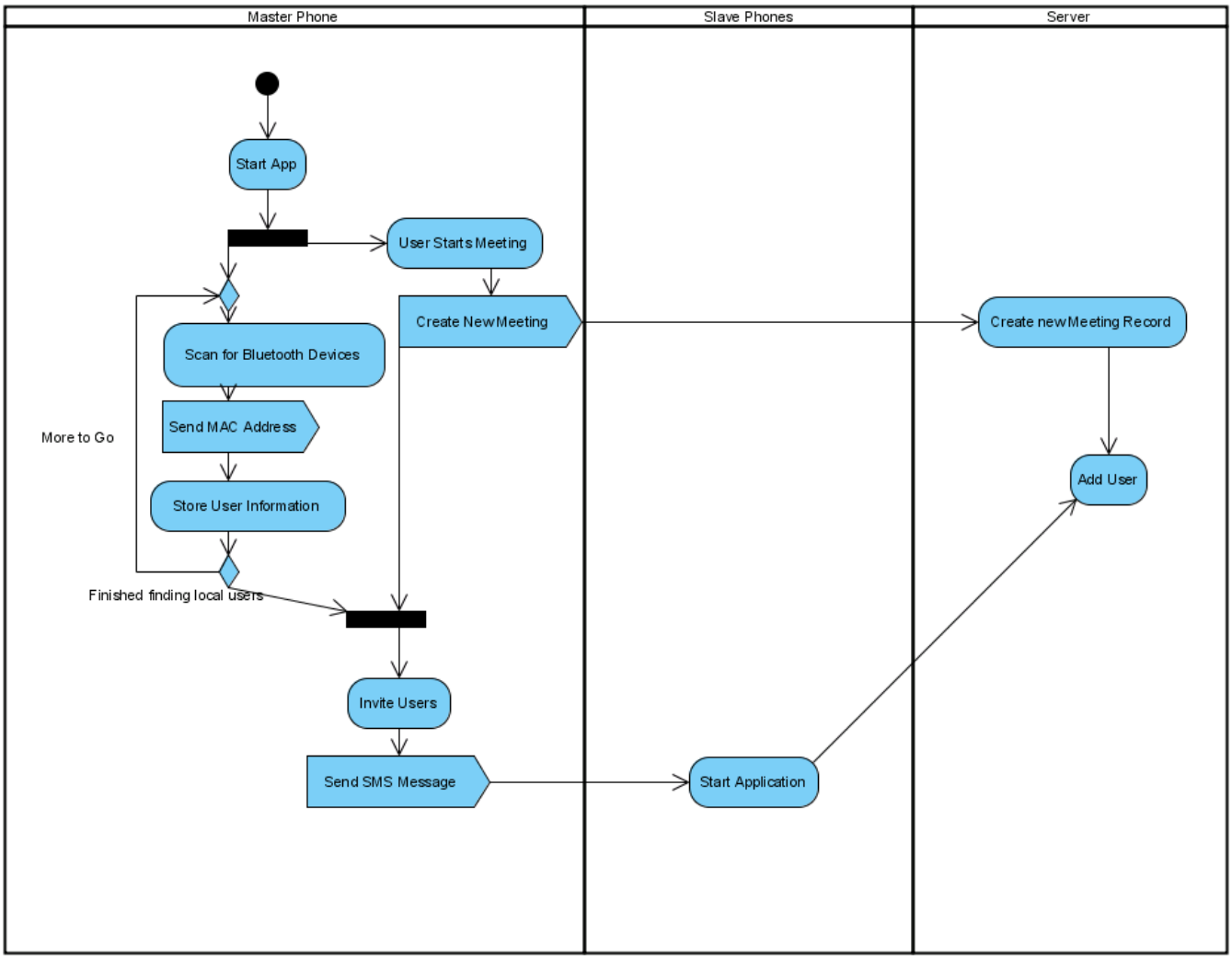


Figure 6 – Creating a meeting and inviting users

This list is retrieved by capturing a list of all Bluetooth MAC addresses in the vicinity, and looking them up on the central server. Since the phone registers its MAC address the first time it logs in, we have a record of all current members' Bluetooth addresses. This means that the system can provide a list of MobileEssence members near us, along with basic information such as their name. This is functional whether or not they are running the MobileEssence client at the time, since we are only using passive information.

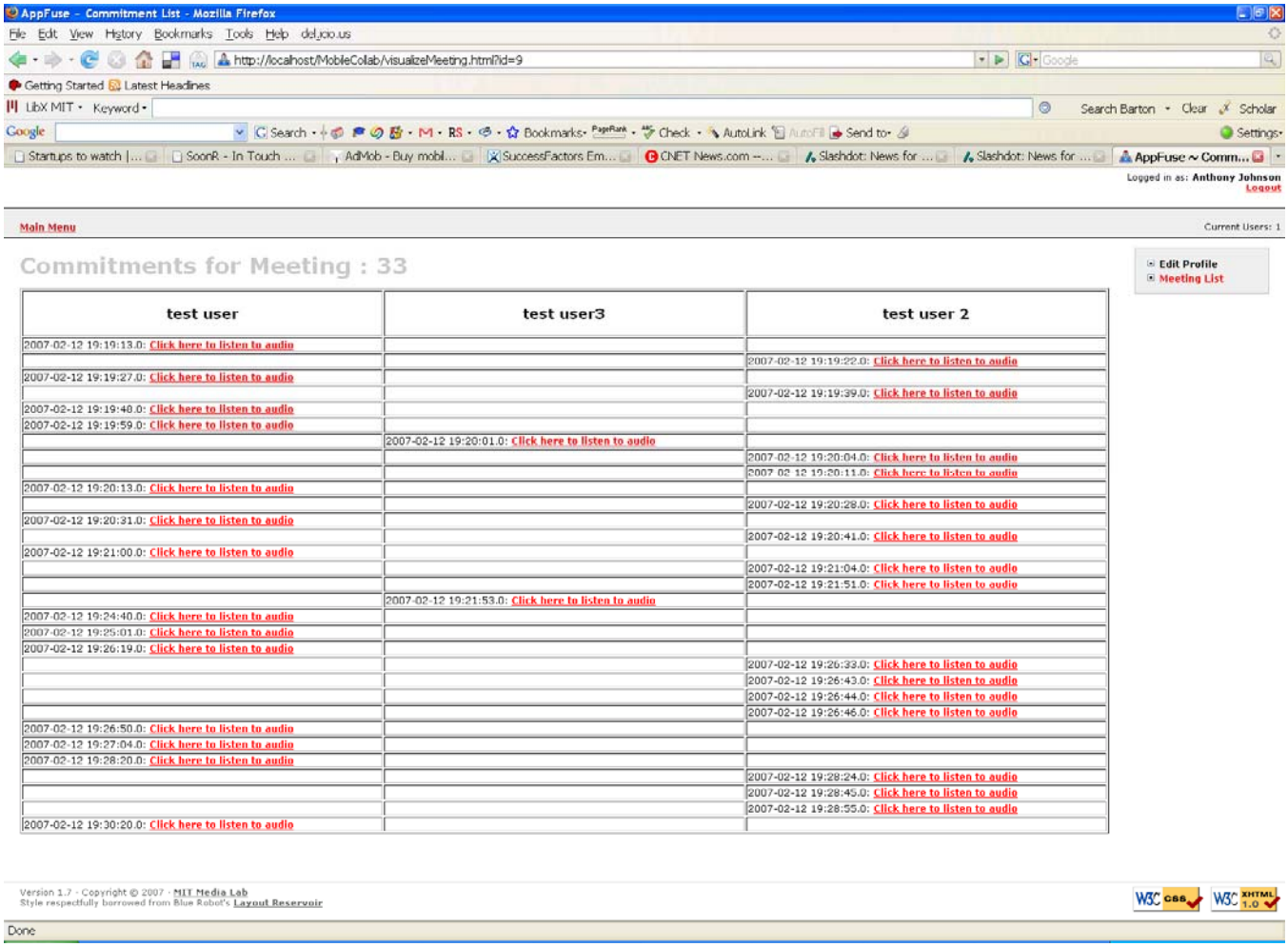


Figure 7 – Audio Only Entries from a 15 minute meeting

Once we have identified a user that we wish to invite to a meeting, we are able to do just that. This is done by sending them a text message to a specific port on their phone which is registered to

MobileEssence. When this arrives, if the MobileEssence system is not running, it is subsequently activated and processes the invitation. The user is then able to accept or reject the offer to join the new meeting. This process can then be done by all members of the meeting until everyone is invited. The list of members is updated on each users' phone, and thus they are able to see the current list of members.

4.2.7 SMS invitation

The SMS invitation described above could also be used to activate the client on members' phones at a preset meeting, or in collaboration with a conference system.

4.2.8 Information review

The client provides a simple interface to allow users to review meeting notes: when a user logs into a meeting, they have access to a list of the commitments made up until that point. They are able to listen to or read any of these notes.

4.3 Web Client

4.3.1 Registration and Account Creation

User management and creation is all done through the primary web interface. The users register information about themselves such as name, email address and phone number. They are then able to download the phone client and login.

4.3.2 Listen

The initial and possibly primary purpose of the website is to allow users to review notes that were taken during a meeting. On the website they are able to replay any audio generated during the meeting, view captured images, or read text. This information can either be used as the basis for further content generation, as described in section 3.4.4, or can be used as a real-time view of the current meeting.

In this latter case, a large shared display projects the view of the current meeting. This information is updated with information as soon as it becomes available, providing real-time feedback of the events in the meeting.

4.3.3 Annotations

Users are able to annotate on the web site. This is done by allowing users to provide textual comments to the audio notes, and/or images which are displayed on the website. The design of the system allows for this to be done on the mobile device, but typically encourages it to be done using the web site.

4.4 Implementation Details for Scenarios

4.4.1 Meeting Room Capture

4.4.1.1 User's Perspective

For the user, starting a meeting and adding users to this meeting is very simple. The master user's interaction can be reduced to 2 steps:

1.) Start the application on their phone and login.(Figure 8)

2.) Go the list of proximate users and invite them. (Figure 9)

The invitees also see just one step:

1.) Application loads up on their phone and asks if they wish to join a meeting. (Figure 10)

Once these steps have been completed, all members are able to capture data, either as retrospective audio data, or other types of information as described in the following sections.

Figure 8 – The First Screen for starting meetings

Figure 9 – A list of proximate users

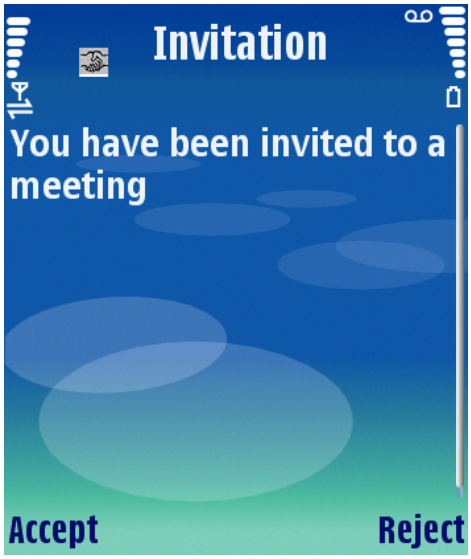


Figure 10 – The screen displayed when a user is invited to a meeting

4.4.1.2 Technical Details

When the first person arrives at a meeting location, they load the application and click on the 'login' button. This starts a new meeting on the server, and initiates the continuous recording mechanism. When other members come in, the first user is able to invite these users by picking their names from the list of other MobileEssence phones in Bluetooth proximity. This list continuously compiled by recording all Bluetooth signal's MAC address and determining whether it is recorded in the MobileEssence database of registered devices. If these users are registered in the database, their contact information is

sent back.[4] A user invites other users by selecting their name and clicking "Invite." This sends an SMS message to that user on a specific port, which is registered on that user's phone for MobileEssence use. Receiving this message, in turn, starts up the MobileEssence system and presents the invitation to the recipient, who is then able to accept or reject the invitation. Once other members have joined, they are able to add other in the same manner. As each of these members join the meeting, their phones are synchronized together.

[4] This is clearly a security risk in its present implementation. Alternatives are discussed in the further work section 5.2.4

Once the meeting starts, one of the users finds a point import. He/She clicks on the commit button. This sends a message to the central server, which then tells all the phones in the meeting to send a copy of their buffer.

Once all the phones in the meeting have received input from the member's phones, the server-side code runs a sequence of algorithms on the input to determine who the last person speaking was as detailed in 3.3.5. The user who spoke, the user(s) that were interested, and the final best copy are all publicly recorded for others to see. Since the web-site is continuously updated, when this new information is added, if the members are using a shared displayed, they are then able to see this updated information.

4.4.2 Conference Call Meetings

Since the system can be initiated through a meeting ID, the application can be run manually by remote callers into a conference call system. As a result, they are able to log in and have access to all of the features that a co-located users would have access to.

4.4.3 AdHoc Hallways Meetings

The AdHoc Hallway meeting scenario is technically done in an identical manner to the Meeting Room scenario, since the meeting is started by one of the participants in an adhoc meeting.

4.4.4 Post-Meeting Collaboration and Expansion

The users are able to log in at any point during the meeting using the web-interface. Here they are able to review the audio through streaming mp3 encoded audio, or simply view the images and text inline with a concomitant time-line. The primary action they are able to take here is to replace audio snippets with a textual summary. Since the 15 second audio snippet is often most useful to jog memory, a textual description provides a way of converting these into a succinct set of meeting notes.

4.4.5 Backchannel Communication during Meetings

MobileEssence provides a mechanism for backchannel communication through SMS messaging. Since at any given point in time, the system is aware of the complete list of members, the system provides an messaging interface that only shows the members of the meeting. This list is updated by polling the server at regular intervals.

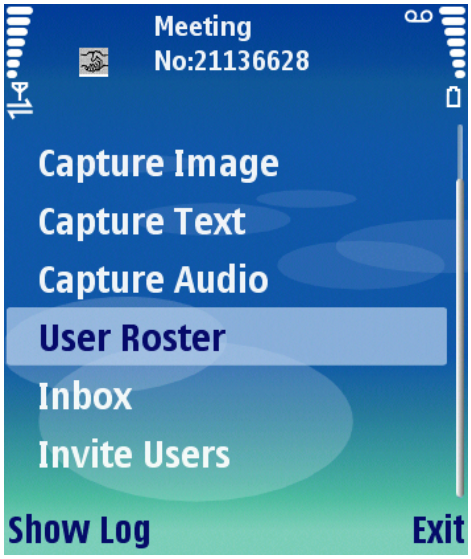


Figure 11 – The Top Level MobileEssence User Interface

When a user chooses another user, they are able to send them a text message which is displayed on the other user's primary screen, as well as being stored in an inbox. If the user receives a message when the application is not running on the phone, it is simply received as a normal SMS message.

4.5 **Evaluation**

4.5.1 Introduction

In evaluating a software system designed for collaboration, we are confronted with several seemingly contradictory goals. The first of these is the evaluation of the software in a setting which elicits normal behavior, both in terms of how it is used and in terms of the manner in which people collaborate using the tools. The second is the necessity of a model which allows the evaluation of the software to be

quantitative rather than entirely qualitative. These two priorities can be difficult to reconcile, since in general, in order to get quantitative results, the experimenter is forced to restrict the subject and/or environment to a situation which is controlled, which is to say to induce behavior which is non-standard with regards to most groups.

In addition to the rather fundamental limitations presented above, in this particular case, we are limited by time to restricting the scope of the evaluation: since the software provides a rather wide spread of tools. As such we were unable to fully evaluate each of the parts of the application in a controlled manner, but rather chose to limit the main evaluations to the use of the tool during meetings and for post-meeting follow-up.

4.5.2 Demographic Heterogeneity

As Mennecke and Wheeler[40] point out, a great deal of CSCW research has been done by controlled experiments using college students. In their opinion, these groups tend to be "ad-hoc collections of university students who have little or no experience neither with CSCW work tools nor with critically examining complex problems." While I tend to disagree with both of these points, the fact does remain that most CSCW has been done on university students. As such, we did not specifically target university students, but rather tried to get a wider swath of experimental subjects by posting study advertisements to Craigslist, an odd-jobs portal accessible to all residents of Boston. This meant that in general, approximately 50% of subjects were current students, and the other half included administrators, managers and several other professionals, giving our study a good breadth of demographics and occupations. This also resulted in some problems early on, due to some of the material that was used in our initial pilot studies. These problems are discussed in section 4.3.

4.5.3 Logical Group Size

When discussing a group which is collaborating to solve a problem, it is possible to talk either about the real size of the group, or the logical size of the group. The latter is not necessarily as quantifiable as the former, but provides a different way of looking at the problem of how different view points are often necessary to come to a optimal conclusion. Numamaker, Voget and Konsynski define these aspects:

"A physically large group from a common culture… may have a high degree of overlapping domain knowledge that results in the group being logically small. Conversely, a physically small multi-cultural group exhibits characteristics of a much larger group because its members have multiple and often conflicting perspectives, points of view, diverse knowledge domains, and opinions that make it logically large." [32] In laboratory experiments, this generally means that as a result of the mechanisms by which experiments are controlled, the group's diversity is reduced. In practice, since many experiments are reducing problems down to a minimum, they find themselves removing any individual diversity in the experiment that would be present in real-world collaborative efforts.

4.6 Hidden Profile Tasks

A significant problem that is faced when designing the experiments evaluating the efficacy of collaboration tools is the quasi-contradictory nature of the goals, as outlined above: meaningful quantitative data derived from a controlled experiment, but which reflects the real use of a tool in the ambiguous, political nature of group interaction. In order to deal with these problems we choose to use Hidden Profile tasks, also known as Stasser tasks. These have been used fairly extensively in recent years to evaluate the effectiveness of various CSCW tools [39]. Stasser[50] defined a Hidden Profile scenario as a situation where "the superiority of one decision alternative over others is masked because each member is aware of only one part of its supporting information, but the group, by pooling its information, can reveal to all the superior option." What this means in practice is that each subject is

only aware of a portion of the information necessary to find the optimal solution to the problem. One of the primary purposes of this type of problem is that it requires participants to share information (i.e. communicate within the group) as well as process the information which is presented to them in the problem.

Inevitably, we found that there were a number of issues which were not addressed by Hidden profile tasks, and we discuss these further on.

4.7 Initial Qualitative Evaluation

In developing our suite of experiments, we performed a set of initial evaluations of the system. These, like subsequent experiments, used Hidden Profile tasks, but the construction of the tasks was much simpler. Our primary goal at this stage was to determine initial issues that people had with the system as it existed at the time, to determine how natural or unnatural people felt the use of the mobile phone as a recording tool was, and to gauge people's general impression of technology in the context of meetings.

For this, we used a set of Hidden Profile tasks developed for the Second Messenger project. These consist of a exercise that asks the participants to choose an undergraduate student for MIT, and one that asks the group to choose the location for a new convenience store. In these particular tasks, there was no absolutely correct answer, even with the inclusion of all the information available to the group.

4.7.1 Conclusions

This stage provided a great deal of insight both in confirming ideas about how the tools was used, as well as indicating limitations within the initial design of the experiment. Some of the initial concerns about the problems associated with studying CSCW tools in a quantitative manner were confirmed, including such problems individual group dynamics taking a significant role in the task, as well as the

difficulty associated with choosing tasks which are applicable across a broad range of people. In groups, however, that used the system extensively, subjects seemed to find the system natural to use after an initial period of around 5 minutes.

One issue that we encountered was that the nature of the tasks' subject matter often encouraged discussion and debate not relevant to "solving" the task at hand and, ultimately, effective collaboration. This was primarily as a result of the heterogeneity of the groups, and the highly mathematical nature of the tasks chosen, which were initial designed for MIT undergraduate students.

In groups where this was not an issue, groups could be divided into two main types: those that embraced the technology, and those that barely used the technology. Group dynamics seemed to play a big part in this, since individuals using the system seemed to encourage others to do likewise.

Groups that used the system seemed to find the tool to have potential, whereas those that did not use it did not see its utility. At this stage we were not able to determine whether they did not use it because they simply did not find this type of interaction useful, or did not find it useful because they did not use it enough. Since we did not encourage subjects to use the system we were not able to determine whether dislike of the system was as a result of failures in MobileEssence.

4.8 Second Version Evaluation

In the first version of the experiments, the primary goal was to determine if the use of the MobileEssence tool had any net effect on a meeting. In order to study this, we took some of the lessons learnt from the pilot study in order to limit the scope of the problems being addressed to the immediate effect on the meeting.

The groups were given two different hidden profile tasks, this time with a single correct answer, followed by a "meaningless" task that required approximately 10 minutes of their time, and finally a recall exercise of the points that were used to arrive at a conclusion.

There are two conditions in each experiment: one allows users to take notes using only pen and paper, which they are then given access to during the recall exercise; in the second, they are allowed to use pen and paper as well as the MobileEssence client to take notes, but are only allowed to access to the audio captured by the group during recall.

4.8.1 Hidden Profile Tasks

The hidden profile tasks were designed to give each of the three participants several different pieces of critical information. If the users shared all additional pieces of information, they were able to narrow it down to a single answer without any external information. The tasks consisted of hiring a manager for a mining operation in a foreign country, and picking a location for a wedding.

The 'meaningless' task was a quantitative task was presented in a completely different format. The main purpose of this task was to give a break between the hidden profile tasks under consideration and the recall exercise.

4.8.2 Recall Exercise

In this portion of the experiment, the individual members of the group were separated and asked to write down the list of reasons their group used to choose the manager or the wedding location. They were first provided with their pen and paper notes to perform this reconstruction for the first task, and then were provided with access to their audio notes to reconstruct the decision rationale for the second task.

4.8.3 Conclusions

For these first versions of the study, our results were largely observational and qualitative in nature. Results observed included:

- Groups that used the technology actively generally found it to be very useful.
- When they used the technology actively, they were better at recalling the decisions that led up to the final choice. Though not statistically significant, we determined that of the groups involved, the two who used the technology most actively and effectively performed better at decision reconstruction and recall than those who did not use the technology as actively.
- People had a great deal of difficulty in grasping the idea that when one pushes a button, it records audio that is already passed. This appeared to be generational with younger subjects grasping the concept quickly. Getting this concept across took time to perfect, although TiVo seems to have struck a chord with most people.
- Groups tended to either all use the technology together, or not at all.
- The more than half of the groups were reluctant to use the new technology, even when they understood the idea of the technology.

4.9 Meeting Recall Evaluation

This experiment was very similar to the previous experiment, apart from two major changes. The first of these changes was the separation of the experiment into two separate events, the second of which was performed online a week after the initial stage; the second change was in the phrasing of the incentives to encourage people to use the tool.

In the new follow-up section of the experiment, which is conducted a week after the subjects' onsite participation, each participant is sent a scanned copy of their written notes for the first task, and the URL of the MobileEssence website with audio notes of the second task. Thus, for one task they have access to the group audio notes, but for the other task only their own handwritten notes. This difference reflects what we feel is the natural state of most meetings: when people take notes, these notes are rarely passed along to others in the group, whereas with MobileEssence, it is inherent in the nature of the system to share access to these notes.

The second different is the changing of the incentive scheme used. In this experiment, all participants were paid for showing up and running the study; however, they were informed that if they took "good" notes using both paper and using the MobileEssence system, they were eligible for a follow-up which would pay an additional amount.

4.9.1 Performance-based Incentive Scheme

The reason that this new scheme was introduced was a tendency in about half of the groups to simply not use the MobileEssence platform. Often this appeared to be as a result of either not understanding the system, or not believing the system could be useful. Both of these would be common if the MobileEssence platform were commercially deployed, however, it meant that the results collected were not a performance evaluation of the actual tool, but rather an evaluation of the preconception of the idea of the tool as well as our presentation of the tool. As a result, an incentive scheme was introduced. Since the subjects were aware of the follow-up exercise (the recall task), the subject was free to define their performance metric. By this, I mean that the subject was free to use their own conception of what a "good" set of notes, or "good" use of the system was. Since they knew the follow-up exercise, it was in their best interest to use the tool in such a way as to make it as useful as possible.

The primary objection to this approach was that, by incentivizing the subject, their behavior could be considered non-standard. However, research has shown that incentives do not have a significant impact on subjects' behavior in similar contexts.[47,48,49]

4.9.2 Performance Scoring

Since in this experiment, there is a set of 6 distinct hidden pieces of information that must be uncovered in order to determine the correct final answer, we are able to provide a very simple scoring mechanism: Each participant is given a score based on the number of hidden points they correctly mark down in their recall. This is compared to the number the group as a whole received during the first exercise to determine a performance score for that individual.

For any given subject, there are three significant numbers that arise out of the study: the group's performance metric and the users aided and unaided (with and without the MobileEssence system) performance score.

4.9.3 Result Analysis

Most collaborations amongst the groups for both tasks ran both smoothly and similarly. Nearly all groups recognized the "hidden" nature of their given criteria in the first task, and planned accordingly in the second. Thus, where they spend the first 15+ minutes discussing cordially the various candidates in Task One before stumbling upon differing data, in Task Two they immediately commenced discussion by comparing their different given criteria. Therefore, collaboration time for Task Two was significantly less than collaboration time for Task One. Indeed, in many cases participants had to be told to begin talking in Task One; some groups went for over 10 minutes studying their sheets in silence, and gentle incentive to discussion was necessary. Groups were told that they had a maximum of 20 minutes to come to a mutual conclusion and were given timely updates, though the limit was not strictly enforced.

The dynamics of many of the groups were and in some cases less than ideal for the purposes of our study. Some participants would overwhelm the discussion, silencing other participants. Because each participant has different but essential information in the hidden profile task, this was particularly detrimental to the group's end goals.

Task One asked participants to imagine themselves as a board of directors of an international coal mining company looking for a new manager of operations in Argentina. There were nine essential criteria that needed to be identified in order to select the correct candidate (Pierce McGyver III). Task Two asked participants to imagine themselves as employees of a wedding planning agency choosing a venue for a wedding reception to be held in New Hampshire. Here, there were thirteen essential criteria that had to be identified in order to select the correct venue (Causeway Chateau). To obtain fair and accurate results, we introduced the technology under study to all participants before the tasks. Then, the first four groups performed Task One with pen and paper, and Task Two with MobileEssence. The second four groups performed Task One with MobileEssence, and Task Two with pen and paper. The results of the two tasks are summarized in the following two tables.

Task One.

Group	Medium	Time to completion	Did they realize the trick? (at what time)	Average No. Criteria Correctly IDed	Final Answer
1	Pen/paper	19m23s	Y (14m32s)	9	Pierce McGyver III
2	Pen/paper	21m35s	Y (16m55s)	6	Jack Derrida
3	Pen/paper	17m08s	N	6	Hester Prynne
4	Pen/paper	23m00s	Y (18m03s)	8	Pierce McGyver III
5	MobileEssence	14m18s	N	3-4	Javier Colon
6	MobileEssence	20m20s	Y (13m44s)	7	Honey Dijon
7	MobileEssence	16m10s	Y (10m34s)	9	Pierce McGyver III
8	MobileEssence	15m28s	Y (8m38s)	5	Honey Dijon

3. Table 2 - **Individual Reconstruction Results Task One**

Task Two.

Group	Medium	Time to completion	Did they discover the trick? (time)	Average No. Criteria Correctly IDed	Final Answer
1	MobileEssence	12m17s	Y (immediate)	9	Causeway Chateau
2	MobileEssence	14m47s	Y (immediate)	10	Causeway Chateau
3	MobileEssence	15m45s	Y (8m47s)	9	South Chad CC
4	MobileEssence	10m41s	Y (immediate)	9	Ye Olde Hofbrauhaus
5	Pen/paper	10m56s	N	5	Royal Concord Theatre
6	Pen/paper	16m52s	Y (immediate)	10	Causeway Chateau
7	Pen/paper	11m56s	Y (immediate)	11	Causeway Chateau
8	Pen/paper	12m30s	Y (immediate)	7	Tempeh Terrace

Table 3 - **Individual Reconstruction Results Task Two**

Most subjects were able to reconstruct with relative accuracy the main criteria (correct or not) for making this selection, and one or two reasons why (and what) was rejected in favor of the final selection. There was a slight but discernable difference between participants' ability and accuracy to recall information using traditional note-taking methods versus using the MobileEssence technology, with MobileEssence providing slightly more details in the reconstruction.

A quantitative comparison of participants' recall(from Table 2 and 3) using hand-written notes and MobileEssence notes indicates a better recall with the latter: groups performing Task One with pen and

paper averaged 4.45 points, whereas groups performing Task One with MobileEssence averaged 6.1 points; groups performing Task Two with MobileEssence averaged 7.8 points, whereas groups performing Task Two with pen and paper averaged 5.9 points. This result, however, is dominated by group's individuals and their interaction. As such, significantly more user groups are needed for statistically significant results.

The primary result that came out of the final study is that MobileEssence users were able to recall the reason for how they arrived at a final decision with slightly higher accuracy than with traditional pen and paper.

5. Usage Analysis

5.1 General User Feedback

5.1.1 Demographic Overview

All subjects who came to run the experiment were asked to provide basic demographics, and some information concerning their perceptions of technology and mobile phone usage.

In order to address issues of inexperience with meetings and technology, we used Craigslist to enlist candidates, since we felt this was representative of end-users for mobile products.

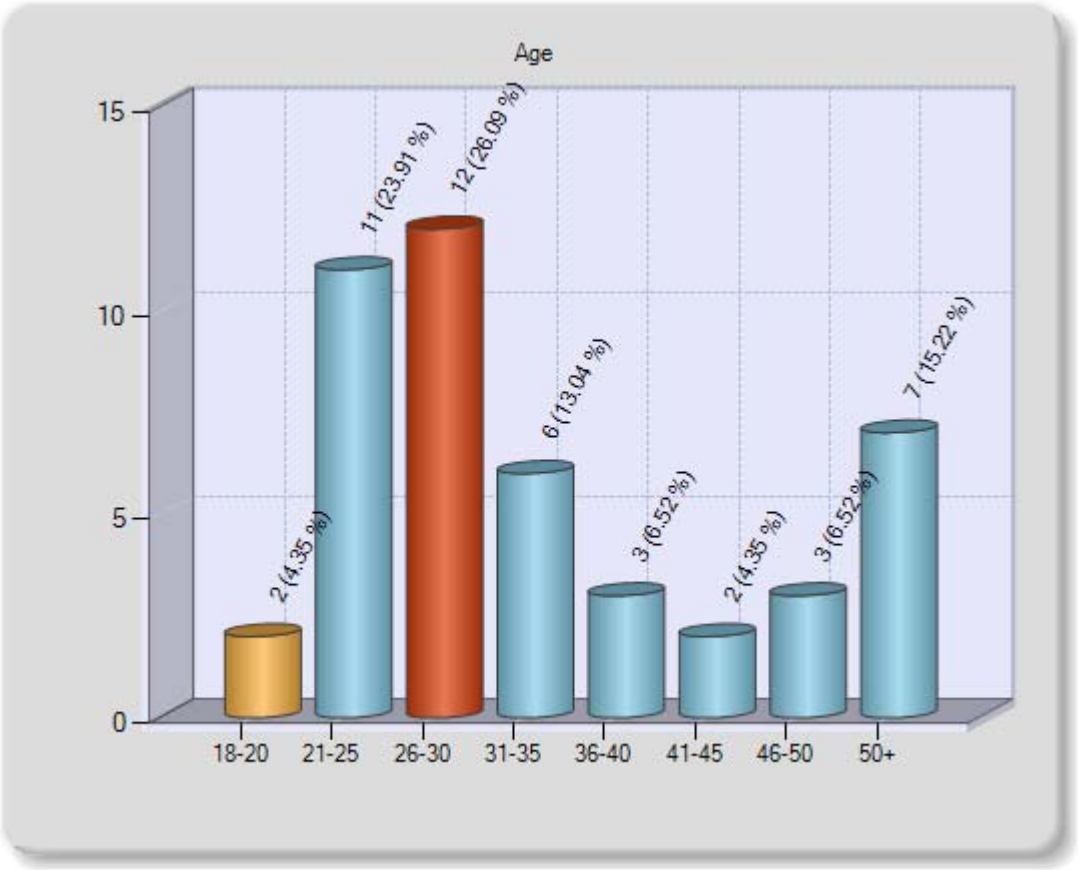


Figure 12 – Age Distribution of Subjects

The majority of subjects were between 21 and 30, and non-students (addressing some of the issues with other CSCW work, as mentioned in section 4.1.)

5.1.2 User Perception of Technology in Meetings

It can be seen in Table 1 that people tend to accommodate computer activities into their daily business lives, but have been more reluctant to bring mobile phone technology into the meeting environment.

	Mean out of 5.	Std.Deviation
Computers help in organizing activities.	**4.53**	**.655**
Computers help me take notes.	**3.45**	**1.12**
Computers make sharing ideas after meetings easy.	**4.55**	**0.789**
Mobile phones are obnoxious during meetings.	**3.87**	**1.12**
Meetings that best when they are structured according to a preexisting plan.	**3.71**	**0.762**
Wireless mobile devices are useful for taking notes during meetings.	**2.45**	**1.01**
Wireless mobile devices are useful for sharing ideas with my colleagues during meetings.	**2.62**	**1.19**
Wireless mobile devices are useful during meetings for communicating with people who do not speak my language fluently.	**2.64**	**0.99**

Table 4

5.1.3 Current Uses of Mobile Phones

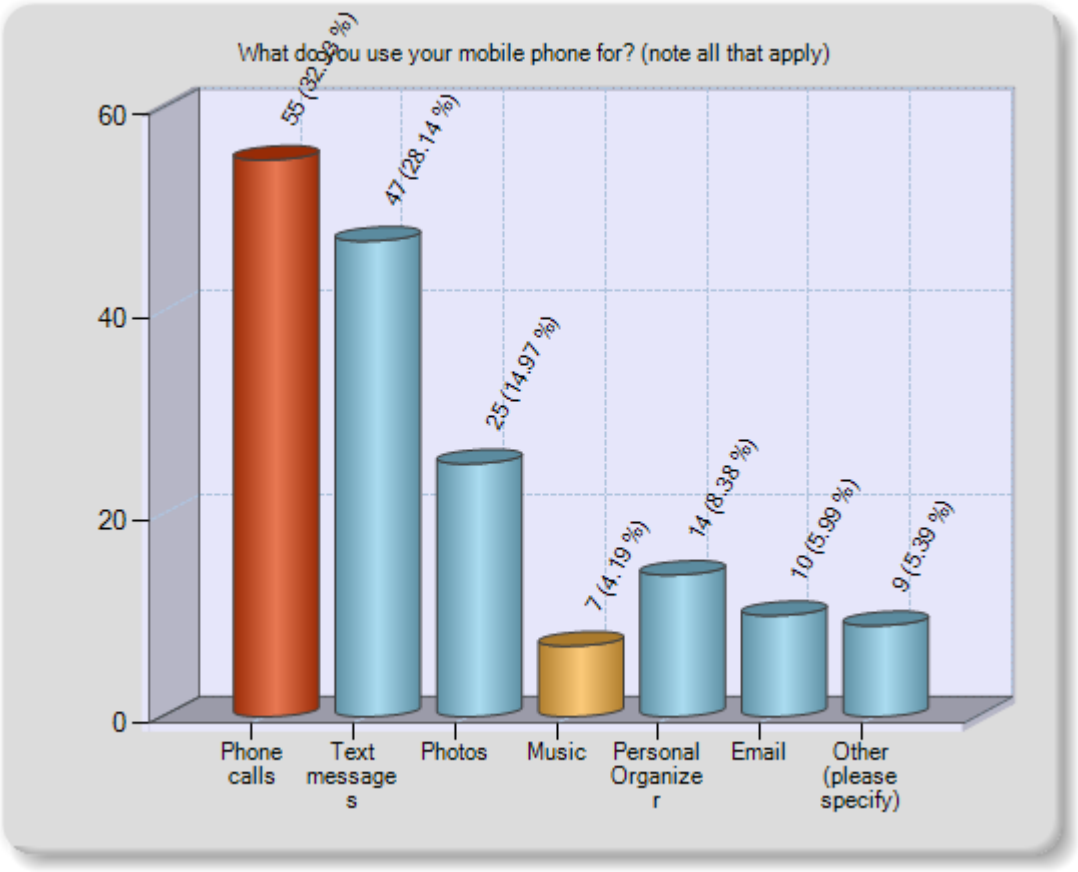


Figure 13 – Current Uses of Mobile Phones

5.1.4 General Overview of user's responses

	Not at All				Very Much	
Do you think the system would be useful in a meeting room?	0.00 % (0)	**20.00 % (2)**	**30.00 % (3)**	**50.00 % (5)**	0.00 % (0)	**3.3**
Do you think the system would be useful in a remote conference call?	0.00 % (0)	**10.00 % (1)**	**50.00 % (5)**	**30.00 % (3)**	**10.00 % (1)**	**3.4**
Do you think the system would be useful on an individual, personal telephone call?	**10.00 % (1)**	**20.00 % (2)**	**30.00 % (3)**	**40.00 % (4)**	0.00 % (0)	**3**
This is useful for me:	**10.00 % (1)**	**40.00 % (4)**	**40.00 % (4)**	**10.00 % (1)**	0.00 % (0)	**2.5**
This is useful for business people:	0.00 % (0)	**10.00 % (1)**	**40.00 % (4)**	**50.00 % (5)**	0.00 % (0)	**3.4**
This is useful for management:	0.00 % (0)	**10.00 % (1)**	**40.00 % (4)**	**40.00 % (4)**	**10.00 % (1)**	**3.5**

Figure 14 – Stage 3 exit survey results

It can be seen from figure 12 that on average, people that used the system generally thought that the system was useful. Figure 12 only includes responses for groups which actually used the system extensively enough to be able to compare it effectively to pen and paper.

5.1.5 Observations

One of the results of our exit survey was that there appears to be a link between how much users used the system and how much they found the system to be useful. Specifically, of the 17(out of a potential 20) exit responses for the 3rd stage, we found that the two groups that did not use the system significantly(less than 5 click for the entire group) did not find the system useful, whereas the groups that did use it gave it an average of 4.5/5 in terms of general utility.

While the numbers of respondents and the interaction of the groups together make this more of a qualitative evaluation than a hard statistical fact, there did appear to an initial barrier for people to get comfortable with the system.

Another interesting observation is that, although people where more or less ambivalent about whether they would want this as a new feature on their phone (2.9/5), more than 60% of people were willing to add this to their existing phone.

6. Suggestions for further development

6.1 Further User Studies

The initial studies have provided a number of very promising results, however, there are number of situations which have not been covered by the studies run. In particular, there is a clear need for a longer, long-term study. This study would most likely be designed to provide a more free-form use of the MobileEssence platform by end-users, in large part to get more comprehensive feedback about what

the potential uses of the tool are, and whether there is potential for a more wide-spread use of this type of collaboration technology.

6.1.1 Ad Hoc Meetings

Research has shown that proximity can be considered a likely factor in generating a collaborative effort [39]: “for people in the same department, people were two-thirds more likely to collaborate if their offices were on the same corridor than if the offices were only on the same floor.”

Currently, the majority of collaboration tools do not afford users with functions which aid co-located collaboration that is unplanned. As described in Section 1, MobileEssence provides this. The tool, however, was only studied in a limited experimental setting, and therefore a great deal more work needs to be done in order to determine its operations in a complete working environment.

6.1.2 In-Situ Voting for Real-time Feedback

In-situ voting is a feature which was implemented, but never tested in any experimental conditions. The feature is described more fully in the technical section, but in general, it allows users to provide instant feedback on voting issues [45]. Possible extensions could include providing a templating mechanism for a variety of different configuration depending on usage.

In the current implementation, the only feedback given to users is a message sent to all users with the result of the vote, although this could be done with a more complex interface for multi-choice polls, or perhaps weighted voting for situations where not all members carry equal power on decisions.

6.2 Speech to Text

In order to determine whether and who is speaking, the system uses a multi-channel version of a speech-detection algorithm used by CMU's Sphinx speech recognizer. This is a continuous-speech speech to text engine, which, if configured properly, could be used to perform a continuous analysis of speech as it comes in. Since the system is entirely server-side, it would have computationally an easy task.

There are several possible uses of Speech To Text in the MobileEssence platform. Two of these are detailed in the following sections.

6.2.1 Speech To Text As An Indexing Mechanism

Vermuri's work showed that, while continuous speech recognition has many limitations when it comes to providing a continuous transcript of a meeting. His work shows that, while it is perhaps ineffective as a transcription mechanism, it is very good at allowing users to find speech segments such as conversations or lecture. As such, in the MobileEssence platform, the use of a search engine could allow users to find meetings through a free-text search.

6.2.2 Speech To Text As A Tagging Mechanism

While this work is now several years old, the technology has not improved significantly enough to warrant re-examination, but there is potential in using a combination of the indexing system above with the tagging system. In this use-case, the user is able to see a list of tags dynamically assigned to segments, and/or meetings based on previously analyzed and tagged meetings.

6.3 Bluetooth Enabled Pen

One potential very powerful addition to the MobileEssence tool is the addition of a pen which is able to be used by the members of the meeting and having these notes be included in the shared space. This can

be accomplished by using a Bluetooth enabled pen such as the Nokia Digital Pen (SU-1B), which allows a mobile device to receive digitized images from a pen in real-time.

Currently, MobileEssence affords user the ability to record shared physical notes through photographs, but this may provide a more natural inclusion mechanism.

6.4 Backend Integration

MobileEssence does not currently provide any way of expanding beyond the initial document created during a group's interaction. The author is of the opinion that the most important way that MobileEssence can change interaction is by acting as a seeding mechanism for a larger collaboration tools, such as a wiki-like project information management tool.

6.5 Email reminder

Email reminders were implemented in the system, but not thoroughly tested. The email reminder system is a tool which sends meeting reminders an email reminder at the end of a preset time after an meeting. This serves to make sure that people do not forgot about meetings by showing them the meetings in which they participated.

6.6 Collaborative Noise-Cancellation

Since the system receives N-simultaneous recordings from the various phones involved in a meeting, it is possible to synchronize these streams together using convolution. Once these have been synchronized, it is possible to remove background noise by determining the shared background and subtracting it.

6.7 Visual Feedback

Currently, there is not mechanism to display information about who is speaking to other users in real-time. This would give users a good understanding of who is speaking when the system is used on a conference call.

7. Conclusions

The MobileEssence platform differentiates itself from previous work through the following aspects:

- note taking
- collaboration after the meeting
- overview of meeting taking place
- voting
- feedback

It is one of the first collaboration tools specifically designed for use with the mobile phone, and has a great deal less cognitive overhead than most collaboration systems. Studies also indicate that it can increase groups' efficiency in certain domains, although we only have a limited sample population and no long-term studies to confirm this. It provides a comprehensive platform for the integration of mobile everyday information generated by all workers into a shared, collaborative space which is can be grown organically from the seeds created by the mobile device.

User studies showed that MobileEssence does not have a significant learning curve, nor a noticeable impact on productivity, and appears to increase recall of events that occurred during the meeting. The three main user studies which were run on the MobileEssence platform were presented, including both lessons learnt, and data collected. These studied: the effects of incorporating the system into a meeting, which proved to have no negative effect on productivity, the effects on short-term recall of information using the tool, and finally the impact of the audio information when attempting to recreate knowledge using long-term memory.

People that used the system for an extended period of time found the system useful, and were generally interested in having this type of functionality in their next phone. We expect that with more frequent use and more familiarity, users would find numerous unforeseen applications that extend far beyond the meeting room. I believe that using mobile phones as the tools for integrating life's and work's event back into software system that we already use will change how we work and interact.

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9. APPENDIX A

CONSENT TO PARTICIPATE IN NON-BIOMEDICAL RESEARCH

Use of mobile devices in collaborative environments

You are asked to participate in a research study conducted by Ted Selker, PhD, and Anthony Johnson from the Media Lab at the Massachusetts Institute of Technology (M.I.T.) You were selected as a possible participant in this study because you are capable of working in a normal business environment. You should read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

• PARTICIPATION AND WITHDRAWAL

Your participation in this study is completely voluntary and you are free to choose whether to do so or not. If you choose to be in this study, you may subsequently withdraw from it at any time without penalty or consequences of any kind. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

• PURPOSE OF THE STUDY

The purpose of this study is analyze people's behavior when using wireless mobile devices in a collaborative setting.

• PROCEDURES

If you volunteer to participate in this study, we will ask you to do the following things:

Participate in three selection tasks, in which you will be asked to read given information and come to a consensus as a group regarding a chosen candidate. Two tasks will be done using traditional pen and

paper methods, and one with the collaboration tools. These tasks will be carried out over the course of a single setting and will take approximatel 1.5 hours.

• POTENTIAL BENEFITS

We hope to be able to better understand group collaboration and build more effective tools to enable this collaboration.

• PAYMENT FOR PARTICIPATION

You will receive a $25 gift certificate to amazon.com as compensation.

• CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.

The in-lab meetings will be recorded on videotape. You are free to watch these as you please, and no one except the investigators will have access to these. They will be erased 2 years from the end of the experiment.

No personal data will be used for the analysis, and will be de-identified once the experiment is over. The data will be reported as aggregate numbers, although some sections from the questionnaires and collaborations may also be included anonymously in research papers.

• IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact Anthony Johnson: anthonyj@mit.edu, 857-204-2305 or Ted Selker: selker@mit.edu

• EMERGENCY CARE AND COMPENSATION FOR INJURY

In the unlikely event of physical injury resulting from participation in this research you may receive medical treatment from the M.I.T. Medical Department, including emergency treatment and follow-up care as needed. Your insurance carrier may be billed for the cost of such treatment. M.I.T. does not provide any other form of compensation for injury. Moreover, in either providing or making such

medical care available it does not imply the injury is the fault of the investigator. Further information may be obtained by calling the MIT Insurance and Legal Affairs Office at 617-253 2822.

• RIGHTS OF RESEARCH SUBJECTS

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you feel you have been treated unfairly, or you have questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E32-335, 77 Massachusetts Ave, Cambridge, MA 02139, phone 617-253 6787.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Name of Subject

_____

Name of Legal Representative (if applicable)

_____ _____

Signature of Subject or Legal Representative Date

SIGNATURE OF INVESTIGATOR

In my judgment the subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

_____ _____

Signature of Investigator Date

10. APPENDIX B

HIDDEN PROFILE SELECTION TASK ONE

Overseas Mining Operations: Participant A

As director of overseas operations for a large multinational corporation, you have been asked to appoint a manager for mining operations in the Cuyo region of northwestern Argentina. Though your corporation has brought employment and strengthenened infrastructure in the region and is thus generally viewed favourably by the local Argentinians, past managers (all foreigners) have had difficulty in working alongside a native wokforce. In making your selection, you must therefore take into account several criteria and demands: those of the American board and shareholders, those of the Argentinian government and employment regulations, and those of the workers themselves. The first demand at least three years of managerial experience and/or an MBA. To comply with immigration regulations, the Argentinian government requires that the candidate speak Spanish and at least one other foreign language. Finally, to best oversee a team of native Argentinians, it is suggested that the candidate have prior managerial experience in foreign environments.Once you have made your selection, you will submit your proposal to other members of the board for final approval.

Overseas Mining Operations: Participant B

As director of overseas operations for a large multinational corporation, you have been asked to appoint a manager for mining operations in the Cuyo region of northwestern Argentina. Though your corporation has brought employment and strengthenened infrastructure in the region and is thus generally viewed favourably by the local Argentinians, past managers (all foreigners) have had difficulty in working alongside a native wokforce. In making your selection, you must therefore take into account several criteria and demands: those of the American board and shareholders, those of the Argentinian government and employment regulations, and those of the workers themselves. Besides a minimum of a Bachelor's degree in an engineering-related field, the first group would like to see demonstrated success in previous career positions (former companies' increase in revenue, stock splits, etc during the candidate's tenure). To comply with immigration regulations, the Argentinian government requires that the candidate *not* have travelled to Argentina between the years of 1976 and 1983 (the regime of the Argentian military). Finally, to best relate to a large native workforce, it is suggested that the candidate have prior experience living and working abroad, either in a professional or volunteer (pro bono) capacity. Once you have made your selection, you will submit your proposal to other members of the board for final approval.

Overseas Mining Operations: Participant C

As director of overseas operations for a large multinational corporation, you have been asked to appoint a manager for mining operations in the Cuyo region of northwestern Argentina. Though your corporation has brought employment and strengthenened infrastructure in the region and is thus generally viewed favourably by the local Argentinians, past managers (all foreigners) have had difficulty in working alongside a native wokforce. In making your selection, you must therefore take into account several criteria and demands: those of the American board and shareholders, those of the Argentinian government and employment regulations, and those of the workers themselves. The first demand a minimum of a Master's degree (MSc) and experience in engineering-related fields. To comply with immigration regulations, the Argentinian government requires that the candidate be at least 35 years old. Due to the unfamiliar environment with little support for foreign families, preference is given to unmarried candidates with no dependents. Finally, to best manage a large native workforce, it is suggested that the candidate have prior experience overseeing teams of at least 50 people. Once you have made your selection, you will submit your proposal to other members of the board for final approval.

Overseas Mining Operations: The Candidates

Name	Simon McGrue
Age	45
Marital Status	Married
Education	BSc, Chemical Engineering, 1983 MSc, Chemical Engineering, 1985
Professional Experience	5 years, chemical engineer, Merck, NJ (stock split 3 ways during tenure) 5 years, management (team of 20), Merck, Barcelona, Spain (company stock up by 12%) 8 years, senior management (team of 70), Merck, Barcelona (company stock up by 6%)
Non-Professional Experience	

Languages Spoken	Fluent Spanish, some Portuguese
Relevant Travel	One year study abroad in Chile (1981)

Name	Maureen Jordan
Age	38
Marital Status	Single
Education	BSc, Geological Engineering, 1990 MSc, Mineral Exploration, 1995
Professional Experience	3 years, general engineer, Ashland Coal Ltd 5 years, management (50 people), Teco Coal, BC Canada (productivity increase of 150%)
Non-Professional Experience	President, Lion's Club, Vancouver Canada
Languages Spoken	Spanish
Relevant Travel	Mexico, Belize, Costa Rica (1989, 1997)

Name	Honey Dijon
Age	34
Marital Status	Divorced

Education	BSc, Geological Engineering (summa cum laude), 1993 MBA, 1998
Professional Experience	4 years, management (50 people), Mezucal, Mexico (profits surpassed $1 billion)
Non-Professional Experience	2 years Peace Corps, Gobabis, Namibia
Languages Spoken	Spanish, Swahili
Relevant Travel	Mexico, Central and South America (1998-present)

Name	Pierce McGyver III
Age	36
Marital Status	Divorced
Education	BSc, Mechanical Engineering, 1992 MSc, Mechanical Engineering, 1993 MBA, 1998
Professional Experience	2 years, mechanical engineer, Boeing, USA (won major US government contract) 4 years, management (team of 60), Airbus, France (company stock up by 12%)
Non-Professional Experience	1 month Habitat for Humanity in Costa Rica (1994)

Languages Spoken	Fluent French, Spanish
Relevant Travel	

Name	Jack Derrida
Age	51
Marital Status	Divorced
Education	BSc, Environmental Engineering, 1979 MSc, Material Science, 1983 MSc, Systems Engineering, 1989
Professional Experience	12 years, junior/senior engineer, Peabody Coal and Fuel, PA USA (fourfold growth of company, stock split 8 times) 8 years, management (40 people), Hunter Valley Mines, Victoria Australia 5 years, management (70 people), Hunter Valley Mines, New Zealand
Non-Professional Experience	
Languages Spoken	Spanish, some French
Relevant Travel	Chile, Argentina (1978)

Name	Daisy Miller
Age	42

Marital Status	Married
Education	BSc, Environmental Engineering, 1988 MSc, Engineering Management, 1992
Professional Experience	5 years, analyst, Beth Energy (company goes public, stock doubles in two years), Manchester UK 8 years, manager (80 people), Beth Energy (stock increases by 10%), Manchester UK
Non-Professional Experience	2 research papers presented and published in 'Engineering and Mining Journal'
Languages Spoken	Spanish, German, Portuguese
Relevant Travel	Brazil (1999, 2000, 2002, 2004)

Name	Javier Colon
Age	52
Marital Status	Single
Education	BSc, Geological Engineering, 1978 PhD, Materials Science, 1988
Professional Experience	15 years, researcher/professor, Colorado School of Mines 10 years consultant, BNI Coal, Queensland, Australia (revenue doubled during his tenure)
Non-Professional Experience	Faculty fellow, LASCOS (Latin American

	Students at the Colorado School of Mines), 13 years
Languages Spoken	Fluent Spanish, some Portuguese
Relevant Travel	Mexico (1990-4), Ecuador (1992), Argentina (1995-7)

Name	Hester Prynne
Age	49
Marital Status	Widowed
Education	BSc, Materials Science (1978) MSc, Mining Engineering, Universidad de Buenos Aires, Argentina (1981) MBA (1987)
Professional Experience	5 years, materials engineer, Carbocol, Ecuador (revenue increase by 17%) 10 years, management (100 people), Carbocol, Ecuador (company stock up by 5%)
Non-Professional Experience	
Languages Spoken	Fluent Spanish, German
Relevant Travel	Central America, Caribbean, Mexico (1982-1990)

11. APPENDIX C

HIDDEN PROFILE SELECTION TASK TWO

Wedding Planning: Participant A

As an employee of Regal Weddings Ltd., you are in charge of planning a wedding to be held in Concord, NH in June of 2008. At present, the bride and groom are in the process of evaluating several different venues for their post-wedding reception. Given the multitude of other wedding decisions to be made, they have asked you to analyze the following venues and select the best possible fit according to the criteria they have given you. They will then, of course, have the final say. In reviewing the venues, you have several factors to consider. The first issue is accessibility: all guests invited to the wedding will be attending the reception, and therefore proximity of the church and venue is an important consideration. Furthermore, the bride and groom would like to make travel to and from the church and reception as easy as possible for their guests. An ideal venue is situated within 10 miles of the church and offers shuttle service to nearby accommodation. Though the guest list has not yet been finalized, the couple have sent an initial round of invitations and anticipate a 75% acceptance rate. Therefore, the dining room must be able to accommodate at least 200 people. The bride and groom are both avid food enthusiasts and hope to treat their guests to a plan to host a sit-down dinner with at least three entrée options; however, only two drink options (red and white wine) are required. Given these demands, the couple recognizes that the venue will necessarily be expensive but hopes to spend no more than $35,000. Once you have made your selection, you will submit the specifications of the chosen venue to the bride, groom, and parents of both the bride and groom for their appraisal. The three couples will be invited for an 'executive visit' of the venue during which they will be given a full tour of the location, taste-test of the menu, and explanation of the contract. You will accompany them on this tour and aid them in making a final decision.

Wedding Planning: Participant B

As an employee of Regal Weddings Ltd., you are in charge of planning a wedding to be held in Concord, NH in June of 2008. At present, the bride and groom are in the process of evaluating several different venues for their post-wedding reception. Given the multitude of other wedding decisions to be made, they have asked you to analyze the following venues and select the best possible fit according to the criteria they have given you. They will then, of course, have the final say. In reviewing the venues, you have several factors to consider. The first issue is accessibility: all guests invited to the wedding will be attending the reception, and therefore proximity of the church and venue is an important consideration. Furthermore, the bride and groom would like to make travel to and from the church and reception as easy as possible for their guests. An ideal venue is close to the church and must have handicap-accessible parking on-site. The couple is hoping for an intimate setting and thus would prefer not to hold the reception in a hotel. Though the guest list is not yet finalized, the couple have sent an

initial round of invitations and anticipate a 75% acceptance rate. The venue should therefore not accomodate more than 500 people. The bride and groom are both avid food enthusiasts and hope to treat their guests to a sit-down dinner, and they request that the kitchen of the chosen venue cater to special dietary needs (vegetarian, kosher, etc). Given these demands, the couple recognizes that the chosen location will necessarily be expensive and has budgeted at least $20,000. Once you have made your selection, you will submit the specifications of the chosen venue to the bride, groom, and parents of the bride and groom for their appraisal. The three couples will be invited for an 'executive visit' of the venue during which they will be given a full tour of the location, taste-test of the menu, and explanation of the contract. You will accompany them on this tour and aid them in making a final decision.

Wedding Planning: Participant C

As an employee of Regal Weddings Ltd., you are in charge of planning a wedding to be held in Concord, NH in June of 2008. At present, the bride and groom are in the process of evaluating several different venues for their post-wedding reception. Given the multitude of other wedding decisions to be made, they have asked you to analyze the following venues and select the best possible fit according to the criteria they have given you. They will then, of course, have the final say. In reviewing the venues, you have several factors to consider. The first issue is accessibility: all guests invited to the wedding will be attending the reception, and therefore proximity of the church and venue is an important consideration. Furthermore, the bride and groom would like to make travel to and from the church and reception as easy as possible for their guests. An ideal venue is located just outside of the city of Concord, in a more rural setting, and will provide a shuttle service to nearby accommodation. Though the guest list has not yet been finalized, the couple have sent an initial round of invitations and anticipate a 75% acceptance rate. Therefore, the dining/ball rooms must be able to accommodate at least 400 people. The bride and groom are avid food and drink enthusiasts and he would like to offer a buffet of appetizers to guests alongside an open bar. Given these demands, the couple recognizes that the venue will necessarily be expensive but hopes to spend no more than $30,000. Once you have made your selection, you will submit the specifications of the chosen venue to the bride, groom, and parents of both the bride and groom for their appraisal. The three couples will be invited for an 'executive visit' of the venue during which they will be given a full tour of the location, taste-test of the menu, and explanation of the contract. You will accompany them on this tour and aid them in making a final decision.

Wedding Planning: The Venues

Name	Weehawken Homestead
Location	Weehawken, NH (6 miles from church)
Accessibility	Car, RV, handicap-accessible parking

	Free shuttle service
Size	300 ppl (dining room), 300 ppl (ballroom)
Dining Options	3-7 station buffet (carving station available) 2-4 course sit-down meal (choice of 5 entrees, specialized entrees available)
Liquor Policy	Open bar Cash bar Beer and wine bar
Estimated Cost	$22,000

Name	Shadyside Grand Hotel
Location	Shadyside, NH (3.5 m from church)
Accessibility	Car, handicap-accessible parking Free shuttle service on weekends
Size	Maximum 450 ppl
Dining Options	Breakfast, lunch, dinner buffets Restaurant catered sit-down dinners (choice of 6 entrees; including those catering to special dietary needs)
Liquor Policy	Open bar Cash bar
Estimated Cost	$30,000

Name	Ye Olde HofBrauHaus
Location	North Bedford, NH (4.5 m from church)
Accessibility	Car, handicap-accessible parking Shuttle service can be arranged
Size	400 ppl (dining room)
Dining Options	Hot and cold buffet 2-5 course sit-down meal (choice of 4 entrees)
Liquor Policy	Beer and wine bar Microbrewery on premises
Estimated Cost	$20,000

Name	Concord Royal Theatre
Location	Concord, NH (7.75 m from church)
Accessibility	Car, RV, handicap-accessible parking Parking garage Taxi and shuttle services
Size	Maximum 500 ppl
Dining Options	Catered buffet 2-4 course sit-down dinner (4 entrees; special dietary plates available)

Liquor Policy	BYOB Open Bar Beer and wine bar
Estimated Cost	$23,000

Name	South Chad Country Club
Location	South Chad, NH (7.8 m from church)
Accessibility	Car, handicap-accessible parking Free shuttle service in summer months
Size	400 ppl
Dining Options	Brunch, lunch, dinner buffet Barbeque option 3-course sit down meal (choice of 2 entrees; special dietary options available)
Liquor Policy	BYOB Open Bar Cash Bar
Estimated Cost	$25,000

Name	The Mount Tremont
Location	Mount Tremont, NH (2.2 m from church)
Accessibility	Enclosed, handicap-accessible parking

	Free inclement weather shuttle service Limousine service for hire
Size	200 ppl (dining room) 250 ppl (ballroom)
Dining Options	3-7 course hot and cold buffet catered appetizers, desserts 2-5 course sitdown dinner (2-4 entrée options, special dietary needs considered) wine pairings
Liquor Policy	Open bar Cash bar Beer and wine bar
Estimated Cost	$36,000

Name	Causeway Chateau
Location	Causeway, NH (5.6 m from church)
Accessibility	Car, handicap accessible parking Parking garage Shuttle service on request
Size	Max. 450 ppl
Dining Options	3-5 course hot buffet w/ carving station dessert buffet 2-4 course sitdown meal (3 entrée options, special dietary options available)

Liquor Policy	Open bar Cash bar BYOB
Estimated Cost	$30,000

Name	Tempeh Terrace
Location	Tempeh, NH (3.5 m from church)
Accessibility	Car, RV, enclosed parking Taxis and shuttle service on request
Size	500 ppl max.
Dining Options	Outdoor and indoor grill/ buffet Outdoor and dinner sit-down dinner (3 course prix fixe menu, with 3 entrée options; special dietary options available)
Liquor Policy	Open bar Cash bar
Estimated Cost	$29,000

Name	Vine and Courtyard
Location	Kingston Crossing, NH (9 m from church)
Accessibility	Car, handicap accessible parking Free shuttle on weekdays; cost per hour on

	weekends
Size	200 ppl (dining room), 300 ppl (ballroom)
Dining Options	Catered appetizers 2-4 course sit-down dinner (3 entrée options; special dietary plates available) Dessert buffet
Liquor Policy	BYOB Open Bar Beer and wine bar
Estimated Cost	$27,000

12. APPENDIX D

DECOY DIVERSION COLLABORATIVE TASK

EL GUSTO COMPANY: SITE SELECTION

The El Gusto Company, a subsidiary of Food Inc., is undergoing expansion. They are in the process of selecting sites for 15 new Mexican restaurants to be constructed in the Northeastern cities during the next year.

The El Gusto management has decided that seven factors are very important in deciding where a Mexican restaurant of the type they have should be located. IN ORDER OF IMPORTANCE, they are:

1. traffic density on the near-by roads

2. competitive situation in the Mexican restaurant segment.

3. parking facilities

4. retail sales in the surrounding community.

5. population density within a 5 mile radius of the restaurant.

6. unemployment in the area

7. population growth in the area.

The management has studied these seven factors and has determined their order of importance as well as the cutoff limits for each factor (included in the chart below).

The El Gusto management hired a consulting firm to evaluate six potential restaurant sites in suburban Philadelphia. The El Gusto management requested that the consulting firm score each site on each factor on a 100 point basis. The results of the scoring are shown in the Information Packet.

The El Gusto management wanted to select one of these sites for construction. Given the importance ranking and cutoff points for the factors, the objective of the management was to choose the best site. Which site did they select?

Data Used for the Task:

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
4. Retail Sales (Min: 24)	30	34	38	23	26	19
2. Competit. (Min: 25)	37	32	25	22	28	18
6. Unemploym. (Min: 13)	13	18	12	16	15	17
1. Traffic (Min: 18)	29	19	18	32	24	16
7. Pop. Growth (Min: 18)	16	15	17	22	16	30
5. Pop. Density (Min: 18)	19	17	21	15	24	12
3. Parking Fac. (Min: 21)	17	28	30	19	25	34

Order:

Rules:

Best Site: The best site is the one that gets eliminated last, when we start eliminating the sites by looking at the attributes in their order of importance, starting from the most important, and eliminating sites that do not meet the cutoff.

2nd Best Site: The site that gets eliminated one before last.

3rd Best Site: The fourth site that gets eliminated.

4th Best Site: The third site that gets eliminated.

5th Best Site: The second site that gets eliminated.

6th Best Site: The first site that gets eliminated.

APPENDIX E

PRE-QUESTIONNAIRE

YOU

Age:

Sex: Male / Female

Occupation: Student / Not Student

Primary Language:
If your native language is NOT English, number of years you have been speaking English:

Other Languages Spoken:

Have you ever lived or worked in a country whose primary language for conducting business was not English?
If so, where? For how long?

YOU AND YOUR MOBILE PHONE

How many mobile devices do you have with you? (check all that apply; note number)
Phone
PDA
Pager
Blackberry-like device
Other:

What do you use your mobile phone for? (check all that apply)
Phone calls
Text messages
Photos

Music
Personal Organizer
Email
Other:

YOU AND YOUR MEETINGS

How many meetings do you attend a week?
0-3
3-5
7-12
12+

What types of meetings do you attend? (check all that apply)
One-to-one
Group
Presentational
Teleconferences
Online Conferences
Informal

What do you do in meetings? (check all that apply)
Brainstorm / Plan
Take notes
Review progress
Assign responsibility
Think of new directions/ ideas
Other:

Have you been in meetings with people whose native language is not English? Y / N

Have you been in meetings with people whose native language is not your own? Y / N

TELL US WHAT YOU THINK:

Computers help me take notes.

Not At All Very Much

● ● ● ● ●

Computers are distracting during meetings.

Not At All Very Much

● ● ● ● ●

Computers make sharing ideas easy.

Not At All Very Much

● ● ● ● ●

Computers are useful for communicating with people who do not speak my language fluently.

Not At All Very Much

● ● ● ● ●

Computers are useful for helping me to understand languages I do not speak fluently.

Not At All Very Much

● ● ● ● ●

Mobile phones are obnoxious in social settings.

Not At All Very Much

● ● ● ● ●

Mobile phones are obnoxious during meetings.

Not At All Very Much

● ● ● ● ●

I am intimidated when communicating with people who do not speak my language fluently.

Not At All Very Much

● ● ● ● ●

I feel that meetings are not as productive when conducted with people who do not speak my language fluently.

Not At All Very Much

● ● ● ● ●

POST-QUESTIONNAIRE

YOU AND YOUR TASK

How difficult was this task?

Not At All Very Much

● ● ● ● ●

How well do you think the group performed at this task?

Not At All Very Much

● ● ● ● ●

How efficiently do you think the group performed at this task?

Not At All Very Much

● ● ● ● ●

How satisfied are you with the outcome of the task?

Not At All Very Much

● ● ● ● ●

How satisfied are you with the amount that you contributed to the completion of the task?

Not At All Very Much

● ● ● ● ●

How satisfied are you with the quality of your contribution?

Not At All Very Much

● ● ● ● ●

Do you think the system allowed you to contribute more than usual to the task?

Not At All Very Much

● ● ● ● ●

Do you think the system allowed the group to communicate their information more clearly and/or efficiently to each other?

Not At All Very Much

● ● ● ● ●

Do you think the task was made easier by the system you just used?

Not At All Very Much

● ● ● ● ●

* Did you use this feature to review or substantiate pieces of information conveyed in the meeting?

Not At All Very Much

● ● ● ● ●

* Did this feature help you to understand exactly what other participants said?

Not At All Very Much

● ● ● ● ●

YOU AND YOUR OPINIONS

Do you think that the system you just used would be useful in a meeting room?

Not At All Very Much

● ● ● ● ●

Do you think that the system you just used would be useful in a conference call over several different locations?

Not At All Very Much

● ● ● ● ●

This is useful for me:
Not At All Very Much

● ● ● ● ●

This is useful for business people:

Not At All Very Much

● ● ● ● ●

This is useful for management:

Not At All Very Much

● ● ● ● ●

This is useful for (Other) _____:

Not At All Very Much

● ● ● ● ●

Please rank *in order of potential usefulness* the applications of this system (1-11).

Note-taking

Note-sharing

File-sharing

Meeting organization

Speaker organization

Real-time planning

Real-time voting

Translation

Backchannel communication

Group communication

Information Recall

* Would you use this feature to review, rewind, or slow down statements or pieces of dialog for greater clarity?

Not At All Very Much

● ● ● ● ●

* Would you use this feature to refer back to and research words, pieces of information, or exchanges that were unclear?

Not At All Very Much

● ● ● ● ●

* Would you use this feature encourage you to feel more comfortable in engaging in post-meeting collaboration?

Not At All Very Much

● ● ● ● ●

Would you want this as a feature on your existing phone?

Not At All Very Much

● ● ● ● ●

13. Appendix F

Since an a comprehensive review of the code which was used for the experiment would be outside of the scope of this thesis, there is a web-site which include source-code documentation. A link to this can be found at:

http://context.media.mit.edu/press/index.php/projects/mobilecollaboration/mobicolab/mobileessence/

Here I will provide access to the source-code, documentation and some comments on difficulties encountered during the development on mobile phones.