Rhizome: Towards An Information Centric OS Shell

by
Kira Corbett

A THESIS

submitted to
Oregon State University
Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Computer Science

Presented October 27, 2021
Commencement June 2022
AN ABSTRACT OF THE THESIS OF

Kira Corbett for the degree of Honors Baccalaureate of Science in Computer Science presented on October 27, 2021. Title: Rhizome: Towards An Information Centric OS Shell.

Abstract approved:_____________________________________________________

Yong Bakos

Rhizome is an information-centric model that uses different interaction methods than traditional desktop systems. I built Rhizome with the specific use case of sharing a photo to observe people using the Rhizome operating system (OS) shell and modern OS shells. The purpose of this is to measure the cognitive load each OS shell has on its users. Moving further from the traditional WIMP model seems to create more promising results and fruitful experiences for users. The results indicate that people were 60% more efficient on average in completing their task using Rhizome instead of a traditional WIMP model.

Key Words: information-centric, operating system shell, graphical user interface, information, cognitive load

Corresponding e-mail address: corbetki@oregonstate.edu
Rhizome: Towards An Information Centric OS Shell

by
Kira Corbett

A THESIS

submitted to
Oregon State University
Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Computer Science

Presented October 27, 2021
Commencement June 2022
Honors Baccalaureate of Science in Computer Science project of Kira Corbett presented on October 27, 2021.

APPROVED:

_____________________________________________________________________
Yong Bakos, Mentor, representing Computer Science
_____________________________________________________________________
Patrick Donnelly, Committee Member, representing Computer Science
_____________________________________________________________________
Pamela Kilpatrick, Committee Member, representing Autodesk
_____________________________________________________________________
Toni Doolen, Dean, Oregon State University Honors College

I understand that my project will become part of the permanent collection of Oregon State University, Honors College. My signature below authorizes release of my project to any reader upon request.

_____________________________________________________________________
Kira Corbett, Author
ACKNOWLEDGEMENTS

Although words themselves may not be big enough to describe my gratitude for my mentor, Yong Bakos, the amount of information on the World Wide Web might be a good place to start to describe the size of how grateful I am for his continuous support, patience, and flexibility during the global pandemic. Yong is a talented and knowledgeable individual ahead of his time which has been a humbling experience to look up to as I dive into the professional workforce. Even though I am convinced Yong Bakos is a robot, his realistic approaches, especially during the pandemic, had him understand us humans quite well.
Introduction

People seem to use computers to interact with information. Whether seeking information on the World Wide Web or sharing a photo, the computer has become a mediator of our interactions with information [1]. Studies have shown that the “digital life” impacts aspects of work, play, and home lives, from intellectual and social experiences to multiple avenues of existence [2].

There are many things in digital mediums to process - finding applications, like Google Chrome, to get to information, logging in and remembering passwords, responding to one friend on social media and responding to that work email in an application, and even managing productivity in tasks. With this world of ever-growing information at our fingertips, we must adapt to new things that we have not experienced before when interacting with our computers [1]. Furthermore, we often interact with information to accomplish a goal or task.

Completing a task often requires many steps that are completed through a computer. For example, when sharing information, like a photograph, users must first locate the photo on their device. Most of the time, this requires digging through personal files on a laptop using the Windows, Icons, Menus, Pointers or WIMP model by navigating with their mouse and keyboard. A user must decide on what method they are going to use to share their photo only after they find their photograph. Should they send it through email? A social media application? A text message? There are a number of options available to complete the simple task of sharing photos but a user must choose one medium. Now a user must navigate to that medium, sign-in to their account, recall their account information. It is only then that the user can now upload their photo to that medium, find the contact to whom they wish to share their photo, then finally send the image.

Send. Let us take a breath and pause.

Using a computer with the abundance of information available today creates a cognitive load on users and their interactions with their computers. The traditional WIMP model has yet to change in over 50 years yet the amount of information continues to grow. Interacting with our information is often restricting and users are often “tied” to their machines [3]. Our machines create a strict one-to-one relationship with our information as our information is restricted within applications or sites often involving obstacles to obtaining those means [13]. Although recent design innovations of newer modern operating system (OS) shells, such as mobile OS shells, provide a multi-touch aspect to interactions, information is still difficult for users to interact with. Users must take extra steps to retrieve information that is nested within applications rather than being able to simply request it directly.
Ideally, the computer interface would optimize a user’s needs and be based on a computer’s systems and integrated with the tasks users must accomplish [3]. Information is being presented in new ways outside of keyboading and pointing that is no longer constrained to a desktop [11]. As we shall see later in this paper, prior work both advances our current WIMP desktop and tries to escape the paradigms.

Rhizome is an operating system designed for humans that explores an information-centric model where information (a user’s content and data) is at the core of a user’s interaction with their computer. Rhizome works to address the gaps in traditional design models by incorporating the applications to the overall OS and between the user and their information. The Graphical User Interface (GUI) incorporates a tagging and targeting system for users to manipulate their information without having to think too much about their tasks. Rhizome OS and the Rhizome GUI are new concepts attempting to deliver an experience without Windows, Icons, Menus, and Pointers and without creating too much cognitive load on a user.

I created the Rhizome GUI shell to simulate an information-centric model to measure the cognitive load a user has while interacting with their information. In this paper, I begin with the background of the WIMP model and information-centric models, then discuss the implementation of the Rhizome GUI shell. Then I explain the method used to test the operating system through simple tasks users performed with the GUI shell. Lastly, I share the results of these user tests and how those tests can provide insight to reducing user cognitive load when using Rhizome as an information-centric operation system.

Background

In order for a human to interact with their information, they use an operating system (OS) shell. These shells represent concepts composed of structured systems and interactions. A terminal consists of file and folder structures that are navigated by typed commands. A desktop consists of a compilation of various applications navigated by WIMP interactions. Mobile devices and tablets consist of touchable interactivity to navigate applications. Regardless of which conceptual model an operating system shell uses, people need these shells to retrieve, store, and manipulate their information.

It is the operating shell that provides access to their applications and their applications that gets the user to the information they seek.
Therefore, a user’s information is often within applications and databases. Users must take extra steps to retrieve information that is nested within applications rather than being able to simply request it from their shell. For an example, let us review the “sharing a photo” task.

When sharing information, like a photograph, users must first locate the photo on their device. Most of the time, this requires digging through personal files on a laptop using the WIMP by navigating with their mouse and keyboard. On more recent mobile devices, there is a set place for photographs to be stored. Once the photograph is found, a user must decide on what method they are to share their photo. Should they send it through email? A social media application? A text message? There are an overwhelming number of options available to complete the simple task of sharing photos but a user must choose one medium. Then navigate to that medium, sign-in to their account, recall their account login information, upload the photo to that medium, find their contact to whom they wish to share their photo, then finally send the image.

The typical personal computer OS shell represents itself as a “desktop.” In the original desktop design, the desktop is the user’s area. This creates a challenge for inherent coupling to real-world metaphors as the same problems arise - the desktops still encounter inconsistencies with the real office [4]. The closest solutions to these real-world desktops tends to lie in the WIMP model which has been still the closest solution today in the 21st century.
The WIMP model is a particular type of GUI that uses Windows, Icons, Menus, and Pointers. Although originally invented by Xerox PARC in 1973 [5], this model has dominated our human-computer interactions with mainstream systems utilizing WIMP at the core of their GUIs. Apple Macintosh, Microsoft Windows, OSF/Motif, NeWS, and RISC OS are all WIMP models [6]. Despite its consistency, many believe that the traditional GUI with WIMP is not suited for emerging computing devices [7].

There are many digital things for a user to process. Designers explore alternatives to WIMP to circumnavigate its limitations. Some of these alternatives choose an area of focus. Take the original Macintosh - it was originally designed with a focus on users who do not have a computer science or technical background. WIMP suits this well but technology in the 21st century is advancing. What does this mean for the next generation of computers? As developers, designers, thinkers, this situation of WIMP no longer fits our needs and the “HCI plateau” creates an opportunity for the next generation of computers with a focus on users who do have advanced computer experience.

The Haystack model argues different users have different needs and preferences when working with information (Karger). The Haystack system aims to provide a user with control of how their information is stored, what relationships the information has with other pieces of information, how the information is presented, and what operations should be available. Haystack provide a semi-structured data model that is adaptable to users and these collections of information and interactions with users could be one example of how users gather their information and manage their electronic life.

Other designs focus on how to support current tasks users face with their device [8]. GroupBar was a project designed around the Windows taskbar as a way for users to group and regroup their content while operating on groups of windows or tasks. A similar project called Task Gallery invoked the three-dimensional windows to create a room of tasks with the user’s main task being centered on a “stage” in the virtual desktop and other tasks placed around the stage in the virtual room’s floors, walls, and ceiling of the gallery.

Email applications were also observed to be used for task management. Users experience problems with their data is in multiple applications and took a “workspace-centric approach” [4].

Kimura is an activity-centered work environment that works to develop better business professionals. Kimura has explored activities on and off the desktop. The Kimura system is based around the focal and desktop regions on the desktop and collections of activity (working context) are automatically tracked and tagged based on their importance [9].
More recently, social media influences our interactions with information. Design models centered around social aspects rather than a user’s data demonstrate a different approach to working with our computers. For example, ContactMap is a “social workspace” that integrates communication and information management by organizing a user’s computer based on their social circles and contacts [10].

Personal information is no longer being constrained to a desktop and information is being presented in new ways outside of applications, keyboarding and pointing. An opportunity exists with one that truly meets the needs of a user that is based on a computer’s systems and integrated with the social networks and tasks users must accomplish [3]. Personal information is no longer [11]. This does not mean to advance our current WIMP desktop but instead to escape the limitations of these systems.

The Rhizome model of information interaction asserts that people only do four things with information: manipulate, contextualize, experience, and explore. Rhizome defines information as content or data and information is represented as a Thing in the Rhizome OS. The designs of the Rhizome GUI shell intends to reduce cognitive load by making it easy to interact with information. A user should be able to accomplish a task with information without having to navigate, click, type, and take too many steps. Rhizome works to reduce these steps by keeping its information not inside applications, sites, or devices and by this nature, the center of a user’s screen is their information as a Thing. Surrounding this into other information directly related to the user’s center Thing.

When a user wants to share information, Rhizome enables a user to “place” information in another person’s context. During this process, it creates a network of user’s associated information through a tagging and tarting system. When a user shares a photo, they physically drag and drop the photo onto their target information. The Rhizome contextualizes the user’s information by displaying a visual representation through a scaled version of their information. The image they wish to share, representing their information, demonstrates the two pieces of associated information. The image that the user just placed now shows an associated icon to the item they placed their image on and vice versa as the location of where the image was placed now also shows an association to the original image. Users have less to think about and in turn less cognitive load from minimal interactions.

I hypothesize that an information-centric shell can enable people to accomplish tasks faster with less cognitive load than current operating systems shells. In this experiment, I focus on sharing information and proving that sharing with Rhizome results in in less of a cognitive load on a user.
Implementation

I implemented a working version of the Rhizome operating system shell utilizing the Rhizome API developed by Yong Bakos. My goal was to test a concept of the new information-centric OS by developing a graphical user interface (GUI) for a specific use case; sharing a photograph.

I created the GUI with the Flutter Software Development Kit (SDK). The Rhizome shell utilizes Flutter to create interactivity on the frontend and the Rhizome API library to provide the information-centric behaviors on the backend. Managing information was possible through this library which was developed in Dart, a programming language developed for building fast and responsive web and mobile applications.

The Rhizome represents all information as a “Thing”. Things are information - it can be any piece of information including an image, text, etc. and these Things exist independently of applications, sites, and devices. Traditional sharing methods are often locked within applications, sites, and devices. For an example, sharing a photo with a friend in a traditional interaction requires a user to first decide which medium (computer, mobile device, tablet, etc.) they are to share their photo with. Then, a user must decide how they will share that photo. (On a mobile device through a text message? On the computer accessing the Internet to log onto an email application and attach a photo to send to a contact?) In Rhizome, information is independent from these devices or applications.

Rhizome provides a tagging and targeting system that contextualizes pieces of information (Things) with other pieces of information (Things).
The tagging and targeting system creates a mapping of related information with the center of the screen being a user’s focal point. To communicate this with the user, I implemented a drag and drop system to interact with this information. A user can see their main information in the center surrounded by related information. A user can touch and hold a Thing and drag it across the screen to drop it on another Thing. I call this behavior “tagging.” The reverse could also happen with the targeting system where a user could drag and drop any Thing in the Rhizome world onto their centered task (or other pieces of information) to target their information. I call this behavior “targeting.”

Under the hood, tagging and targeting creates relationships with the information by contextualizing it. The benefit of the tagging and targeting system is that it works relate a user’s information that does not require much effort from the user themselves. Logging onto system A, trying to remember your password for system B, and figuring out where something is on system C demands a lot of cognitive processing for a user. The tagging and targeting system aim to reduce the amount of cognitive load a user must face. Instead of dealing with logins, passwords, and trying to find that one file, Rhizome keeps a user’s information at the center of interactions so there are fewer steps.

To prepare to test a working concept of Rhizome, I started with focusing on a single use case of sharing a photograph. With the single use case of sharing a photo in mind, this drag/drop or tag/target system was centered around images.

A user would start with their most recent piece of information. In this case, the user was given an image as their information in Rhizome.

Figure 2. The Rhizome screen at the start of the application.
In order to access related content to this focused Thing, a user would have to zoom out of their Thing to expose greater access in the Rhizome world and therefore more information. This includes many pieces of information on the screen with their focused piece of information (an image Thing) at the center. To the left of their Thing, there were highlighted places and to the right of their Thing were highlighted people. Above and below the center Thing were related information Things which included tags and targets using the tag/target system.
The experiment relied on the following information-centric API calls for contextualizing information:

- query - being able to retrieve and display all the information in the Rhizome
- retrieve - focus on one specific piece of information
- seek - focus on a concept of a piece of information which includes seeing everything related to that concept (tags and targets.)

These API calls supported user interaction with their information.

My implementation initiated changes to the Rhizome library. I discovered that the Rhizome API needed to change to accommodate a variety of information. Originally, the API accepted only a variable type of a String (text-based information) for the Uniform Resources Identifier (URI). However, a user’s information could also be multimedia, an application, software, etc. The API change recognizes that information is not solely a String but that information is dynamic. The API change generates a URI for each dynamic piece of information instead of solely implementing a String. This could now permit images, for example, to be contextualized.

While a complete Rhizome GUI shell would support more interaction, this implementation focuses on the experiment task of use case of sharing a photo. The shell uses the Rhizome API to test basic information-centric behaviors while a user interacted with their Things through a tagging and targeting concept. These tests of behaviors allowed us to explore interactions with our computers and information that remain independent of applications, sites, and devices that exist in current models.

Method

I used methodologies of human-computer interaction (HCI) to measure and observe people using the Rhizome operating system shell and a modern OS shell. I focused on a single use case of sharing a photo for each OS shell, and assessed the cognitive load a user may experience utilizing each system.

Participants

This study engaged fifteen people ages 20-40 from a variety of backgrounds of both technical and non-technical experience. Most people who participated in the study were students who volunteered from Oregon State University – Cascades in Bend, Oregon. The remainder of people were acquaintances of other participants who also volunteered. Future work notes on expanding these demographics to make a complete conclusion about the Rhizome information-centric model.
Experiment
The Rhizome GUI Experiment consisted of one task performed on three different OS shells: a laptop, a personal device, and Rhizome GUI. The user was given the following scenario:

Imagine you just came back from Moab, Utah from a great mountain biking trip with your friends Joe and Sara. There was lots of biking, lots of exploring, and lots of photos! Now that you are back in Bend, Oregon, you are reminiscing about your trip in Moab so you want to keep those memories fresh - remembering the bike trails, the views, and the friends you were with. You also need to share your photos with Joe and Sara.

Because you also want to keep those memories fresh with their appropriate details, your task is to share photos of your mountain biking trip.

During this task, I measured two primary metrics: time and number of steps. Time was defined as the duration it took to complete the task of sharing a photo. When a user began viewing the photo, the time began. Steps was defined as the number of interactions a user performs which includes clicks, typing, swiping, and mouse movements. The amount of processing or cognitive load a user takes while using a laptop, a personal device, and Rhizome was measured through these two metrics.

OS Shell 1: Laptop
The user subject first accomplished the task with a laptop and was provided with a sheet of contact information and a default image from their “Moab trip.” The user was given the option to place the photo where they normally store their photos as I am interested in measuring this task in their most natural form. Next, the user was instructed to share the photo on their laptop with myself using any method, platform, and form of communication they wish. During this session, I tracked the method of sharing the user used to perform the task, the time it took to complete the task, and the number of steps the user took.

OS Shell 2: Personal Device
Next, the user subject completed the task with the second OS shell. The second OS was a personal device of choice (e.g. a mobile device.) Given the same sheet of contact information and the same default image, the user was again given the option to store their photo on their personal device where they may normally process photos. Next, they were instructed to share the photo on their personal device with myself using any method, platform, and form of communication they wish. Again, I tracked the method of sharing the user used to perform the task, the time it took to complete the task, and the number of steps it took.

OS Shell 3: Rhizome GUI
Third, the Rhizome GUI was deployed on a 2nd generation iPad and divided into two parts. Part A asked the user to share their photo twice while using the Rhizome GUI. The user was given access to the iPad to use the Rhizome GUI and vaguely asked to
“share the photo with their friends ‘Joe’ and ‘Sara’”. In order to share their photo, they must first zoom out of the main screen then drag and drop their photo to both pseudo-characters Joe and Sara. Once the user completed this task, they were asked to repeat the task. Users were asked to perform the task a second time because they were now performing a task on software they have never seen before. I assumed that users had familiarity with a laptop and personal device and attempted to provide some experience for the initial learning curve. This also helped provide data on examining the performance of a user as they interact with a new system.

Part B was formulated to focus and test the tag/target system in Rhizome. For the last two tasks in Rhizome, the user was first asked to share their information (the photo at the center of their screen) with anything on the screen - any person, place, or thing. Then the reverse was asked for the user to share anything on the screen (any person, place, or thing) with their photo. This drag and drop process continued to observe how a user would complete their tasks and was predicted to measure the cognitive load tasks have on a user while using Rhizome. By allowing users more freedom in these tasks it was also testing the limits of the Rhizome API in the backend.

All data was recorded in a spreadsheet. The information, the time it took to complete the task, and the number of steps to interact was data logged.

Data Tracked
- The placement of the default photo on the user’s laptop and personal device
- Method of sharing information
- Time to complete the given tasks
- Number Steps
- Observations of user

<table>
<thead>
<tr>
<th>User #</th>
<th>Laptop Photo Location</th>
<th>Laptop Time</th>
<th>Laptop Steps</th>
<th>Method of Sharing</th>
<th>Personal Device Photo Location</th>
<th>Personal Device Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>Desktop</td>
<td>9:34</td>
<td>5</td>
<td>Discord</td>
<td>Photo Album</td>
<td>20.04</td>
</tr>
<tr>
<td>User 2</td>
<td>Desktop</td>
<td>1:13:32</td>
<td>12</td>
<td>Instagram</td>
<td>Photo Album</td>
<td>11.74</td>
</tr>
<tr>
<td>User 3</td>
<td>Desktop</td>
<td>21:05</td>
<td>6</td>
<td>Google Photos</td>
<td>Email</td>
<td>14.56</td>
</tr>
<tr>
<td>User 4</td>
<td>Desktop</td>
<td>33.8</td>
<td>7</td>
<td>Email</td>
<td>Computer Files</td>
<td>35.6</td>
</tr>
<tr>
<td>User 5</td>
<td>Desktop</td>
<td>19.59</td>
<td>9</td>
<td>Email</td>
<td>Photo Album</td>
<td>22.9</td>
</tr>
<tr>
<td>User 6</td>
<td>Desktop</td>
<td>20.13</td>
<td>7</td>
<td>iMessage</td>
<td>Photo Album</td>
<td>20.16</td>
</tr>
<tr>
<td>User 7</td>
<td>Downloads</td>
<td>25</td>
<td>9</td>
<td>Email</td>
<td>Photo Album</td>
<td>12.46</td>
</tr>
<tr>
<td>User 8</td>
<td>Downloads</td>
<td>36.36</td>
<td>6</td>
<td>Instagram</td>
<td>Messages</td>
<td>4.81</td>
</tr>
<tr>
<td>User 9</td>
<td>Downloads</td>
<td>20.28</td>
<td>8</td>
<td>Discord</td>
<td>Messages</td>
<td>14.21</td>
</tr>
<tr>
<td>User 10</td>
<td>Desktop</td>
<td>21.83</td>
<td>7</td>
<td>Discord</td>
<td>Photo Album</td>
<td>13.08</td>
</tr>
<tr>
<td>User 11</td>
<td>Desktop</td>
<td>15.06</td>
<td>5</td>
<td>iMessage</td>
<td>Messages</td>
<td>9.15</td>
</tr>
<tr>
<td>User 12</td>
<td>Desktop</td>
<td>23.04</td>
<td>7</td>
<td>Discord</td>
<td>Photo Album</td>
<td>26.8</td>
</tr>
<tr>
<td>User 13</td>
<td>Photos</td>
<td>118.06</td>
<td>7</td>
<td>Google Photos</td>
<td>Photo Album</td>
<td>17.86</td>
</tr>
<tr>
<td>User 14</td>
<td>Google Photos</td>
<td>8.04</td>
<td>6</td>
<td>Discord</td>
<td>Google Photos</td>
<td>4.16</td>
</tr>
<tr>
<td>User 15</td>
<td>Downloads</td>
<td>18.1</td>
<td>7</td>
<td>Email</td>
<td>Photo Album</td>
<td>8.43</td>
</tr>
</tbody>
</table>

Figure 5. Spreadsheet of data collected from users.

After completing the task on the three OS shells, the user completed an exit survey.
Rhizome Exit Survey

Thank you for participating in the Rhizome GUI experiment.

You were asked to perform the same task on three different devices. Please rate the level of difficulty it was to perform the task using a LAPTOP?

☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5

Easy  Difficult

You were asked to perform the same task on three different devices. Please rate the level of difficulty it was to perform the task using a PERSONAL DEVICE?

☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5

Easy  Difficult

You were asked to perform the same task on three different devices. Please rate the level of difficulty it was to perform the task using RHIZOME?

☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5

Easy  Difficult

Please rank the devices from easiest to use to hardest to use. (1 easiest, 3 most difficult)

Laptop
Personal Device
Rhizome

If there was a device(s) that it was easier to perform the task on, what aspects made this task easier?

____________________________________________________________________

____________________________________________________________________

Anything else you would like to add about your experience?

____________________________________________________________________

____________________________________________________________________

Figure 6. Rhizome exit survey.
Limitations
I made the assumption that users were familiar with their current OS shells using their laptop and personal devices. I assumed this because this study focuses on measuring the subject’s interactions with their devices and not training users how to interact with their devices. Although all interactions were qualitatively measured with through time and number of steps, each user was also given the opportunity to share their subjective level of comfort with their devices in the exit survey since it varied a lot depending on the person.

In some cases, users would perform the tag/targeting in reverse order than what I was attempting to prompt. I considered there some error in my communication with describing the task the user was to perform. I had to remain vague on their instructions to observe their behavior with a new system, communication could have resulted in some error. One preventative measure to address this was following a self-written guide to conducting the experiment so that my instructions would remain accurate user to user.

Lastly, there were differences in the traditional laptop and mobile device relative to the Rhizome shell. For the first two tasks on the user’s laptop and personal device, they were asked to share a photo by sending it to myself. This was to create some form of a similarity between the various OS shells and confirm that (1) a user successfully completed the task and (2) to provide set start and end points to the task.

There were some considerations taken into account when analyzing the data. First off, the data collected was in a small pool of users primarily due to COVID-19. The small pool of users reduced exposure to the diversity of the experiment making the results of the subpopulations limited and data limited. It would be important that the information analyzed from this experiment takes this factor into account as further assessment would need to take place in future work.

Results
I anticipated that subjects would be able to accomplish their tasks faster and with less cognitive load than using Rhizome instead of traditional operating system shells. The development of the shell has also informed us of the usability of the Rhizome API, identifying ways to make it scale and implement an info-centric system that is not tied to a specific device, application, or site.

OS Shell 1 (Laptop) and OS Shell 2 (Personal Device)
This experiment assumes that users have some familiarity with common computing devices including a laptop and personal device such as a smartphone. On average, users spent 27.9 seconds to complete their photo sharing task on a laptop and 7.3 seconds on a personal device. It took the average user 7 interactive steps to complete the task on their laptop and 6 interactive steps on their personal device.
OS Shell 3 Part A (Rhizome)
Users have no familiarity with Rhizome beforehand. This experiment predicts that there will be a learning curve for users when using a completely new GUI shell so users were given two attempts to perform the same task of sharing photo.

In Attempt #1, it took the average user 12.4 seconds to share a photo and 4.4 seconds on Attempt #2. The users performed around the same number of steps with the average user performing 3.5 steps in Attempt #1 and 3 steps by Attempt #2. All users took exactly 3 steps by Attempt #2. I believe this resulted because the user understood how to complete their task intuitively by the second attempt. This demonstrates that Rhizome is intuitive and does not require much time or effort as users were directly interacting with their task instead of randomly tapping, dragging objects.

OS Shell Part B (Rhizome)
Rhizome consisted of an additional testing component of asking users to continue sharing photos in an ordered way within the shell. The average user spent 2.3 seconds tagging and 2.1 seconds targeting and completed the task with about 2 steps. Both the tagging and targeting require the exact same interactions by dragging and dropping an item onto another item. Although the time spent tagging and targeting were relatively similar, this could propose the time difference was contributed due to a user thinking about who or what they want to tag. Additionally, it is important to note that the user was always asked to tag something first then target.
When given a specific task to complete, users demonstrated that while using Rhizome they could complete their task with less cognitive load as each user took exactly 3 steps to complete their task. However, when users were given the continued task of sharing but left to their own choices of who, what, where, and how many things they share with, this is when I noticed more hesitation as users were now taking an average of 4.6 seconds to complete their task. In future work, it would be worth examining that if restricted to the same number of steps for both part A and part B if the cognitive load would increase due to the additional factor of making choices.

Given that Rhizome is a completely new GUI, it is not quite a direct comparison from Rhizome to our current computational devices. However, future work could examine more closely on testing Rhizome against current computational devices when it is more familiar to users as just in the short learning time, users went from an average of 27.9 seconds to 4.4 seconds to complete the task and 7 steps to 3 steps.

Results of Surveys
In the exit survey, users were asked to rank the level of difficulty it was to perform the task using the laptop, personal device, and Rhizome. With one being the easiest and five being the most difficult, the average user rated the laptop as the most difficult at 1.87 out of 5 to use when sharing a photo.
Users were then asked to rank the level of difficulty of using (clicking, moving, tapping) the devices in relation to each other with one being the easiest and three being the hardest. The average user rated Rhizome as the easiest device to use and the laptop as the most difficult.

The final survey question asked users what made tasks easier if there were any device(s) that was easier to perform a task on.

If there were any device(s) that was easier to perform the task on, what aspects made this task easier?
The share button makes it easy.

Rhizome drag and drop.

Rhizome - intuitive, simplified, less steps

Dragging and dropping for the laptop and rhizome. The laptop was harder because I have to save it first/login.

The phone was easiest because I'm used to it and it was easy to text right back.

Being familiar with the UI made completing the task simpler.

Preexisting knowledge made navigation easier.

Less clicks on the iPad

Rhizome was easier because I didn't have to login or find a photo or contact.

The click and drag photos/images, lack of account concerns (google).

Familiarity

The laptop was easiest as I am most familiar with it.

Some common themes users described to make interacting with their devices easier included:

- pre-existing knowledge of something
- familiarity of a device or interface
- less clicking; dragging and dropping was faster and/or easier for some users
- no logging in or finding of information (rhizome)
All users were also given space to share any additional thoughts about their experience.

<table>
<thead>
<tr>
<th>Additional Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lag was bad</td>
</tr>
<tr>
<td>Too many options on other platforms, don't know the best way [to share]</td>
</tr>
<tr>
<td>After understanding the Rhizome was actually very simple, it was the easiest to use.</td>
</tr>
<tr>
<td>I enjoyed the ease of use it was clear how to use Rhizome without any instruction.</td>
</tr>
</tbody>
</table>

There were users that performed tasks very differently than the average user. One user was unfamiliar with using a laptop. In this case, I provided guidance to demonstrate how to scroll and attach a file in an email so they could complete the first testing scenario of sharing a photo on their laptop.

When given the task to “share a photo with their friends Joe and Sara”, another user attempted to drag the people icons onto the photo rather than dragging to share the photo to the people icons. All other users would drag the center photo to their pseudo-friends Joe and Sara.
Figure 13. The focused task of the given photo to share with pseudo-friends 'Joe' and 'Sara'.

Given that most users described familiarity as an aspect of ease in their experience, I would expect future work to provide more insight to the learning curve when using something new and something unfamiliar. Is sharing a photo with a person actually a difficult task using Rhizome or is it just the initial learning curve a user is having a difficulty with? My predictions considered room for a learning curve so to test this users were asked to perform completing the photo sharing task twice.

Figure 14. Results of testing the learning curve by comparing a first and second attempt.
One of the biggest findings from this was that once a user was familiar with the system and task in their first attempt, they were on average 60% more efficient in completing their task the second time around. The first attempt, users completed their task with an average of 12.40 seconds. Immediately after, users completed their second attempt with an average of 4.44 seconds.

![Rhizome Number of Steps](image.png)

**Figure 15. Results of testing the learning curve (measured in interactive steps) between the first and second attempt.**

The number of steps it took users on average to complete the same task in attempt 1 was similar to the average number of steps in attempt 2. Generally, the users were observed to have less fumbling and more focused interactions. This included less random interactions like randomly touching the screen in an attempt to see what happened and more strategic interactions like directly dragging and dropping.

Through this experiment, there were four shells identified that users commonly use: Windows, Mac, iOS, and Android. The most common way for users to share their photos on a laptop was through email and Discord, a voice and text chat system. Note that it is difficult to derive a conclusion on the method of sharing given that some of the users who had a computer science background often used this method for communicating. The most common way for users to share their photos on a personal device was through a text message.

This study aims to measure the cognitive load a user experiences when interacting with their information through Rhizome, an information-centric model. How do we know if a user is really cognitively overloaded? Although studies show an increase in
time when a user has an increase of items to process [12], the measurement of time
does not demonstrate all of the cognitive load a user could experience. This study
experiments with collecting the time it takes to process the task and the number of
interactive steps a user takes to assist us in assessing some cognitive load.
Additionally, many users in this experiment expressed some common themes to make
interactions easier to use. Future work measuring a user’s learning curve could help
produce more information about interacting with new conceptual models in
computers.

Conclusion and Future Work
This thesis explores an information-centric model to escape existing limitations on
current models and measure the cognitive load a user has while interacting with their
information. During this research, I discovered that an information-centric model
does reduce the task complexity for a user when measured by time and the number of
steps (interactions) they take while completing a task. Working with a new user
interface can be challenging to introduce to users but multi-touch models like
smartphones are successful in comparison to a laptop. Moving further from the
traditional WIMP model seems to create promising results and explorations in these
different paradigms could provide room for more fruitful experiences for users that
require less time and interactions.

I also discovered that there were frequent themes in the relationship of human-
computer interactions which included the users’ comforts and familiarity with their
devices. People like stability and familiarity. Big companies like Microsoft and Apple
cannot just add new features to their current systems, especially in the realm of HCI
[3]. We as users are like “children in the computer age” and children want stability.
Children want to hear and see the same thing over and over again. Just like children,
as users we also like stability and taking this into consideration, going forward with
HCI exploration it seems that integrated designs would be beneficial to addressing the
comfort and familiarity of technology people experience today.

This research has numerous directions in expanding the Rhizome information-centric
model. First, due to a small sample size with COVID-19, a larger sample size and
greater demographic would be of benefit to providing more reliable data. Although
the demographics in this sample size did include a diverse population, it would be
good to collect data from people of younger ages (younger than 18) and older ages
(seniors). The current data was collected from people ages 19-40 with a variety of
backgrounds ranging from technical to non-technical.

Rhizome cognitive load was measured in time and number of interaction steps.
However, how do we truly know a user is cognitively overloaded? With a more
dialed in approach to cognitive overload, it would be interesting to identify at what
point a user triggers “cognitive overload” and what point is their information
processing insufficient.
Lastly, it would be interesting to expand the Rhizome proof of concept use case. This study conducted an experiment with the task of sharing a photo. Testing another proof of concept that integrates more steps and takes more “thinking” from the user would help dial in greater improvements to an information-centric model. Even expanding the proof of concept as far as actually being able to send data to other people using two Rhizome shells would deliver a full experience from start to finish using the Rhizome OS.

Other interesting things to note include some observations of the users. For an example, most users were attracted to Things in Rhizome that had images instead of text-based Things in Rhizome. Another interesting note is some users had very integrated systems. One user’s personal device was a Google Pixel 5 which was very integrated with Google products. This user was able to complete the task of sharing photo very quickly. Questions remain - is this because this user has some technical background? Is this because an integrated personal device was tightly knit with applications that made the task of sharing a photo more quickly? It would be interesting to investigate whether different devices and their different platforms have quicker ways of completing tasks.

I hypothesized that an information-centric shell can enable people to accomplish tasks faster with less cognitive load than current operating systems shells. In this experiment, I focused on sharing information and proving that by minimal interactions there is less of a cognitive load on a user. Traditional conceptual models consist of Windows, Icons, Menus, and Pointers (WIMP) which limit ways people interact with their information because it is dependent on the user’s device, applications, and sites. This has proven to be more time consuming and harder to find the information they are seeking.

With the Rhizome GUI shell being one example of moving away from the WIMP model and exploring new paradigms in human-computer interactions, this thesis demonstrates both qualitatively and subjectively from users that it was faster, “intuitive”, and prevented them from having to search for their information. Rhizome works to explore this new area with a user by providing an alternative way to conceptualize information through organizing, archiving, storing, retrieving, and manipulating their information to help reduce the cognitive load to interacting with information.
The Anti-Mac Interface outline emphasizes a big point to human-computer interaction - we must arrive at a new Internet desktop and one that is truly shaped to meet users’ needs. With the traditional WIMP model, desktop metaphors are restricting and misleading to both users and designers to create more “powerful interface mechanisms.” We need to begin development of a new Internet desktop that is based on a computer’s systems and the tasks users really have to accomplish. This is not about advancing current standards of a desktop, but instead to escape these restrictions.

Originally, the Macintosh was optimized with a specific set of users in mind; users who do not have a computer science background. Today’s WIMP model works well with current computer capabilities. But what will happen when the next generation of computers arrive? Designers need to take advantage of the current HCI plateau especially with the idea of the Anti-Mac principles that describe the next dominant set of computer users: people with advanced computer experience.

This publication will serve critical information in supporting my argument about re-shaping the way humans interact with computers and how necessary it is that we “think outside the WIMP model box.”

In the original desktop design, the desktop is the user’s area. Many users, however, are still low-medium skilled users and have different needs from power users. This still creates a challenge for inherent coupling to real-world metaphors as the same problems rise - the desktops still encountered inconsistencies with the real office.
In this chapter, there are three projects described to create a more efficient way for users to manage and perform tasks.

GroupBar was based around the Windows taskbar and allows users to group and regroup windows while operating on the groups of windows (tasks).

Scalable Fabric is a system surrounding multi-window “tasks” on Windows with a “focus-plus-context” display to provide context of work where the user focuses.

Task Gallery focused on a 3D window manager through a room of tasks; the current task is displayed on the “stage” of the virtual gallery while other tasks are placed on the floors, walls, and ceiling of the gallery.

Each design was discussed on how task management was improved and where each design could improve. There has been “ample evidence” that rapid and repeated task management software is of great values.

Matching computation activity can be challenging across various activities so Kimura is an activity-centered work environment that works to develop better business professionals. One thing that is unique about the Kimura research is that it has explored activities on and off the desktop. The Kimura system is
based around the focal and desktop regions on the desktop and collections of activity (working context) are automatically tracked and tagged based on their importance. Collecting information about users and their tasks is something helpful to assess in the Rhizome GUI and make decisions about collecting information (e.g. automatic tagging.)


ContactMap is a “social workspace” as it integrates communication and information management by organizing a user’s computer based on their social networks and contacts. Another project, Soylent, is a bottom-up approach but used to construct ContactMap-like applications. I will use the philosophies of a “social workspace” to take in consideration when designing and implementing a GUI.


Recall that the desktop metaphor is one of the earliest and primary ways of interacting with information. But that is changing. Personal information is no longer being constrained to a desktop and information is being presented in new ways outside of keyboarding and pointing. This concluding information about the seven dimensions of computing changes will be valuable to addressing and adapting to the new ways of attempting to represent users and their electronic lives.

https://psycnet.apa.org/fulltext/2007-06096-007.pdf?auth_token=fbe61cc8fb593aa4c7bad546eb7872255c74711a


Something that stood out to me is the idea that users are often “tied” to their machines, creating a one-to-one relationship but concept activity-based computing (ABC) removes the ties to files and users and incorporates activities to users, particularly in clinical settings. During my research, I will
use the ideas of ABC to challenge modern application-centered computing and interruptions it can have during a user’s task.