CollabXR: Bridging Realities in Collaborative Workspaces with Dynamic Plugin and Collaborative Tools Integration

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Figure 1: Cross-Reality Collaboration with CollabXR Integrated in Microsoft Teams – Left: User joining an immersive experience in Teams using a laptop; Middle: User participating in immersive collaboration via a tablet; Right: User accessing the collaboration through a WebXR-supported browser, adaptable for both VR and non-VR experiences.

Abstract

Hybrid meetings, often constrained by the limitations of videoconferencing, typically lack immersive and cohesive collaborative experiences, leaving participants feeling disconnected. Extended Reality (XR) technology counters this by enabling immersive spaces for both remote and co-located participants, thereby enhancing social presence, non-verbal communication, and educational experiences. As Mixed Reality (MR) platforms become more accessible, there is a shift towards cross-reality, platform-agnostic collaboration. However, this shift introduces unique communication challenges due to interaction asymmetries across different modalities. Addressing these issues, this paper presents CollabXR, an open-source framework developed using Babylon.js, WebXR, and Colyseus, specifically designed for the research community. CollabXR features a unique runtime plugin system for custom code and data integration and is seamlessly integrated with widely-used collaborative and communication platforms. It serves as a research platform for developing novel interaction techniques to facilitate cross-reality collaboration, overcoming communication asymmetries in scenarios where complete symmetry is unachievable.

Index Terms: Human-centered computing—Collaborative interaction—;——Human-centered computing—Virtual reality—

1 Introduction

Current hybrid meetings, heavily reliant on videoconferencing, often struggle to provide a fully immersive and unified collaborative experience. This leads to participants feeling disconnected from the shared space concept. Extended Reality (XR) technology offers a transformative solution by enabling both co-located and remote users to engage in shared immersive virtual spaces. XR brings a new dimension to these meetings, significantly enhancing interaction quality and participant engagement. Its impact on enhancing social presence and facilitating more natural forms of communication, such as non-verbal cues and gestures, represents a substantial improvement over traditional videoconferencing methods.

As Mixed Reality (MR) platforms become more accessible and require minimal setup, the trajectory of collaboration is shifting towards a cross-reality, platform-agnostic model. This transition highlights the need for seamless integration of XR technologies in collaborative settings, accommodating users across VR, AR, and traditional screen-based interfaces.

However, the inherent asymmetries in cross-reality collaboration pose significant communication challenges [12], disrupting the fluidity and effectiveness of interactions among participants using different modalities such as VR, AR, and traditional screens. To tackle these challenges, there is a pressing need for an open-source tool specifically designed for the research community. Such a tool would not only facilitate cross-reality collaboration but also enable the exploration of novel interaction techniques. These techniques are aimed at mitigating the impact of these asymmetries and enhancing collaboration and communication, especially in situations where complete symmetry is unattainable or unnecessary.

This paper introduces CollabXR, an open-source framework designed to facilitate cross-reality collaboration (Figure 1). Developed using Babylon.js, WebXR, and Colyseus, CollabXR offers functionalities akin to existing XR collaboration tools in the market, such as Microsoft Mesh, Spatial and Frame, by allowing users to add interactive content, including models and animations. However, takes a step further by introducing a runtime plugin system, which empowers users to augment the platform's functionalities with their own custom code and data. Furthermore, CollabXR leverages the Microsoft Graph API and Microsoft Teams SDK for seamless integration into Microsoft Teams. While the current implementation of CollabXR is integrated with Microsoft Teams, its flexible design also allows for adaptation to various other communication platforms, such as Zoom, Slack, and Discord. This integration enables both synchronous and asynchronous cross-reality collaboration, thus effortlessly blending CollabXR into existing workflows and enhancing the collaborative experience across various virtual environments.

2 Related Work

Extended Reality (XR) technology has revolutionized virtual meeting experiences by enabling co-located and remote users to engage collaboratively in shared three-dimensional virtual spaces. Immer-

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sive platforms hosting hybrid meetings facilitate a wide array of applications, ranging from remote assistance [8] and maintenance to business meetings [2] and collaborative projects [6]. Research has consistently highlighted the advantages of immersive meetings, especially in collocated environments. These benefits include enhanced social presence [11], improved non-verbal communication [4], and enriched educational experiences [13]. A significant factor contributing to these benefits is the medium's support for embodied communication and natural gestures [9].

Several commercial virtual meeting platforms support Head-Mounted Displays (HMDs) and desktop devices, including Frame [1], Spatial [10], Mozilla Hubs [7], and Microsoft Mesh [5]. These platforms offer functionalities conducive to virtual collaboration. Mesh, for instance, integrates immersive spaces within Microsoft Teams to facilitate interaction, co-presence, and enhanced immersion in a 3D digital environment. While sharing the goal of immersive collaboration with CollabXR, a key distinction of CollabXR is its open-source framework. This aspect significantly contributes to its adaptability and potential for innovation in cross-reality collaboration research. In addition, Ubiq [3], a Unity-based framework for Social Virtual Reality (SVR) systems, is aimed at research and educational applications. It offers features like customizable avatars, and voice chat, and supports multiple XR platforms, including desktop and web clients. While sharing similarities with CollabXR, CollabXR differentiates itself by its seamless integration into Microsoft Teams, enhancing its utility in current workflows. This integration makes CollabXR a vital tool for researching cross-reality collaboration in real-world settings, a focus that sets it apart from Ubiq's primary objectives.

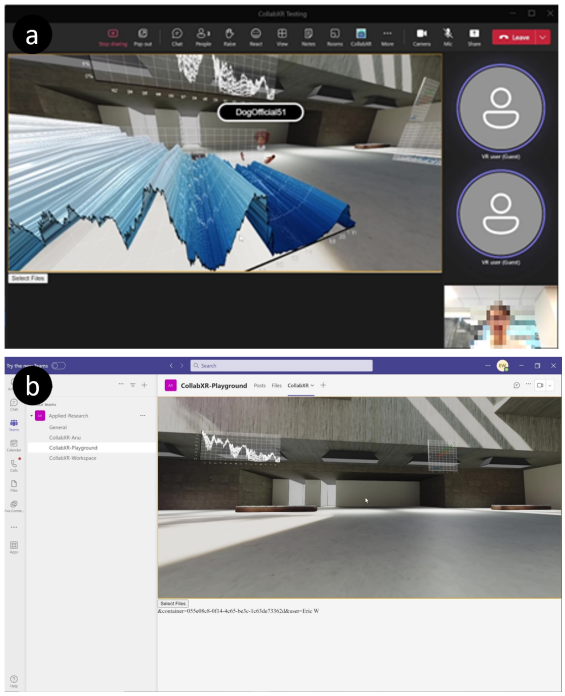

Figure 2: CollabXR Client as a WebXR App in MS Teams – (a) Meeting app interface. (b)Tab app interface for a Teams channel.

3 Design

The design of CollabXR is rooted in its innovative approach to enhancing virtual collaboration, seamlessly integrating into existing workflows and leveraging the latest in XR technology. This section delves into the two pivotal aspects of CollabXR's design that set it apart: its unique integration with Microsoft Teams for both synchronous and asynchronous collaboration, and its advanced runtime plugin system. Each aspect addresses specific needs in the realm of XR collaboration, contributing to CollabXR's versatility and effectiveness in a variety of collaborative contexts. We explore these design elements in detail, illustrating how they collectively shape a more efficient, flexible, and user-friendly collaborative environment.

3.1 Seamless Integration with Current Synchronous and Asynchronous Workflows

CollabXR introduces a versatile approach to collaboration within Microsoft Teams, offering its WebXR client app as both a Meeting app and a Tab app, as illustrated in Figure 2. The Meeting app (Figure 2 (a)) of CollabXR focuses on synchronous collaboration, allowing users to join the same immersive spaces for real-time virtual meetings. This facilitates dynamic interaction and decision-making in a shared virtual environment. On the other hand, the Tab app (Figure 2 (b)) supports asynchronous collaboration, where team members can individually access and contribute to the immersive space at their convenience, adding content or reviewing updates. This seamless transition between synchronous and asynchronous modes in Teams is essential for modern workflows and represents a key goal of CollabXR: integrating the potential of XR collaboration into everyday work processes. Though CollabXR is presently tailored for Microsoft Teams, it can be easily adapted for use with platforms such as Zoom, Slack, and Discord.

To cater to the varied needs of different meetings and projects, CollabXR enables the creation of diverse immersive environments and interactions. For instance, teams can use CollabXR for detailed 3D data visualization in project planning, immersive learning experiences in educational settings, or collaborative brainstorming sessions where team members can interact with virtual models or designs. Each of these environments can be uniquely tailored and associated with specific meetings or Teams channels, demonstrating CollabXR's adaptability to a wide range of collaboration scenarios.

3.2 Enhancing Customization with the Runtime Plugin System

CollabXR enhances the customization process in XR environments with its runtime plug-in system, addressing a common limitation found in many current XR platforms, as depicted in Figure 3. While platforms like Spatial and Mesh offer toolkits for building custom 3D environments, these typically require an offline approach. Users must write and compile scripts, upload or deploy the scene, and then restart the application to experience the changes. This process can be disruptive, especially during collaborative sessions.

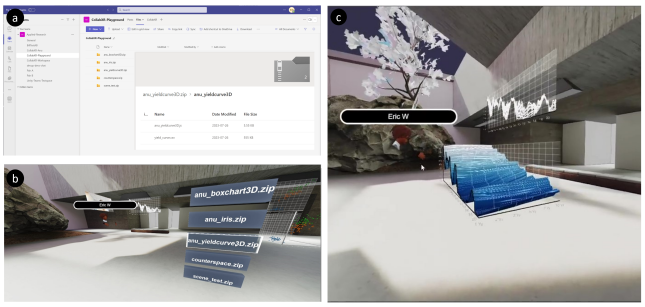

Figure 3: Overview of CollabXR Run-time Plugin – (a) Structure of the plugin zip with custom script and data, stored in a Teams channel; (b) Process of users selecting and CollabXR client app loading the plugin at run-time; (c) Execution of plugin code by CollabXR client app to display 3D visualization with custom data.

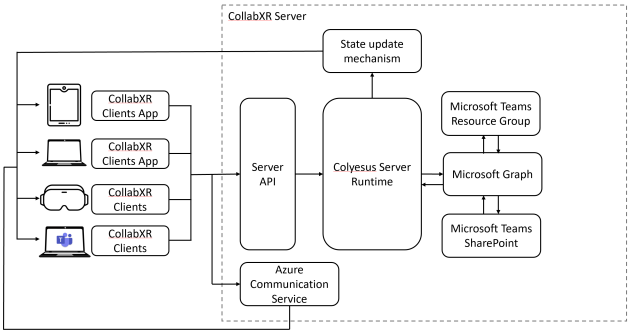

Figure 4: CollabXR client-server architecture

Consider a scenario where a team is engaged in an immersive collaborative experience and wishes to introduce a 3D visualization within a custom environment. Traditionally, this would necessitate restarting the application and rejoining the session, interrupting the workflow. In contrast, CollabXR's runtime plug-in system, shown in Figure 3 (a) as the plugin zip structure and in 3 (b) as the process of selection and loading, allows for immediate integration of custom scenes without restarting or reloading the application. The seamless integration, as demonstrated in Figure 3 (c) where the plugin code executes to display 3D visualization with custom data, ensures that the collaborative process remains uninterrupted, enhancing the fluidity and efficiency of the team's interaction. Moreover, this feature empowers users to rapidly add content or extend functionality during an ongoing session, adapting to varying needs and dynamics of the collaboration in real-time. Such flexibility and responsiveness are crucial in dynamic and fast-paced collaborative environments, making CollabXR a valuable asset for XR collaboration.

4 System Implementation

CollabXR adopts a client-server architecture, leveraging Babylonjs, Colyseus, and Azure Communication Service to facilitate multiuser WebXR experiences, complete with avatars and voice chat functionality, as shown in Figure 4.

4.1 CollabXR Server: Synchronization and Integration

In the server-side architecture of CollabXR, the system employs Colyseus, a versatile open-source multiplayer framework. Integrated with Node.js, Colyseus uses WebSocket communication to effectively synchronize the real-time state of virtual environments and avatar movements, ensuring a consistent and unified experience for all participants.

Additionally, the CollabXR server incorporates the Microsoft Graph API, which is instrumental in retrieving relevant Microsoft Teams information. This includes data about the teams a user belongs to, the current channel they are on, and their meeting status. With this information, the CollabXR client can dynamically load appropriate immersive experiences tailored to the user's current context in Teams (Figure 5).

For voice communication and camera functionality within the XR collaborative space, CollabXR utilizes Azure Communication Service. This integration allows for seamless voice chat and visual presence, vital components for effective communication and collaboration in XR settings.

4.2 Client-side WebXR application

In the client-side architecture, CollabXR employs Babylon.js, a sophisticated web-based 3D engine, for rendering its immersive virtual environments. This powerful tool ensures high-quality visualization

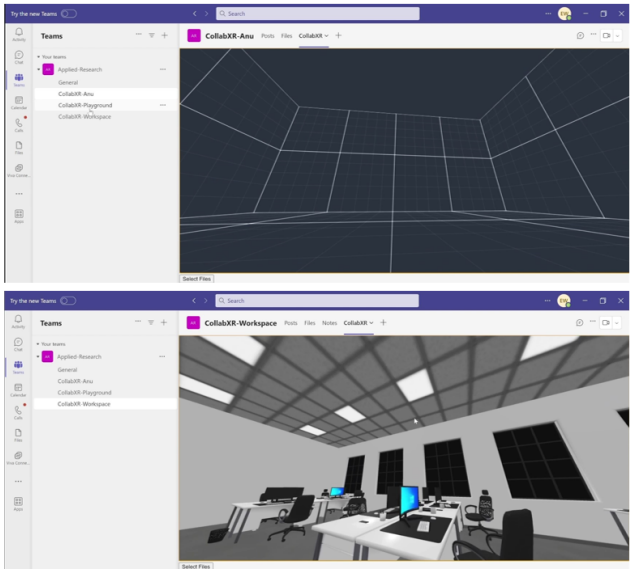

Figure 5: CollabXR Customization for Teams Channels, demonstrating tailored immersive experiences per channel.

of avatars and interactive virtual objects, utilizing WebGL or WebGPU for efficient 3D content rendering. Babylon.js facilitates the creation of essential XR interactions, including navigation, pointing, and object manipulation, thus providing an intuitive interface for user engagement within virtual spaces.

Further enhancing its versatility, CollabXR is built on the WebXR platform, enabling cross-platform functionality. This design choice ensures compatibility across a range of devices, offering users a uniform experience irrespective of their hardware choice. For avatar integration, CollabXR supports the Ready Player Me Avatar, providing a diverse range of customizable avatars suitable for various user preferences.

Integration with Microsoft Teams is achieved through the Microsoft Teams JavaScript client library (TeamsJS). This integration allows CollabXR to operate seamlessly as either a Meeting app or a Tab app within the Teams environment, aligning with typical workflow processes and enhancing user accessibility. While integrated with Microsoft Teams, CollabXR's design allows for easy adaptation to various platforms.

The runtime plugin system in CollabXR represents a significant advancement in customizability and dynamic content integration. Plugins, delivered as zip files, consist of data and custom JavaScript scripts that leverage Babylon.js for the development of personalized immersive experiences. This system enables users to incorporate custom models, animations, and XR interactions, akin to traditional Babylon.js usage. Network synchronization for interactive objects is managed dynamically through a predefined meta-object format, which simplifies the synchronization process by allowing users to specify synchronized properties with custom metadata.

When loading these plugins, the CollabXR client app processes and executes the included JavaScript modules directly, obviating the need for app reloads. This approach not only maintains the continuity of the collaborative experience but also allows for real-time updates and modifications within the virtual space. As new objects are introduced via plugins, their properties are dynamically synchronized based on their metadata, ensuring seamless integration and interaction without necessitating server-side code modifications.

5 Conclusion

In conclusion, this paper has demonstrated how CollabXR, an innovative open-source framework, addresses the pressing needs of modern hybrid meeting environments. By leveraging the capabilities of Extended Reality (XR) and Mixed Reality (MR) technologies, CollabXR overcomes the inherent limitations of traditional video-conferencing, offering a more immersive and unified collaborative experience. Its unique runtime plugin system allows for extensive customization, enabling users to tailor the platform to their specific needs with custom code and data.

The integration of CollabXR with Microsoft Teams highlights its practicality and relevance in current workflows, making it a valuable tool for both synchronous and asynchronous cross-reality collaboration. CollabXR's current Microsoft Teams integration does not limit its compatibility, as it can be modified for other communication platforms. Through this framework, we have provided a solution that not only enhances social presence and communication in virtual spaces but also addresses the communication asymmetries that arise in cross-reality interactions.

Looking ahead, the potential for CollabXR extends beyond its current capabilities. The platform lays a foundation for further research and development in the field of virtual collaboration. Future work could explore more advanced interaction techniques, deeper integrations with other platforms, and broader applications in various fields such as education, healthcare, and enterprise training. CollabXR stands as a testament to the evolving landscape of collaborative technologies, offering a glimpse into the future of how we connect, share, and engage with each other in virtual environments.

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6 Disclaimer