Softplane: Information Visualization on mixed-reality platforms

Hongyuan Jiang

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Abstract

Softplane: Information Visualization on mixed-reality platforms

Hongyuan Jiang

Chair of the Supervisory Committee
James Pierce
School of Art + Art History + Design

This thesis examines the relevance and impact of Mixed Reality in near-future scenarios and investigates how Mixed Reality can be presented across different platforms. Using the Research through Design method, I created prototypes to probe various design aspects and gain insights into scenario environments and users involved. I developed an interactive prototype and speculative videos to refine the information currently presented, propose situated content visualization, and enrich the visualization format. The outcome suggests that Mixed Reality has great potential for enhancing user experience and providing new opportunities for complex information visualization.

Softplane:
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INTRODUCTION

My fascination with information visualization began when I came across a video called "Microsoft: Productivity Future Vision" around six years ago. At that time, I was a novice industrial design undergraduate, focused on creating aesthetically pleasing designs. However, this video completely transformed my perspective on product design. It presented a visionary world where information was seamlessly accessed through various devices, revolutionizing the way people interacted with technology.

The video showcased scenarios such as holographic projections bringing marine science footages into classrooms and fabric gadgets enabling cloud meetings with unparalleled portability. It portrayed an vision of interactions that was almost too ideal. Since then, I intentionally shifted my design practice to establish a strong connection between hardware and software. However, as technology advances and hyperconnectivity becomes more prevalent, I find myself grappling with societal and ethical concerns that arise. These concerns sometimes challenge my belief in the potential of information visualization.

Nevertheless, one thing remains unwavering: the notion that **hardware without software is like a person without a soul**. Although there is still a long way to go, I remain committed to exploring the possibilities and pushing the boundaries of information visualization.

BACKGROUND

The rapid development of technology has paved the way for the creation of applications that serve as decision-making tools for everyday challenges. For instance, mobile pathfinding applications assist users in finding optimal routes during many situations, aiding quick and accurate decision-making. Designing such applications requires careful consideration of user interaction and effective visualization strategies. Various computing paradigms have emerged to fulfill these objectives, including virtual reality (VR), augmented reality (AR), and mixed reality (MR). VR offers a computer-generated environment where users can immerse themselves with the help of VR headsets. However, VR has faced challenges in establishing a connection with the real world. AR addresses this issue by introducing computer-generated content into the real world, enabling user interaction with an augmented environment. Despite the significance of AR, effectively merging the real and virtual worlds remains a major challenge, leading to reduced user immersion. MR emerged as a solution to this challenge by seamlessly blending the real and virtual realms, creating a unique environment that establishes a window between the two(Rasimah et al., 2011).

Furthermore, the practical application of mixed reality (MR) has demonstrated its significant value in various business-to-business scenarios. Early adopters such as DHL, the U.S. Navy, and Boeing (Siyaev & Jo, 2021) have already harnessed the power of MR to provide on-demand, step-by-step visual training for workers. MR enables tailored instruction based on a worker's specific experience or common errors encountered in their field.

For instance, at KPN, a European telecommunications service provider, field engineers conducting repairs utilize MR smart glasses to access a product's service history data, diagnostics, and location-based information dashboards. These MR displays assist them in making informed decisions to effectively resolve issues, resulting in an 11% reduction in overall service team costs, a 17% decrease in work-error rates, and improved repair quality.

Similarly, Xerox leveraged MR to connect field engineers with experts instead of relying solely on service manuals and telephone support. This approach led to a remarkable 67% increase in first-time fix rates and a 20% boost in engineers' efficiency. Additionally, the average problem resolution time decreased by two hours, resulting in reduced staffing requirements. Taking it a step further, Xerox now employs MR to directly connect remote technical experts with customers. This innovation has significantly improved the rate at which technical problems are resolved by customers without on-site assistance, leading to cost savings in travel for Xerox and minimized downtime for customers. Consequently, Xerox's customer satisfaction rates have soared to an impressive 95%(Porter & Heppelmann, 2017).

These real-world examples highlight the tangible benefits that MR brings to business operations, demonstrating its ability to enhance training, decision-making, problem resolution, and overall customer satisfaction in various industries.

Moreover, academia has dedicated significant research efforts to develop comprehensive frameworks aimed at supporting developers in this domains. During the literature review, one framework that particularly intrigued me was proposed by Rokhsaritalemi(Rokhsaritalemi et al., 2020). This framework outlines five distinct layers of MR application development. The first layer focuses on system components, while the second and third layers address architectural issues related to component integration. The fourth layer pertains to the application layer responsible for executing the architectural design, and the fifth layer is dedicated to the user interface, enabling seamless user interaction. The framework provides a systematic approach that can be employed by designers in practical MR implementation. In addition to the framework, the concept of scenario-based design also convinced me to take a more tangible approach to development by interweaving different layers through a real-world scenario. The scenario serves as a narrative description of an envisioned usage episode(Rosson & Carroll, 2002), providing a concrete context for the process.

With the support of my committee members, I have been fortunate to collaborate with a team from Meta in exploring the possibilities of integrating MR capability into the future workflow of data technicians within the data center. This unique opportunity provides me with an almost perfect scenario to delve into. The complexity of the setting serves as an ideal platform for thesis exploration.

RESEARCH & DESIGN

Mixed Reality Opportunity
in Data Center Operation

Cloud computing is widely recognized as a service paradigm for the present. In the context of cloud computing, data centers serve as common hosting environments, typically housing numerous densely packed blade servers to optimize space utilization(Arregoces & Portolani, 2003). As servers in these data centers face overwhelming data loads, the maintenance of these facilities becomes paramount for the uninterrupted operations of Meta. Data technicians play a vital role in performing these maintenance services, which encompass various tasks such as working with individual servers, replacing faulty components, managing infrastructures, and overseeing backups.

While data centers may have a greater potential for complete automation compared to the previous examples mentioned in the last section, we believe it is still advantageous to integrate MR technology in the current stage as it enables gradual enhancements in work processes, efficiency, and overall quality.

Given the high demand for maintenance services, data technicians often need to swiftly familiarize themselves with the environment and handle ten to a dozen cases per day, necessitating quick decision-making on-site.

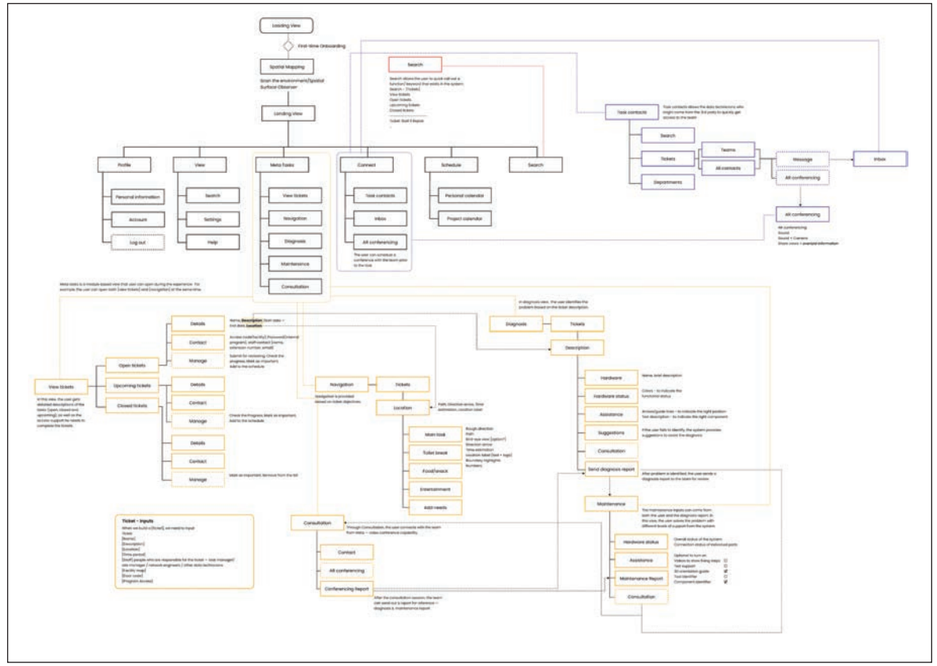
The tickets encompass a wide range of tasks that data technicians are responsible for within a data center. For instance, technicians are frequently required to install and upkeep data servers as well as network equipment. To elaborate further, they are tasked with replacing any faulty hardware components and ensuring their proper functionality. Additionally, their responsibilities involve monitoring the performance of servers on a daily basis, maintaining an environment that optimally regulates server conditions, and resolving network and server issues through troubleshooting.

Understanding users needs
by constructing Information Architecture

With that kept in mind, I delved deeper into comprehending the specific needs of technicians. Due to the confidential nature of data centers, direct insights from team members at Meta were limited through interviews alone. Consequently, I embarked on secondary research by analyzing the job descriptions of data technicians published by Meta. Among the various tasks outlined, I distilled them down to five that I believe hold relevance within the context of MR. These tasks encompass:

1. Understanding service tickets
2. Navigating the data center environment effectively
3. Accurately identifying the service components
4. Adhering to established protocols while completing maintenance
5. Documenting and escalating as necessary.

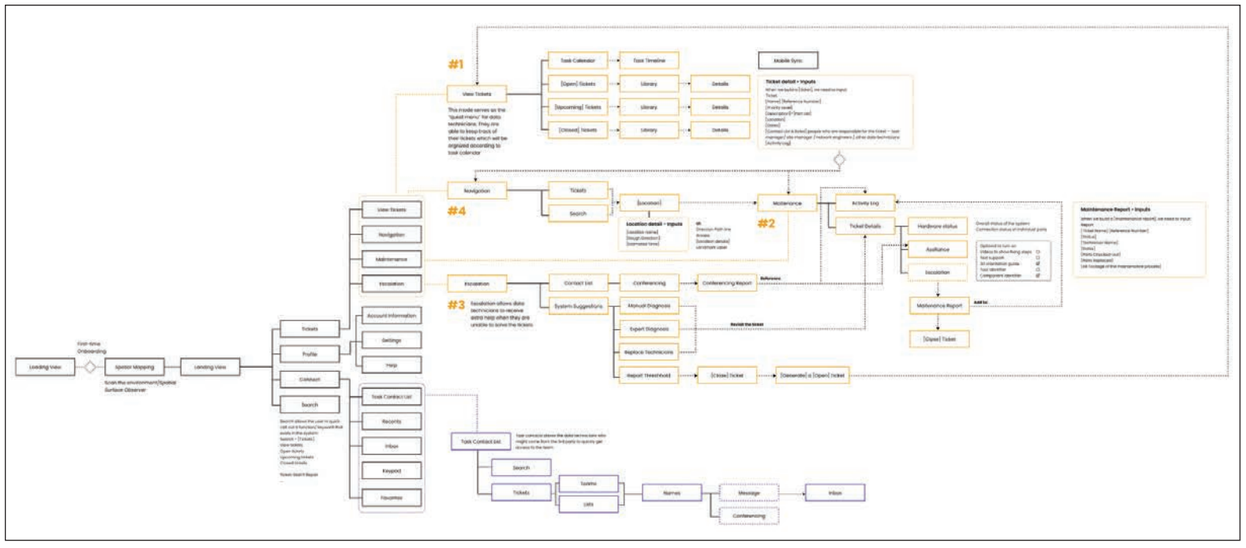
Having identified these needs, I proceeded to develop an initial information architecture aimed at turning all the needs into system features. The initial draft included five distinct domains:
[Tickets], *serving as the starting point for the user experience, enabling data technicians to browse through their daily tasks;*
[Navigation], *which facilitates wayfinding for technicians to reach the designated service locations;*
[Diagnosis], *providing assistance to data technicians in identifying service issues;*
[Maintenance], *offering guidance to aid technicians in problem-solving; and lastly,*
[Escalation], *granting data technicians the ability to connect with other teams within Meta.*
These domains also illustrated the potential benefits of MR in supporting data technicians in a data center.



The first draft of Information architecture, Figma

Getting closer to the real environment through refinements

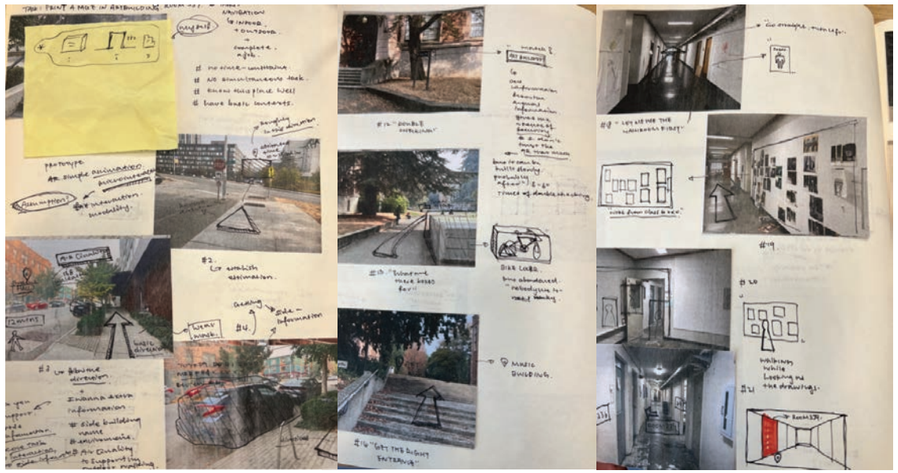
I utilized the initial draft as a basis for discussion during the meeting with the Meta team. The outcome of the meeting revealed that the draft version closely aligned with their vision, with one notable exception: the team emphasized that most diagnoses were conducted by artificial intelligence, rendering the diagnosis component in the system redundant. Additionally, the team assisted me in prioritizing these domains based on the current operational flow of the data center. The meeting instilled confidence that I, at least on the architecture level, was progressing in the right direction.



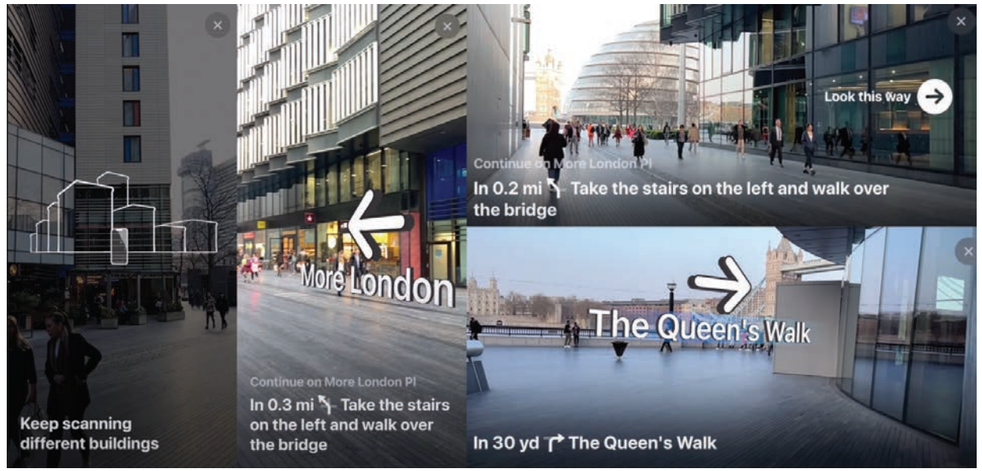
The second draft of Information architecture, Figma

Imagery Journal

Simultaneously, I embarked on exploring MR interface design patterns. To begin, I attempted to create an unrestricted visual documentation using an imagery journal. As a self-assigned task, I sought to locate the printer in the graduate studio of the Art Building. Holding my smartphone slightly below eye level, I simulated the experience of having an MR device in front of me. While capturing the footage, I verbalized my thoughts and ideas, brainstorming potential features that could aid in the navigation process. My objective was to collect a diverse range of information types that would serve as valuable resources for my future interface development.



A snapshot of the imagery journal, pen and notebook



MR navigation pattern, Apple

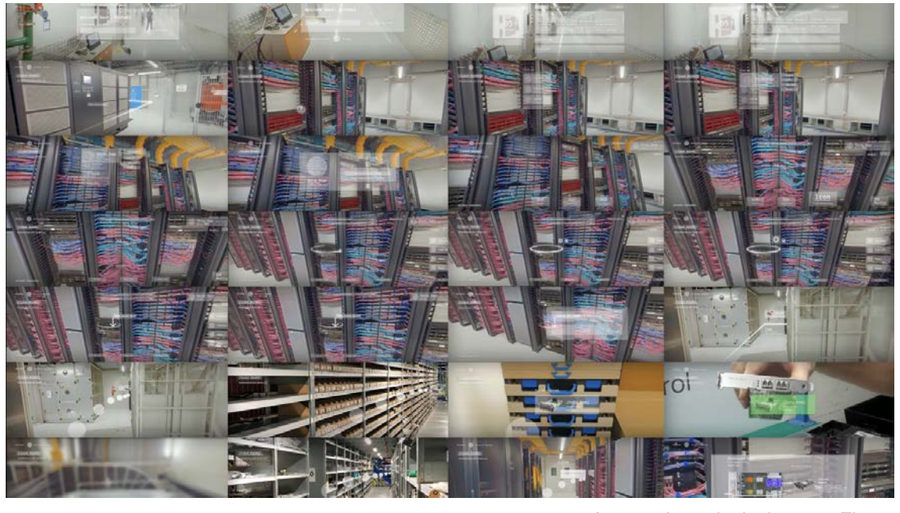
Existing Design Pattern

Additionally, I curated a board that compiles established design patterns from the industry. I organized these patterns into distinct categories based on their features, such as navigation, labels, orientation anchors, dialogue boxes, and more. This collection serves as a valuable resource for reference during the design process

A snapshot of potential microinteraction that captures “service anchor”, Figma

Wireframes that capture the envisioned features

Following that, I proceeded with the creation of preliminary wireframes that depict the envisioned features outlined in the Information Architecture. Due to the constraints of limited access to the data center environment, I resorted to utilizing online footage captured by a 360-degree camera to enhance my understanding of the data center environment. By referencing existing MR applications, I superimposed component boxes onto the footage, allowing me to explore wireframes that address elements such as the placement of information, component sizing, and even microinteractions that need to happen between each frames.



A snapshot of wireframes, Figma

Parallel Scenario

The subsequent phase of development presents its own set of challenges. Data centers, being the core infrastructure for Meta's operation, are highly secure environments. Therefore, physically being present there to validate usability decisions becomes almost impossible.

To address this limitation, I devised a strategy to introduce a parallel scenario that echoes the user needs of data technicians. After careful consideration of several options, I selected librarians as the most closely aligned user group in the parallel scenario. I found numerous similarities between data technicians and librarians in terms of their user needs. For instance, both professions require navigating through an environment without distinct landmarks. Additionally, they share the need to identify objects that lack prominent physical features on shelves or racks. Moreover, both will be benefited from indoor navigation systems to guide them to their desired destinations.

While exploring the parallel scenario, I became intrigued by the potential of dual-platform interaction, wherein information is presented in the most easily digestible format through the most suitable device. This realization came from an instance where I attempted to present a book abstract to a user and found that the view became overwhelming due to a large amount of text. It occurred to me that it is important not to impose all types of visualizations on a device simply because it is considered technologically advanced. Instead, we should empower users with the freedom to choose the most effective form of presentation that suits their preferences and needs.

To achieve this, I started laying down wireframes through the following three approaches:

1.Smartphones-only
By adopting this approach, users can rely solely on their smartphones for engagement. During the exploration of wireframes, I adhered to established design patterns for mobile applications. The emphasis on a "smartphone-only" experience ensures a seamless flow for users, eliminating the need to constantly shift attention between different devices. Information visualization is simplified as users can access all the necessary information within a single view.

However, challenges arise when attempting to render navigation in both MR and traditional plan views due to limitations posed by screen size. This hinders users' ability to intuitively receive information. Additionally, it should be noted that holding a phone may not always be the most convenient option for librarians in their daily tasks.

2.MR headset-only

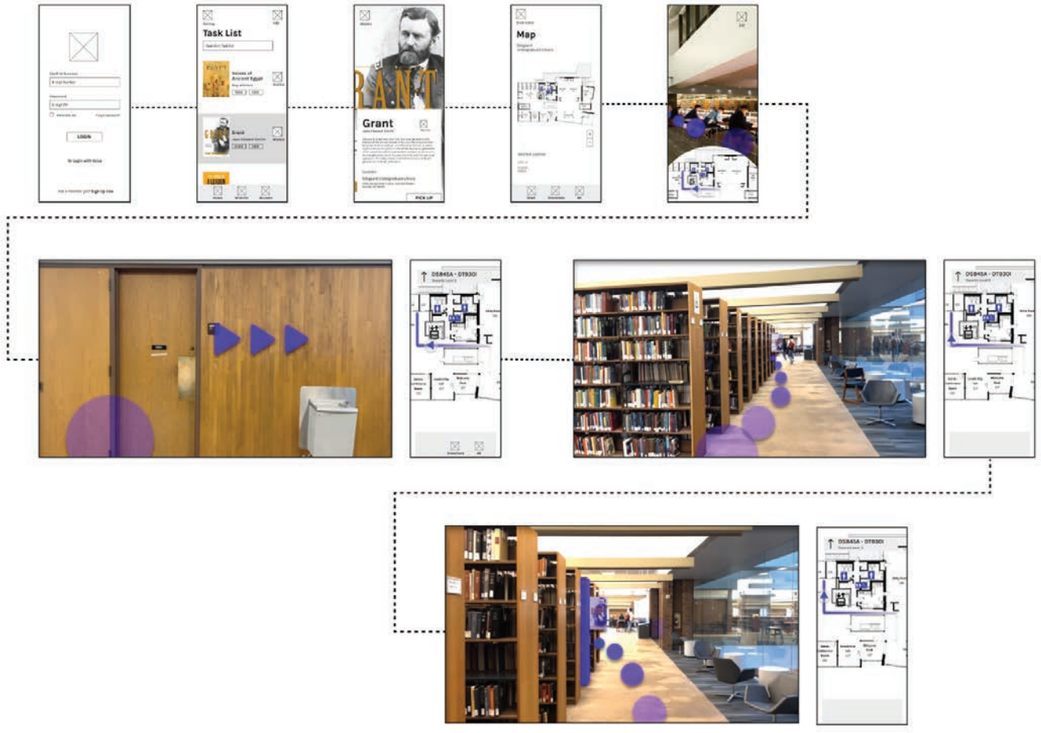
Given the limitations of using a smartphone, I embarked on the second exploration, wherein the entire experience is built around an MR headset. In this scenario, librarians are able to perform tasks hands-free and receive information in various formats. This approach also allows for more natural and anthropomorphic interactions.

However, utilizing an MR headset for interactivity requires substantial user inputs, such as eye tracking and gestural recognition. It may also demand additional effort from users, particularly when engaging in complex inputs like typing on a virtual keyboard. Furthermore, the book abstract example became evident that overlaying long paragraphs of text in front of a user did not intuitively improve efficiency nor create a pleasant experience.

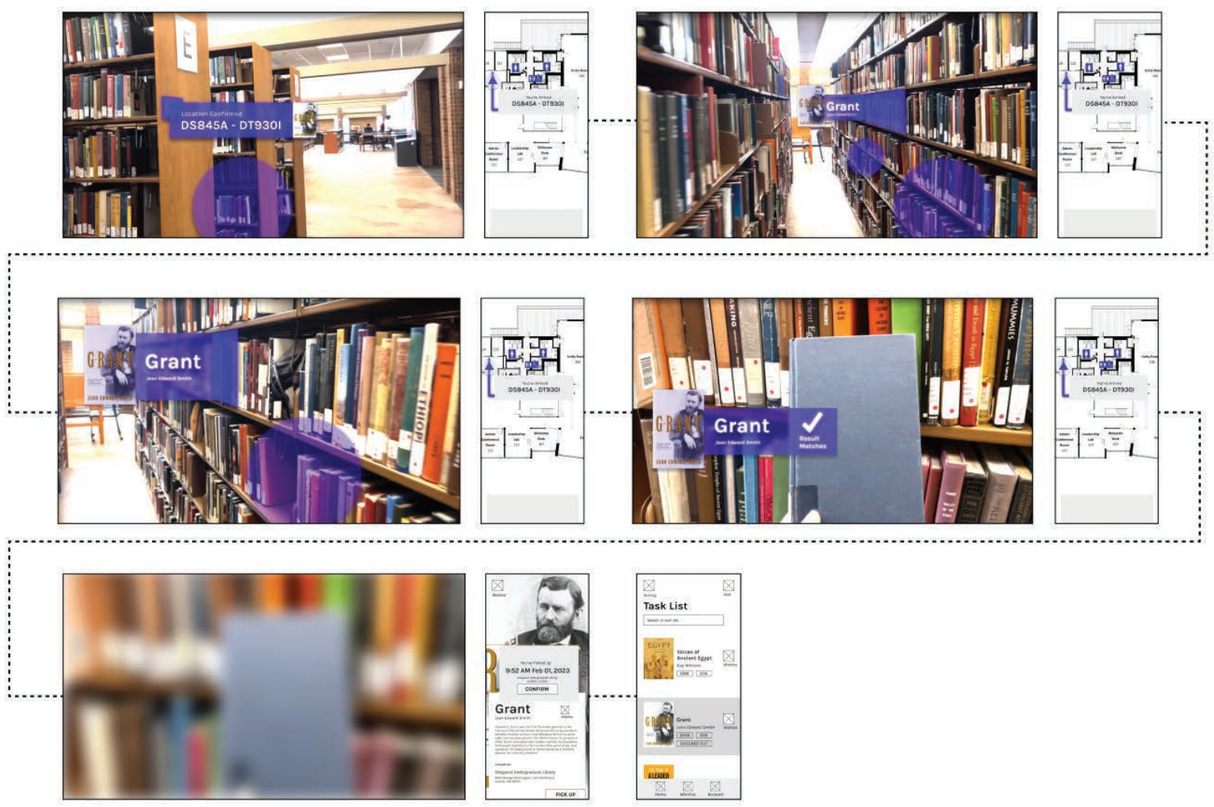
3.Smartphone + MR headset

By incorporating dual-platform interaction, I can leverage the strengths of both devices and enhance the system's flexibility. Based on the previous two explorations, I categorized the required interactions into three distinct types:

i. **Interactions between the user and the system:** Examples include activities such as logging in or out, agreeing to the system's policies, acknowledging licenses, configuring system preferences, completing user profiles, and more.
ii. **Interactions between the user and the environment (including the physical environment and objects):** Examples of these interactions encompass tasks like navigation, object recognition, object identification, route optimization, viewing objects in 3D, and other related activities.



Design exploration for the parallel scenario, Figma



Design exploration for the parallel scenario, Figma

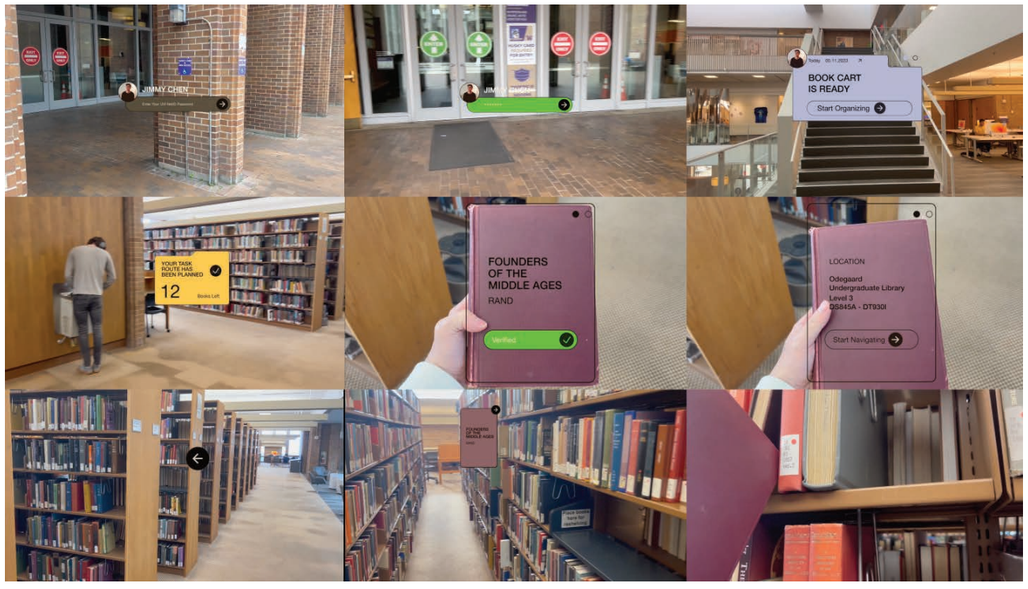
iii. **Interactions between the user and other users within the system:** This category includes interactions such as video conferencing, writing emails, making calls to contacts, setting up collaboration spaces, and other forms of communication and collaboration among users.

This categorization enables a comprehensive understanding of the different types of interactions required and guides the development of appropriate features. Furthermore, the key insight gained from the exploration is the importance of assisting users in managing their workload by allocating interactions to different platforms based on the specific interaction target. Interactions with the system itself can be more efficiently completed on a phone, as users often need to perform multi-step setups, read lengthy text paragraphs, and so on. During these tasks, users are less likely to engage in simultaneous activities, making the inclusion of MR capabilities less essential.

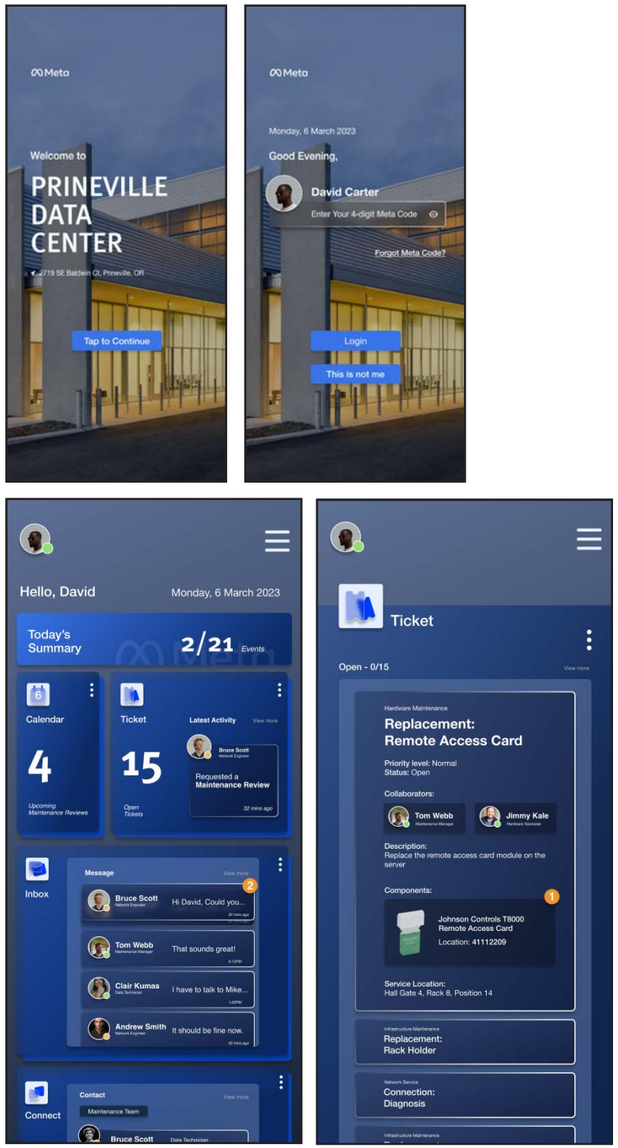
On the other hand, certain environmental and human interactions can benefit from a more fluid and immersive experience. For instance, drawing inspiration from existing design patterns, navigation can be redesigned in the MR space. By tailoring these design patterns to better meet the needs of users, the MR environment can provide a more effective and relevant user experience.

Prior to embarking on the final implementation of the artifact, I undertook one final step, which involved creating a brief concept video. This video aimed to provide a comprehensive walk-through of the entire user flow within the parallel scenario.

It's important to note that the intention of this one-minute video was not to showcase my vision of the future workflow for librarians to the public. Instead, it served as an internal assessment for me to evaluate the tools used for the production as well as the insights gained from all the preceding research, and condense them into the most suitable form for application within the data scenario.



A snapshot of scenes in the video, Adobe Premier



A snapshot of [Ticket] feature on mobile device, Figma

Designing for Data Technicians

My final deliverables consist of two components. The first part is a click through prototype in mixed reality (MR) that encompasses the features outlined in the information architecture. This prototype is designed to effectively support the various requirements encountered by data technicians in their daily work scenarios.

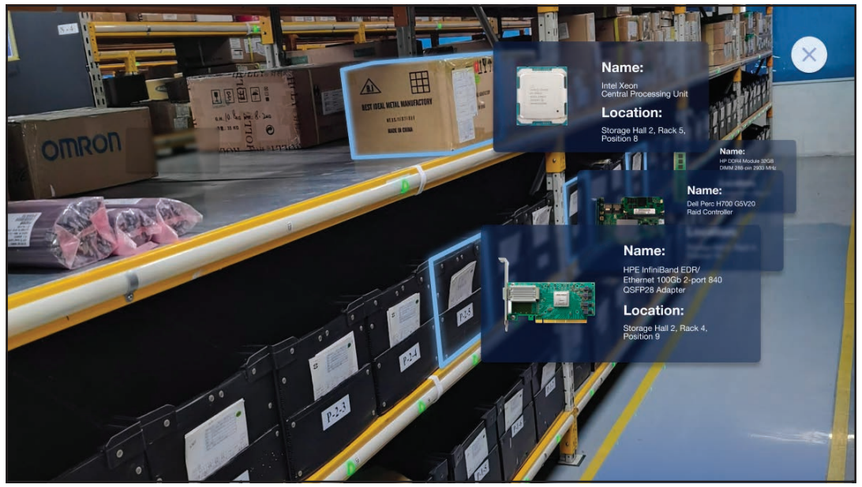
The second part aims to offer the general public an authentic experience of interacting with the environment. While it is interactive, it only represents a small fraction of the overall experience.

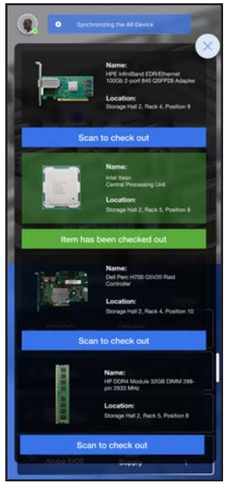
MR Prototype

[Ticket]

In contrast to the portrayal in the parallel scenario, within the data center environment, [Ticket] assumes a crucial role as the initial focal point of the entire experience. Data technicians have the ability to access comprehensive information related to the ticket in a single, consolidated view.

The boxes that encompass contact information and component details of other team members are transformed into buttons, which data technicians can click to access a more detailed view.



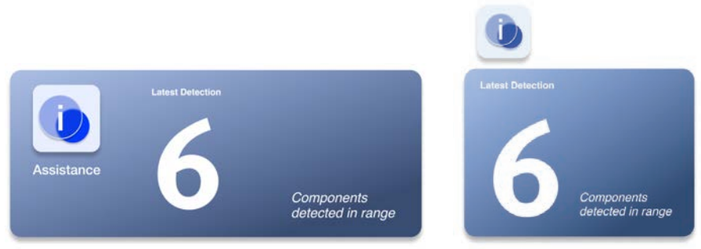


A snapshot of [Navigation] feature on mobile device, Figma

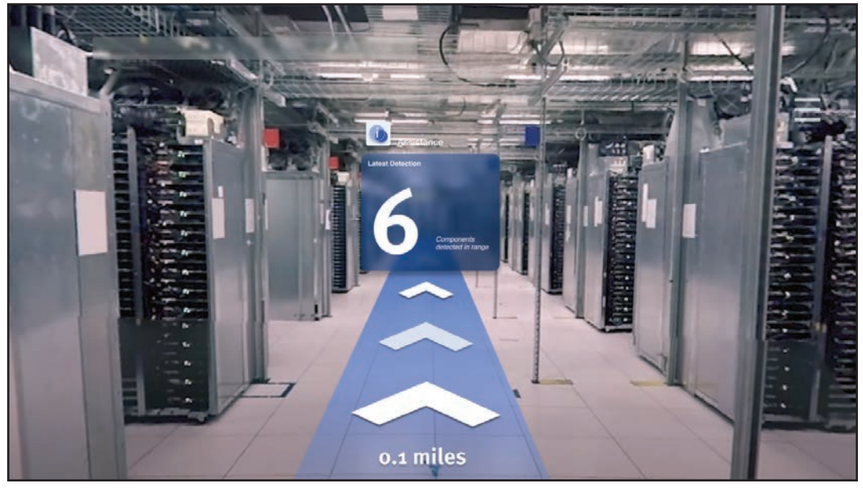
[Navigation]

Once the ticket is initiated, [Navigation] supports data technicians not only in finding their way but also in optimizing their routes. It provides suggestions to technicians when they are near locations they need to visit later. Additionally, it allows users the flexibility to utilize both devices. While engaging with the MR goggles, the mobile devices display a comprehensive checklist of detected surroundings, providing technicians with ample spatial information to enhance their efficiency.

Furthermore, the presentation of the suggestion box adapts dynamically as the technician moves. Our aim is to ensure that technicians are not obstructed by the overlaid information and remain well-informed while performing their tasks.



The presentation of the box adapts dynamically, Figma



A snapshot of [Navigation] feature on mobile device, Figma

[Escalation]
[Escalation] provides data technicians with the ability to connect with other teams within Meta. Due to the time constraints of the thesis project, [Escalation] was explored in two of the most common ways.

[MR conferencing] capability enables data technicians to directly connect with engineers, facilitating collaborative problem-solving for maintenance tasks. They can place an anchor and leave comments in specific locations, which will be overlaid on top of the object in the real-world environment. [Message] serves as another common communication tool that data technicians utilize for effective communication.

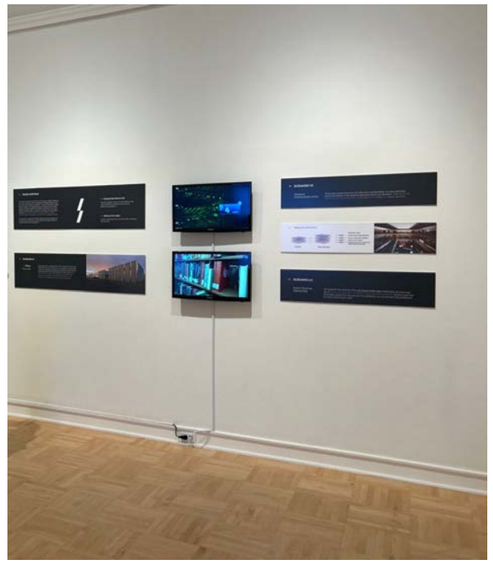
A snapshot of [Escalation] feature on mobile device, Figma

[Maintenance]
[Maintenance] will be selectively activated when the technician requires assistance, offering an optional function that won't constantly appear on the main view. This feature encompasses various aspects that facilitate the visualization of valuable information, including maintenance history, hardware status, and step-by-step guidance.

A snapshot of [Maintenance] feature on mobile device, Figma

Installation at The Henry Gallery

My exhibition at the Henry Art Gallery in Seattle, Washington, ,titled "Softplane," embodies the fundamental concept of my thesis. It not only serves as an introduction to my research topic but also documents my entire journey throughout the thesis process. The installation features three monitors that showcase the progression of my work, starting from the parallel scenario video, then moving to logic prototypes in Unity, and finally culminating in the development of a prototype with enhanced 3D model fidelity. This installation also serves as a reminder to visitors of the significant amount of effort required to develop an MR application. It pays homage to all the colleagues working in the field, recognizing their diligent efforts in advancing this particular field of study.



The installation in The Henry Gallery

Interactive Prototype

After completing the click-through prototype on Figma, I had a strong desire to explore the possibilities in actual application development. I chose to focus on a specific aspect of the experience, which is "object detection and feedback," as the basis for my prototyping. Before diving into Unity, I first established the fundamental logic that would simulate such interaction. We utilized the camera as the trigger for potential interactions. When the camera approaches a designated object within a specific range, the object is triggered and changes its color to green; otherwise, it remains grey. With this concept in mind, I began prototyping in Unity. The purpose of this prototype is to suggest a potential approach to enhance our current indoor navigation experience. Situated data is used to guide and inform the user, allowing them to only see the target. In environments where clear landmarks are absent, the colored object can serve as a crucial anchor, aiding the user in reaching their destination efficiently.

A snapshot of interactive prototype, Unity

DISCUSSION

Reflection

This thesis explores the significance and influence of Mixed Reality in scenarios anticipated in the near future, as well as explores the presentation of Mixed Reality across diverse platforms. Through the utilization of the Research through Design methodology, we created prototypes to investigate various design elements and gain valuable insights into scenario environments and user interactions. We developed an interactive prototype and speculative videos to enhance the existing information presentation, propose context-specific content visualization, and enrich the format of visualization.

As for my approach, it is important to acknowledge the limitations and drawbacks of creating a parallel scenario. While the user needs of data technicians and librarians may align to some extent, they differ significantly in terms of task complexity. Data technicians deal with artifacts and systems that are far more intricate and demanding. The complications and mental load associated with these tasks may significantly impact the visualization decisions I made based on the parallel scenario. Additionally, the influence of the physical environment is completely overlooked in the scenario I created. Factors such as noise levels, temperatures, and human densities can all have an impact on how information is perceived. By not accounting for these environmental elements, the design may not accurately reflect the real-world challenges faced by data technicians. Therefore, creating a parallel scenario is not an ideal or comprehensive design strategy. I chose to adopt this approach due to resource limitations and the need to make the best use of available resources to align with my envisioned goals.

It is crucial to recognize the potential shortcomings and limitations of this approach and to continue exploring and refining the design based on real-world data center environments and the specific needs of data technicians.

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