Abstract:

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This document describes the proposed solution, the final implementation, and the results of a preliminary user-task analysis.

The Development and Testing of gReader: A Universally Designed, Device-Independent Email Client

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I. Introduction

The ubiquity of email messaging necessitates the need for anywhere, accessible design. As such, this research project proposes a plan for offering access to e-mail that is largely platform independent. The project is the design of a Text-To-Speech (TTS) application that reads e-mail to users, records the messages in two popular media types for transfer to portable entertainment devices and portable communications devices. The application is named gReader. As part of the research, a user task analysis was conducted on eight users ranging from 19 to 34. These users were surveyed for their interest in the developed application, likelihood to use the gReader product and their desire to communicate through electronic messaging. According to the feedback gathered during the user task study, the product seems to meet the needs of users but interest in the product is only moderate. The prototype succeeded in delivering email content in an easily comprehended manner.

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Background

While varieties of electronic messaging solutions have flourished in the past 10 years, email messaging stands out as the most commonly used. The benefits of all electronic messages are clear: low cost and immediate delivery. While most electronic messaging techniques offer their respective advantages, email messages afford the largest set of benefits. Email messages afford the ability to archive conversations, unlike instant messages. Email messaging affords the ability to communicate comprehensive amounts of information easily, unlike text messages. Email is the preferred mode of electronic messaging for delivering business information and personal information to be archived.

Email messaging has become a common means of communication in the wide spectrum of our daily lives. Reading email can be accomplished on a variety of devices. These devices fall into two distinct categories; portable communications devices and portable entertainment devices.

Portable Communication Devices

Portable communication devices are electronics whose primary functions focus on the delivery and receipt of a communications. These devices include traditional portable phones, portable data assistants (PDA's), and the hybrid of both technologies commonly known as smart phones. These devices offer portable access to email and common instant messaging technologies via small devices.

The more advanced portable communication devices offer the ability to connect the device to a more powerful computer to synchronize content between the device and the host computer, download content via the host computer, or adjust settings on the device.

When designing user interface systems for these devices, the typical hardware limitations include small screen size, less than ideal data entry methods, and a scaled down processing, storage, and network capabilities[i]. The design of software systems for these devices typically requires device specific coding practices. Although many devices have adopted standard operating systems such as Windows Mobile the hardware and processing limitations typically require device specific accommodations.[ii]

The most popular devices in this category include Blackberry Smart Phones, iPaq portable and the newly released iPhone.[iii]

Portable Entertainment Devices

Portable Entertainment devices are primarily designed to entertain users through a multi-media experience. The most pervasive technology in this category are media players such as Apple's iPod. Related rechnology also includes portable gaming devices such as the Sony PSP.

Like many portable communications systems, these devices typically run on a proprietary operating system that requires hardware specific software development. These devices typically offer the ability to connect to a more powerful desktop or laptop computer for added functionality.

Universal Accessibility for Email

Current research and solutions to improve universal accessibility of e-mail messaging primarily focuses on the use of screen readers. By design, screen readers improve the existing visually oriented interfaces by announcing application content. This approach serves a limited audience. For people without sight, a screen reader is a necessary and useful application. For people with sight, screen readers are a slow ineffective means of interacting with a computer[iv]. By definition, current screen reading technology is therefore not effective design for universal accessibility. Many screen readers serve merely as assistive devices.

Email is so pervasive that access to email must be universal. Email should not be limited to sighted individuals. Email should not be limited to users with the time to read it at a desktop or laptop computer. The content of an email message should be available to its recipient when they are driving, jogging, or otherwise distracted.

This project proposes an application that improves the universal accessibility of email systems. Email has successfully pervaded society by being a low cost, simple, and relatively hardware independent solution. This project attempts to follow these same design characteristics. The project endeavors to serve the wide variety of portable equipment by providing a device independent means of reviewing e-mail.

PROJECT MOTIVATION

The motivation for this project is best illustrated by four simple examples of its proposed use.

Imagine that User A has a meeting that is 20 minutes away by foot. User A owns a PDA, but walking the busy city street, makes it difficult to read email. The screen does not work well under bright sun light and the small screen is difficulty to manage while walking across streets. User A could benefit from a system that allows them to hear their latest messages while they walk to their destination.

User B has a list of driving directions that were emailed to them. Normally they would print the driving messages and review the printed copy while driving. Instead User B can move the audio version of their message onto a their Apple iPod. Users B's car has an iPod port that is typically used for listening to music, but during this journey user B can switch to the audio track containing their driving directions.

User C is very strongly visually impaired. They can use screen magnification software and a screen reader to retrieve their email using a popular email client. The use of the two assistive technologies requires the user's undivided attention. User C is very busy and would like to multitask on the computer. Because of its small interface and built in text to speech functionality, the proposed applications would allow User C to review their latest emails while actively engaged in another task on the computer.

User D is a busy parent. They know they have several messages from family members, but they have little time to read them. While on their morning jog they alternate between listening to their email messages and music on their media player.

II. DESIGN

The application's interface was designed using the developer's research and experiences in accessible interface design. The core goals of the application's interface were informed by Jacob Nielsen's Heuristics of Usability. In particular, the interface design emphasized consistency and standards, visibility of systems status, recognition rather than recall[v]. The design's core goals were to create a minimalist auditory and visual view of an email that is meaningful and useful to its audience.

The application fits in an interface of approximately 200 pixels by 400 pixels, with two conceptual layers. These layers are message preview and full message view. The interface contains three distinct sections; message navigation, message display, and message retrieval.

A. Message Navigation

Message navigation uses the common forward, backward, play and stop design metaphor. Each of these controls has a screen reader friendly description and a shortcut key mapped to the numerical keyboard. The physical layout of the numerical keyboard provides distracted or visually impaired users an easy, tactile reference for navigation. See figure 1 for a diagram of key mappings to message controls. The user can also use the tab and the keyboard direction keys to navigate between elements and messages.

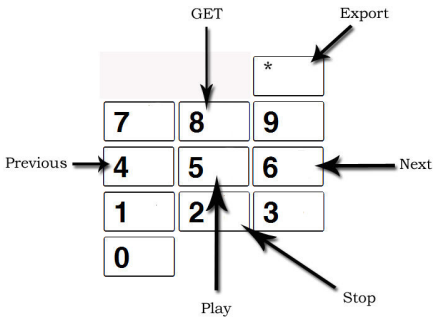

Figure 1

Since the mouse requires both visual and tactile senses, mouse navigation is the least effective way to use the application. However, to encourage ease of use, mouse navigation is supported.

B. Message Display

Messages are displayed as either summaries or complete messages. Each message is visually displayed in a scrolling horizontal display. Text is scrolled from left to right repeatedly. This scrolling text was chosen for the same reasons it was adopted in the financial industry. It allows for dense information display in a limited space.

Messages are also read using TTS. The TTS voice is automatically selected using the default voice for the user's computer.

Users can change the rate of display and reading through a slider control. Although the slider control is not ideal for visually impaired users, it was the most clearly understood common control for managing rates in preliminary test.

C. Message Settings

To improve the simplicity of the design, it uses only three setting to retrieve email content. These settings are the user id, user password, and the location of the email server. Although most email applications require much more management, this project favored simple implementation over a customizable one.

Designing an Aesthetic Minimalist Display

Instead of trying to provide an inclusive topography of all email messages, the design provides a single view of the core content of a single message.

In the first layer of message review, the user is provided with information about who sent the message, the message subject, and the message length.

In the second layer, the user is presented the entire message. The only relationship apparent between messages is their order in the message cue. The newest messages are presented first, while older messages are presented last.

By limiting the functionality of the application, the interface could remain small and simple.

The interface is also made less intrusive through a few visual elements. When the application is not in focus, it becomes transparent. If for example, a user wished to hear their email, but wanted to review the contents of a file folder, they can move the folder window over the project interface and continue to view the scrolling content of their message.

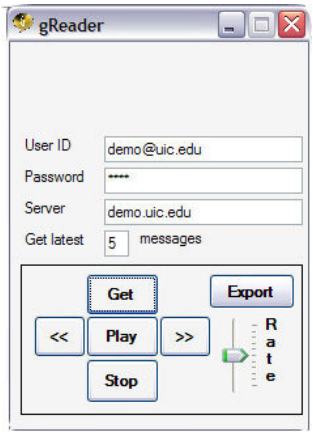

Figure 2

TECHNICAL OVERVIEW

The project application was developed using a variety of proprietary and open-source technologies. These technologies are described by their domain within the complete application. The three domains are email retrieval, text to speech conversion, and media file conversion. The final project was completed using Microsoft's Visual Basic.Net language with the Visual Studio 2005 IDE.

Email Retrieval

Email retrieval is accomplished through the POP3 standard using the popular open source Indy Sockets library. The Indy Sockets library manages network sockets connections and email retrieval.

Text to Speech

At the heart of the system is Microsoft Corporation's Speech Software Development Kit. This Speech SDK manages all text to speech operations.

Media File Conversion

In order to facilitate wide support of portable communications and entertainment devices the application provides media files in a variety of formats. Because most devices have relatively low storage limits and fairly low fidelity audio the final audio version of the files must be compressed. For a large number of devices the Windows Media Audio (WMA) file format proved most appropriate. This file format is supported by a wide variety of portable devices [vi] and provides quality file compression. An uncompressed, wav file format, is also saved to assure we support across devices.

Visual Studio Environment

The applications were developed in the Visual Studio environment. The environment affords rapid applications development appropriate to the needs of this fledgling application. The Visual Studio environment also afforded application level support of accessible applications using control tags. These control tags encourage accurate voice rendering of the application's content in screen readers by allowing developers to specify what a screen reader reads.

III. User Study - Survey

Demographics and Device Ownership

A preliminary user study was conducted to evaluate the strengths and weaknesses of the proposed application. Eight participants were asked to complete a paper survey recording their habits. The survey assessed the messaging patterns of the study participants.

Nine, 6-page surveys were provided to unpaid volunteers ages 19 to 35. The collection of 3 females, and 6 males were polled for standard demographic data. The group had a mean age of 24, with an average educational level just short of a Bachelors degree. Two users spoke English as a second language and no users reported hearing issues, reading disabilities, or visual impairments.

The participants were asked to report the types of portable communication and entertainment devices they owned. Their responses are reported in **figure 3:**

	Participant Number								
User #	1	2	3	4	5	6	7	8	9
Age	24	20	19	22	27	35	23	20	28
Own Apple iPod?			✔	✔	✔			✔	✔
Own Any Brand Mp3 Player?	✔					✔			
Own Portable Game Device?		✔		✔			✔	✔	
Own Portable Phone?	✔	✔	✔	✔	✔	✔	✔	✔	✔
Own Smart Phone or PDA?								✔	

Figure 3

As described in figure 3, all respondents owned portable communication and entertainment devices. The most commonly owned device was a portable phone, while the most common entertainment device was a portable music player. Only participant number 8 owned a smart device.

Device Usage Habits

Portable Entertainment Device Usage

The participants were asked to describe the frequency with which they use their portable hardware. To calculate usage habits each respondent was asked to mark one value on a scale appropriate to the question. Each scale value was given a score from zero, does not own the device, to a max value equal to ten times the number of possible answers. For question 1, for example, the range for usage included don't own (0), don't use (10), less then once a month (20), monthly (30), weekly (40), daily (50), several times a day (60), and hourly (70).

The average respondent used their portable device at least several times a week. Their average use per session was slightly over 1-2 hours usage length. When available on their device, the participants connected their portable device to a desktop or laptop computer at least one time a week. Two thirds of the participants installed software on their desktop or laptop computers to facilitate usage of their device. One third of the participants installed software on their device.

Portable Communications Device Usage

The average participant used their portable communications device almost daily, with a mean response falling just short of several times a day. The average respondent chose not to connect their portable communication device to a desktop or laptop computer although this was commonly an option for them. Interestingly, participant 2 and 8 stated that they connect their portable device to another computer daily and weekly respectively. Participant 2 was the only respondent that owned a PDA.

Users were also asked which activities they complete on their communication device. Participants 2 and 8 were the only respondents to conduct any e-mail tasks on their devices.

All respondents were asked to describe whether specific, commonly described challenges to delivering content to mobile devices positively, negatively, or neutrally effected their decisions to use the electronic messaging functions on their communication device. The factors were data transfer cost, viewing screen size, speed of data transfer, speed of accomplishing tasks, ease of accomplishing tasks, input quality, ability to accomplish task while mobile, audio feedback provided, and the ability to synchronize the device with a traditional computer. For the average respondent the most positive factor was the "Ability to accomplish tasks while mobile". The most negative factor for usage was "data transfer cost," with all respondents responding that it either neutrally or negatively effected their usage of mobile electronic messaging.

In the free form written comments section of the survey, users stated that they "can access the web with my phone but I have never done so." Most comments identified high cost of data transfer or that they were not sure if they could check email from their communication device. One respondent put it succinctly, "money = bad, small screen + small buttons = bad."

Email Usage

The respondents were asked about the frequency with which they check and manage their email. The average respondent checks email daily to several times a day. They reported spending an average of 4 minutes reading email each time they checked it. User number 8 spent the longest time at nearly 10 minutes per email review session. The median time spent checking email during a review session was 3 minutes.

Although some respondents did have email capable technology, very few used it. On average, the respondents rarely checked their email or instant messages on their device. The average of response was less than one time a month. The responses were highly variable, with users who have the technology either checking at least one time daily or choosing not to use the technology at all.

To gauge the most important functions of an email system, each respondent was asked to rank key email tasks by their frequency of use and their importance to the respondent. Their choices were reading, deleting, replying, forwarding, categorizing and sending new messages respectively.

All respondents, except participant 7, ranked reading messages as the most frequent task. All respondents ranked either categorizing or forwarding messages as the least used function.

All respondents ranked reading messages as the most important function. Most users ranked reading or deleting messages as the second most important function. Again**,** all respondents ranked either categorizing or forwarding messages as the least important function.

Interest in the Project's Proposed Solution

7 of the 9 respondents expressed interest in checking their email from a portable entertainment device. 5 of the 9 respondents expressed interest in having their email read to them via a portable entertainment device.

IV. User Study: Application Testing

Once the user group completed the survey, they were split into two groups. Each group was asked to report the contents of 5 separate email messages. The control group was asked to read 5 messages from a screen. The test group was asked to read the same 5 messages from the gReader email prototype. Each group was provided with the same email content, presented in the same order. Each group was asked to answer the same questions about the email content.

The control group read five html-formatted files containing an email message and the Yahoo mail interface. Since the response times were timed, it was deemed appropriate to remove the variability of server response time be providing locally stored HTML files.

The test group was provided the gReader prototype and a pair of headphones for listening to the content of the email. Since response times were timed, all messages were cached locally to remove the variability of server response time.

Each user was timed in 30-second intervals. Since speed of review is not a primary goal for the gReader application, time was used to determine relative ease of review. It was also hoped that a 30 second time interval would minimize differences between users reading comprehension and familiarity with the computer.

The first participant, a 24-year-old female opted out of the study when asked to participate in the application testing. She sighted her discomfort with the English language as her reason.

User Task Analysis Equipment

Tests were conducted on a Dell Laptop computer 1.8 GHz laptop computer with an external mouse. The test group was provided a pair of Koss headphones. Each study was conducted individually. Participants were provided a blank sheet, figure 4, with a set of comprehension questions about an email. They were instructed to review each email individually and to focus on answering the questions as accurately as possible.

The email messages reviewed were organized by increasing complexity.

- **Message 1** contained a 107 character long body, 2-sentence description of a meeting time and place.
- **Message 2** contained a 233-character long body, 5-sentence request containing a contact phone number and two specific questions requiring a response.
- **Message 3** contained a 532 character long body, 11-sentence resume request. This message contained several typographical errors, and a bulleted list.
- **Message 4** contained an 849 character long body, without complete sentences. This message contained HTML, abbreviations, a non-English name, and some special characters.
- **Message 5** contained a 726 character long body, without complete sentences. This message described a meeting a specific location, a web address, and highly formatted text.

V. Evaluation

Accuracy Evaluation

Control group and study group responses were aggregated and analyzed for their accuracy and response time. Answers were marked as either 100% correct, 50% accurate or 0% accurate. 50% accuracy was attributed when a user provided only one answer for a question that required two statements.

Neither the control group nor the study group answered all questions with 100% accuracy. As expected, accuracy rates were highest for the first 2 messages, which were the simplest messages. Questions 1 through 6, corresponding to the first 3 messages, had at least a 75% accuracy rate for both groups. The gReader users exhibited better accuracy with the more difficult questions. Questions 11 and 12 were answered more accurately by the average gReader user than by the control group.

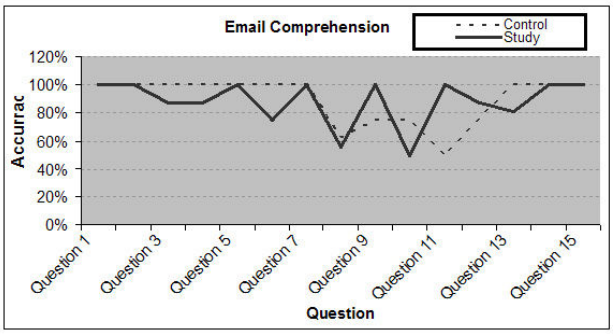

Figure 5

Response Time

Response times were recorded in 30-second intervals for each group of three questions. As expected, users of the gReader application took more time to review messages than the control group. GReader also demonstrated more variability in time. As demonstrated by the 4th and 5th question group average time to respond, gReader takes significantly longer to review longer messages.

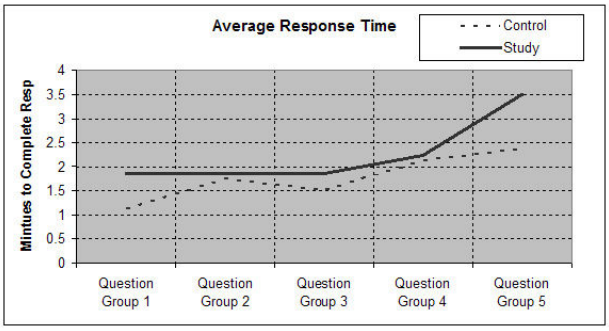

Figure 6

Evaluation of Individual Users

Study participant number 5, had the poorest accuracy of all the participants. This 35-year-old male identified himself as speaking English as a second language. User 5 also answered the questions in the least amount of time for all control and study group participants. User 5 also had at least one auditory misinterpretation. User 5 incorrectly communicated a date as the 30th instead of the 13th, a mistake that may indicate auditory misunderstanding. Removing user 5 from the study group averages yields significantly higher gReader accuracy rates, but it also increases review times by nearly 25%.

Control participant number 4 had surprisingly poor accuracy. This 27-year-old female also spent the most time answering each question set. She was 0% accurate on question 10, which had a median response accuracy of 100% across both groups. She also responded slightly below average on questions question 12.

Both user 5 and user 4 were on the older side of the participant group. User 5 held a graduate degree, while user 4 held a bachelor degree. Neither user indicated any known hindrances to their reading comprehension or their auditory abilities. Although User 5 did identify himself as speaking English as second language it is reasonable that neither user had general comprehension problems that extend outside the study. Given user five's abnormally fast response times, it may be that this user simply rushed through the experiment or ignored the study instructions that stated accuracy was more important than speed. Since both users indicated interest in the notion of having email messages read to them, it is unlikely that lack of interest prevented them from responding well.

VI. Observations

Users of the gReader program had on average lower accuracy rate than the control group and an average lower time to comprehend. However, the gReader users did prove more accurate for questions 11 and 12. Based on the post study feedback of users, it is essential that the gReader application provide a pause button and a means to rewind to a segment of the message. The original design allowed users to slow the pace of speech through a slider, but few users had realized they could use it to help them better comprehend the message.

Qualitative and quantitative results gathered from this study indicate that the gReader application functioned as designed. Users of the application were able to comprehend the content of messages with only a marginal increase in time. The keyboard shortcuts and small space design were received well.

Although the application was tested in a controlled environment it seems that gReader has the potential to improve the usability of mobile e-mail messaging. It also seems that users who suffer from limited vision would be able to use the application.

VII. Future Work

Many enhancements can be made to the gReader application. Based on user response, informal polling after the study and observations made by the researcher the following items require more in depth review:

Development for a Mobile Phone: although many users stated that they are not interested in gReader functions on their phone the academic investigation into such technology for use by people with vision impairments may prove useful.

Testing against a Visually impaired Audience: this research merely tested the application in controlled environment of able bodied users. It would be useful to test the application against an audience of users with physical impairments and mental impairments that effect vision and reading comprehension.

Test using a Screen Reader as a Benchmark: it would be beneficial to test the gReader application speed and accuracy against a convention screen reader. It is hoped that a gReader will outperform conventional screen readers.

VIII. Conclusion

The results of the user task analysis are favorable. The users were able to comprehend complicated content within an email message using the gReader application. Although gReader users experience slower reading times and lower general accuracy the differences were not severe enough to warrant dismissal of the project. The goal of this project was to provide an additional method of reading emails.

Survey respondent had agreed that the most important email task is reading. They also described having access to their email while mobile as the most positive experience with existing technology. The gReader application provides users with these two important functions at a low cost and with minor trade-offs. While users of the gReader system may not be able to review email as quickly as they would when reading it, they can review email when reading is not an option. They are also provided access to their emails through audio players, which until now have not offered such functionality.

As with any software project it is clear that the application could be refined for more accurate affinity between user's needs and application capabilities. However, this study does indicate that the gReader approach is a plausible, practical solution to a common accessibility concern.

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