THE PLANT LADDER: A USER-FRIENDLY PLANT MANAGEMENT SYSTEM

THE USABILITY OF THE COMPUTER USER INTERFACE

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
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In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Electrical Engineering

By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed   Date: November 2, 2020

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The computer user interface has changed in structure over time. Raymond (2004) stated that an early form of the computer used in the 1950s, called a batch computer, took in punch cards through its user interface (Batch Computing section, para. 1). The cards were then internally operated on by the machine without any human interaction during the process (Batch Computing section, para. 2). Raymond noted that the batch computer interface was "rudimentary. Users had to accommodate to the computers rather than the other way around…" (Batch Computing section, para. 1).

The first computer designed to accommodate the average user was the Xerox Alto released in 1973 that included a graphical user interface, movable windows, icons, and a mouse (Computer History Museum, n.d.). These user-friendly features directly inspired the Macintosh computer released by Apple in 1984 (Raymond, 2004, The first GUIs section, para. 3). Apple's advertising of the Macintosh, depicted in Figure 1, emphasized the interface's usability for everyone (Apple Inc., 1984). The Macintosh expanded the computer's user base from engineers to common people, evidenced by the widespread adoption of the technology by which there were "1 million Macintoshes [sold] by 1998" (Asher, 2017).

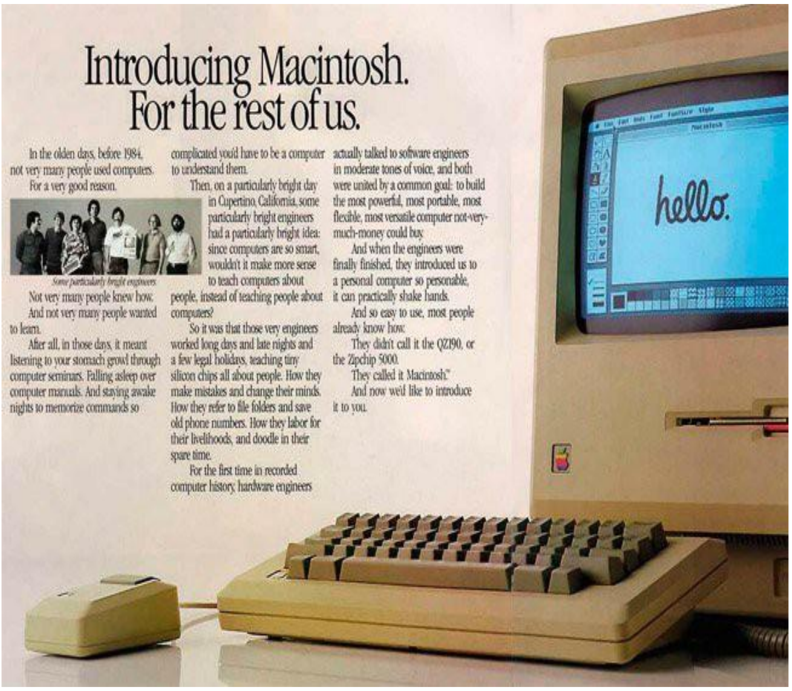

Figure 1: Macintosh 1.0 Computer Advertisement. A depiction of a user interface that catered to the average user indicated with the phrase "For the rest of us". (Apple Inc., 1984).

This brief history of the development of the computer user interface shows how much interface design and the interface's corresponding usability has progressed. There is a large structural difference from the first Macintosh released in 1984 compared to the retina display touch screen computer user interfaces seen in smart-phones today (Asher, 2017). This history also reveals that usability has always been a design concern, even for early computer user interfaces.

The technical and STS research will relate to user interfaces and their usability. For the technical project, my team and I will build a user-friendly plant management system that is controlled through a smart-phone application user interface. For the STS thesis, the loosely coupled research will focus on how the historical progression of the computer user interface has impacted usability. The Gantt chart in Figure 2 outlines both technical and STS deliverables.

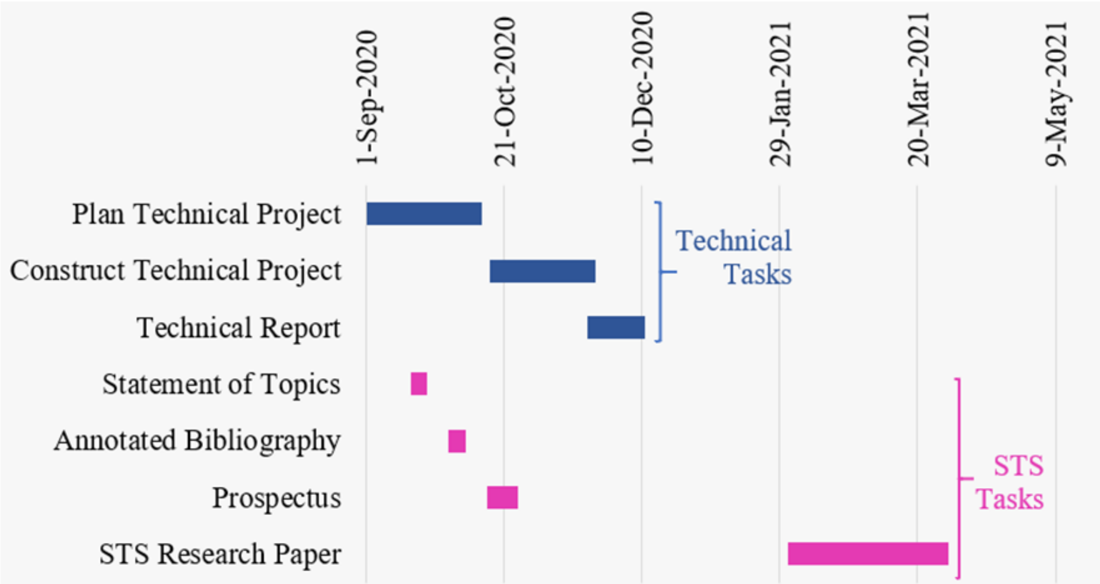

Figure 2: Gantt Chart. A list of the prospective timelines for each of the technical and STS tasks. (Tran, 2020a).

Technical tasks will be completed by the end of the Fall 2020 semester while STS tasks will spread out across both the Fall 2020 and Spring 2020 semesters.

THE PLANT LADDER: A USER-FRIENDLY PLANT MANAGEMENT SYSTEM

My team, comprised of Computer Engineers Sonia Aggarwal and Catherine Rogers in addition to Electrical Engineers Brooke Bonfadini, Victoria Nilsson, and I, will construct a plant management system with guidance from Harry Powell of the Department of Electrical and Computer Engineering and a budget of $500.

For those living in smaller spaces or urban areas, having potted houseplants dispersed throughout their space is a popular way to bring greenery indoors. However, it can be complicated to take care of each plant's individual needs, and having many of these potted plants can take up precious area in already small spaces. To alleviate this issue, the technical project, called the Plant Ladder, will be a user-friendly vertical plant management system where the potted plants are stacked vertically to condense them to a central location.

MECHANICS OF THE PLANT LADDER SYSTEM

The Plant Ladder aims to use controlled environment agriculture to maintain the health of houseplants in small indoor space. Bethke and Lieth (n.d.) defined controlled environment agriculture as the "production of agricultural crops under modified, highly controlled conditions in greenhouse or indoor growing spaces…" (para. 4). These controlled conditions could include light, CO2 levels, and humidity (Gomez et al., 2019, p. 3). For simplicity, soil moisture and light will be the two chosen conditions for The Plant Ladder system.

The components in the system include a phone application, water pumps, LED lighting, sensors, and a microcontroller. All components in the system send or receive data to or from the microcontroller, which is a small computer that acts as a central control unit (Gudino, 2018). The block diagram in Figure 3 on the next page illustrates component interactions.

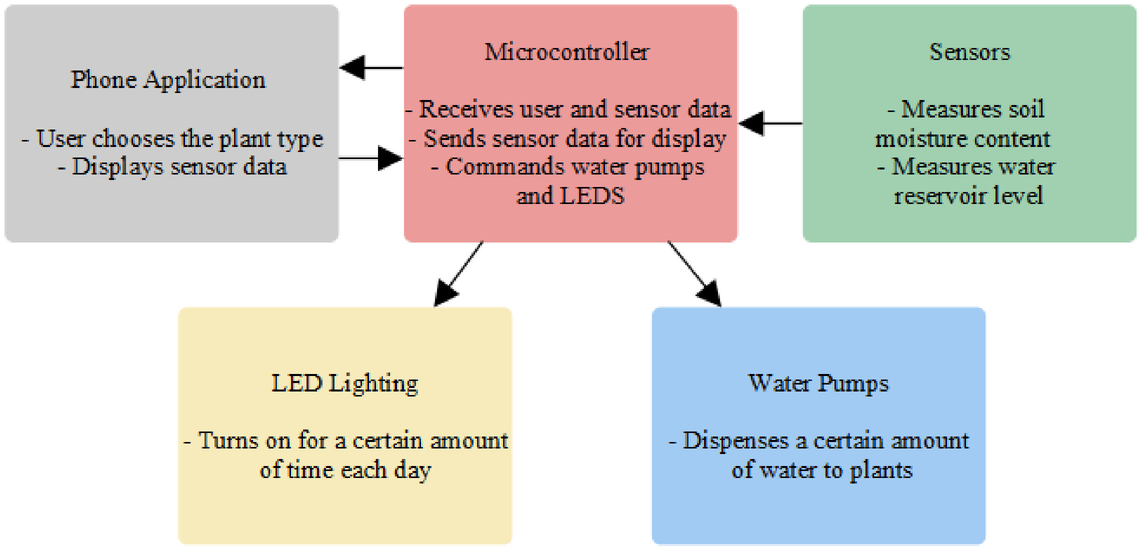

Figure 3: Plant Ladder Block Diagram. Visualizes the relationships between all system components with a microcontroller acting as the central control unit. (Tran, 2020b).

The system is semi-automatic. To operate it, the user would choose a plant profile through the phone application based on the house plant that they have. Soil moisture and light threshold values stored in the chosen profiles will be sent to the microcontroller through Wi-Fi (Texas Instruments, n.d.). These threshold values then determine the actuation of the water pumps and the LED lighting based on input sensor readings (Sandhya, Pallavi, and Chandrashekar, 2017, p. 2).

USABILITY OF THE PLANT LADDER SYSTEM

Compared to our system design, other similar designs lack accessibility for the intended user group. For instance, the most similar structure to our proposed design is a vertical farming water control system prototype with internet of things capability (Ismail & Thamrin, 2017, p. 1). In Ismail and Thamrin’s (2017) design, the water pumps in the control system can be actuated once the sensors’ readings fall below the threshold soil moisture value of 800 (p. 2). The user would be required to access the microcontroller hardware and modify its code if they wanted to change this threshold value to another plant's preferred soil moisture level. This would be a challenging task since most of the general user base of house plant owners are unlikely to have technical engineering experience. Our solution to improve usability integrates the aforementioned plant profiles as options into the phone application user interface. These profiles easily allow the user choice of and modification of threshold values based on the type of plant that they select. The phone application interface also allows the user a convenient way to modify the system indirectly instead of through its hardware.

Through the technical project, our team hopes to ease the maintenance of indoor plants for plant owners through a more user-friendly automated system. The technical research will be presented in a scholarly article that will describe the inner workings of each system component and explain the benefits of the design for the system's intended user group of house plant owners.

THE USABILITY OF THE COMPUTER USER INTERFACE

The STS thesis will be presented in a research paper. The aim of the research is to understand how the historical development of the computer user interface has affected its usability. To do this, an in-depth evaluation of the social and technological factors that have impacted the computer user interface's development will be necessary. Additionally, the meaning of the term usability is variable to different types of people. A system that is user-friendly for an engineer may not be as user-friendly for the average person. Therefore, it will be important to map which user groups are associated with a certain computer user interface development stage when considering usability. The following sections will develop the background knowledge and primary frameworks needed to contextualize the STS research.

WHAT IS A COMPUTER USER INTERFACE?

To further discuss user interfaces, it is important to know exactly what constitutes a user interface. Marcus (2002) defined the user interface as:

> A computer-mediated means to facilitate communication between human beings or between a human being and an artifact. The user interface embodies both physical and communicative aspects of input and output, or interactive activity. The user interface includes both physical objects and computer systems (hardware and software, which includes applications, operating systems, and networks). (p. 24)

Thus, a computer user interface acts as a buffer between a computer system's technological complexity and humans; it links the two mediums. For effective communication to be possible, The Interaction Design Foundation (n.d.) asserted that a user interface design should focus on usability as "[users] don't care about your design, but about getting their tasks done easily and with minimum effort" (Designing User Interfaces for Users section, para. 2).

INFLUENCES ON COMPUTER USER INTERFACE DESIGN

To fulfill the Interaction Design Foundation's guidance on user-friendly interfaces, the various factors that influence a user interface design should be considered. These factors are revealed by framing the computer user interface through Pinch and Bijker's (1987) Social Construction of Technology (SCOT) approach as shown in Figure 4 on the next page (p. 119).

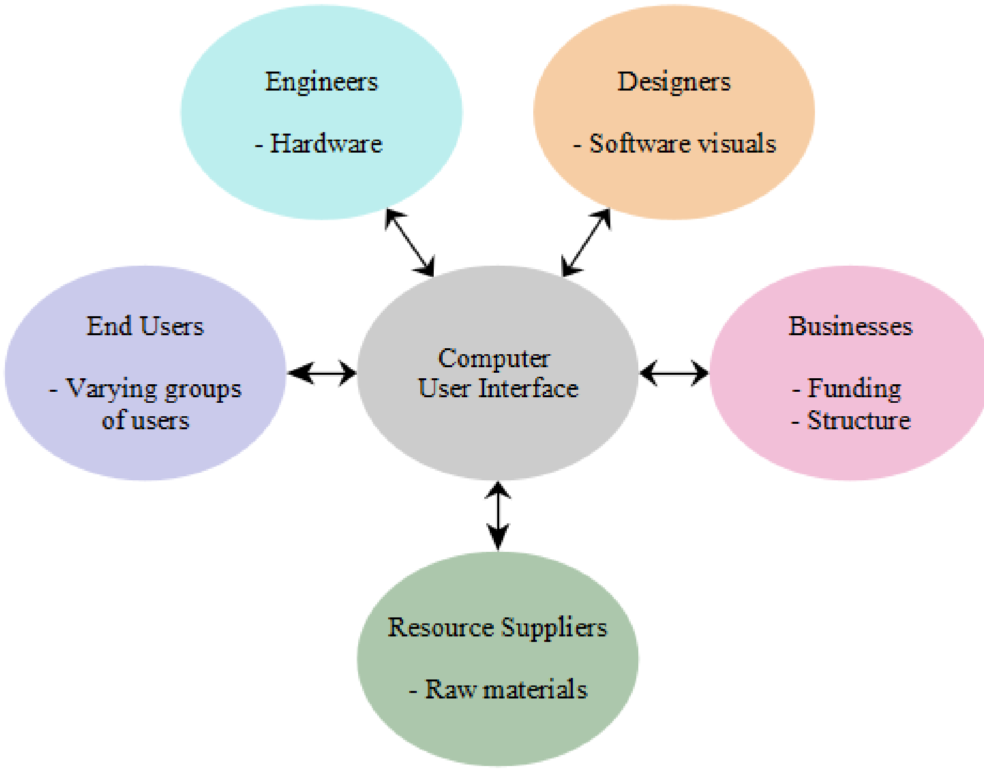

Figure 4: SCOT Model for the Computer User Interface. A depiction of the relevant social groups that influence computer user interface technology. (Adapted by Tran (2020c) from W.B. Carlson 2007).

The SCOT model places the computer user interface as the central artifact with the surrounding relevant social groups all influencing the artifact's outcome. Referring to Pinch and Bijeker's (1987) SCOT approach, Yousefikhah (2017) explained that, "Different interpretations of social groups about the concept of an artifact indicates different problem definition, and thus a diverse range of developed solutions" (p. 37). Each relevant social group has interpretive flexibility or differing perspectives on the design of the computer user interface.

For example, engineers are mainly concerned with just the hardware of the computer user interface. From there, designers can then only create software visuals that can be supported by the hardware. Both engineers and designers are constrained by the raw materials available from resource suppliers. They are also limited by any rules set by businesses on the structure of the design and the amount of funding available. Furthermore, end users provide feedback during the process that can influence the design outcome. With their differing perspectives, each of these relevant social groups impose specifications on the design which in turn impacts the usability of the resulting computer user interface. The double arrows in Figure 4 indicate that all groups can be end users as well.

GROWTH OF THE COMPUTER USER INTERFACE'S END USER GROUP

The SCOT model in Figure 4 defines end users as one of the relevant social groups but does not specify exactly who the end users are. This is because the computer user interface representation in the SCOT model encompasses all the developments of the technology over time. Figure 5 below presents a concept chart specifying how the computer user interface's end user group has grown alongside its technological development.

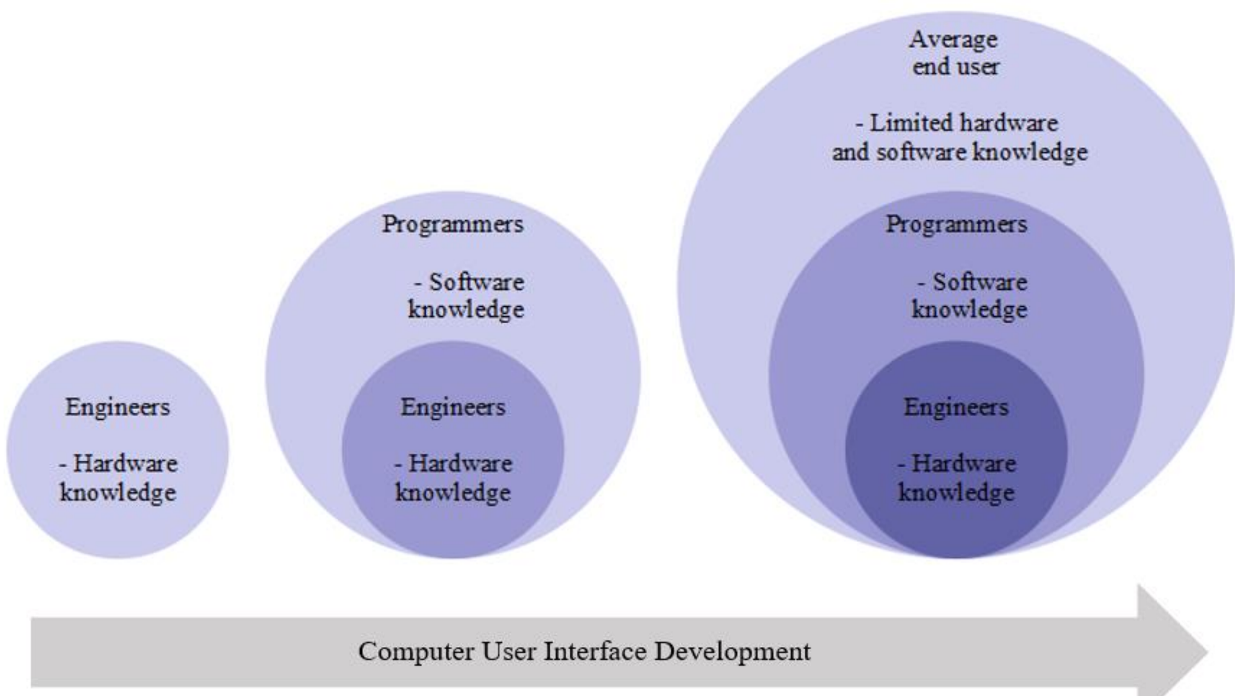

Figure 5: Concept Chart of the Growth of the Computer User Interface's End User Group. The user group expands to a wider audience of users with the technological development of the computer user interface. (Created by Tran (2020d) based on research by Jonathon Grudin 1990).

The concept chart is based on ideas written in a conference proceeding by Grudin (1990), a professor of human-computer interaction at the University of Washington Information School. Each of the three main circles in the chart broadly represents the overall end user group as the computer user interface developed over time. In the proceeding, Grudin stated that “The first computer users were engineers who required a relatively full understanding of the hardware…aspects of the hardware were dealt with by typical users of the time, engineers and programmers – hardware was the central part of the user interface” (p. 263). This is represented by the furthest left circle in Figure 5 where the user group is only engineers that have hardware knowledge.

With more development in the computer user interface, focus turned to software “freeing the user, namely the programmer, from having to know about the hardware” (Grudin, 1990, p. 263). The middle circle in Figure 5 on page 8 represents how the user group grew to include both programmers who have software knowledge as well as the original user group of engineers.

Continuing, Grudin (1990) noted that the creation of the interactive terminal was a pivotal development in the computer user interface that created “vast non-programmer markets” (p. 263). The non-programmer markets are average users who have limited software and hardware knowledge. This largest overall user group is represented by the right circle in Figure 5 which includes the inner two groups. Altogether, Grudin’s research shows that the progression of the computer user interface’s development furthered the technology’s reach of influence to a wide expanse of various types of user groups.

RELATING COMPUTER USER INTERFACE DEVELOPMENT TO USABILITY

The complication in creating a computer user interface today is the same as it has been historically. Grudin (1991) expresses that "Contact with system users is required, but determining how direct or extensive this contact need be and actually achieving it have been surprisingly difficult" (p. 59). Determining the degree of contact or deciding exactly what features a computer user interface should have is still a large concern because technology continues to grow in complexity. Asher (2017) points out that:

> Looking back, we can see that keyboards, mice, and trackpads were really just hacks meant to close the gap between spoken language and touch with computing surfaces. And they worked well for the better part of 30-plus years. Now we are on the edge of a return to more natural interfaces that involve our fingers, voices, and bodies in space. This is all made possible by advances in network infrastructure, cloud-based computing storage and computational power, and aggregation of the data needed to teach machines to understand and interpret our human interactions. (Bringing Humanity Back to Computing section, para. 2)

By examining past computer user interface designs through a sociotechnical lens, creators, including engineers, can gain insight into how to tackle usability issues in future interface developments. Consequently, these more informed creators will be able to bring a greater degree of positive social and technological outcomes to the end user group.

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