Metaverse and blockchain based 3D-2D interfaces for improving agile teams communication

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Abstract

Distributed and hybrid Agile teams often encounter communication challenges that risk psychological safety and collaboration quality. To this end, this study investigates how contemporary metaverse and blockchain technologies can support the enhancement of virtual Agile meetings in terms of communication and emotional awareness. Here, we propose a 3D-2D interface to simulate Agile meetings incorporating real-time affective conversational analysis, blockchain-based identity management, and visual indicators. Early insights suggest that visualizing conversational tone and emotional states may help reduce negative communication patterns and enhance awareness of collective well-being. These insights indicate that such a socio-technical framework has the potential to contribute to effective communication and psychological safety in distributed Agile teams.

Keywords

Psychological Safety, Metaverse, Agile, Blockchain

ACM Reference Format:
Andrea Pinna, Maria Ilaria Lunesu, Xiaofeng Wang, Xiaozhou Li, Samuele Mannai, and Gianni Fenu. 2026. Metaverse and blockchain based 3D-2D interfaces for improving agile teams communication. In *1st International Workshop on User Interface and Experience for Software Engineering (UISE '26), April 12–18, 2026, Rio de Janeiro, Brazil.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3786169.3788395

1 Introduction

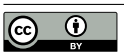
Agile software development relies on a set of well-established practices that facilitate collaboration, communication, and coordination among team members. These practices, such as daily stand-up meetings, retrospectives, sprint planning, and pair programming, foster the frequent and structured interactions that are critical to the agile value. Historically, such interactions rely on co-located teams with informal meetings that support knowledge sharing and collective problem-solving. As teams become hybrid or distributed maintaining active and proactive communication and interaction becomes more difficult, posing a risk to psychological safety and software quality [25]. Psychological safety is broadly defined as a climate in which people are comfortable expressing and being themselves, meaning the condition in which team members can speak openly, admit mistakes, highlight a problem, and take risks without fear of negative consequences. Several studies link it to team effectiveness and software team performance [1, 9, 21]. Remote and hybrid work, in addition to complicating team coordination, alters the rhythms of interaction and requires the use of mediated channels that can erode psychological safety by amplifying misunderstandings, perceived isolation, interruptions, and reluctance to speak [4, 15].

Completely digital workspaces realized in persistent 3D virtual worlds (i.e., the metaverse) partially help solving this problem because they enable more realistic meetings via avatars and allow recreating agile rituals through scene-integrated tools [6, 26]. Blockchain-based virtual worlds are strongly connected with the concepts of wallet and smart contract, ideal for managing digital identity, accessing control, and visual recognition of the people involved in the meeting [11, 12, 18]. However, little attention has been paid to the study of interfaces and 3D scene elements aimed at improving communication and psychological safety [21]. Because remote environments amplify barriers to open communication and collaborative problem solving, it is necessary to evaluate which socio-technical interventions can help rebuild and preserve psychological safety in remote teams [1].

In this work, we introduce research on 3D and 2D interfaces to maintain and improve communication and psychological safety within blockchain-based 3D scenes during rituals in agile meetings.

Specifically, the purpose of this research is to study which interfaces and virtual interactive tools could effectively improve the quality of conversations and interactions between team members. To this end, two research questions will be investigated.

RQ1. *Which interfaces and virtual elements best exploit the characteristics of the metaverse and blockchain to improve communication and psychological safety in virtual team meetings?*



UISE '26, Rio de Janeiro, Brazil

ACM ISBN 979-8-4007-2401-5/26/04
https://doi.org/10.1145/3786169.3788395

RQ2. *Which indicators and visualization methods better help maintain psychological safety without compromising trust or creating new sources of insecurity?*

Herein, we design and implement a blockchain-based 3D-2D interface that integrates an immersive virtual meeting environment with real-time affective conversational analysis. Various in-scene tools will be evaluated for their effectiveness in assessing team psychological safety, answering RQ1. Meanwhile, an integrated system will be used to evaluate multiple approaches to embed multidimensional real-time indicators of psychological safety and communication within the 3D scene, answering RQ2.

The remainder of the paper is organized as follows. Section 2 reviews the literature and background for related topics. Section 3 presents the architecture of the system and explains the workflow. Section 4 outlines the experimental design. Section 5 concludes the article.

2 Communication of agile teams in virtual immersive environments

Effective communication represents a foundational value of Agile software development that influences nearly every aspect of team performance and project outcomes. Many studies have shown that team communication quality is a significant factor that affects team dynamics, productivity, and effectiveness [13, 23]. Teamwork communication has been explored in depth in literature, with an emphasis on constructive listening , mutual support, and acknowledging others' interests and achievements [7, 16, 24]. The effect of the tone of voice as well as the playful manner of a team leader is also highlighted [5, 19], which influences the general mood and serenity of the team members. Communication is more effective if team members feel free to express their concerns. Various tools have been developed to help analyze team moods based on interactions and communication methods. The widespread use of artificial intelligence (AI) represents a valid alternative in this case, with tools that analyze both verbal and nonverbal communication among agile team members [14]. In addition, virtual assistants can automate the creation of summaries of Scrum ceremonies via large language models (LLMs) [2].

2.1 Agile processes monitoring and communication

Monitoring and controlling agile projects are essential practices that help maintain alignment with project goals, manage risks, and address emerging issues. While agile methodologies promote self-organizing teams and adaptive planning, consistent monitoring ensures that the iterative process remains goal-oriented and responsive to change. Common visual management tools include burn-up and burn-down charts to track project progress and Kanban boards with work-in-progress (WIP) limits to visualize workflow and identify potential bottlenecks. Automated tracking systems further support task assignment and progress control. The flow and tasks management, as well as changing requirements, sometimes have an emotional impact, especially in agile teams that try to meet the different needs of customers and developers. Several studies analyze the emotional states of team members. For example, the Emotimonitor tool (a Trello power-up) enables team members to express their emotions using emojis, helping the team leader to remain aware of the developers' well-being [10].

2.2 Agile virtual and ephemeral teams

Since their birth, agile teams have been defined as "small , co-located and self-managing groups [16]. With globalization and the diffusion of the Internet, virtual teams emerged [8, 20]. A trend accelerated by the pandemic [3, 17]. Managing virtual and distributed teams includes isolation and communication barriers due to geographical, temporal, and cultural distance. Lack of face-to-face interaction can impede relationship-building, leading teams to adopt informal social practices [22, 23] and collaboration tools (e.g., virtual meetups, stand-ups, Kanban boards, messaging tools) to preserve Agile principles and coordination. Ephemeral teams are temporary groups that include highly specialized developers hired to address specific tasks or, in the Scrum framework, for only one iteration or slightly more. This kind of organization is becoming more common in hybrid and modern startup contexts where flexibility and speed are crucial. In virtual meetings, due to language barriers, cultural differences, and connection issues, a new member of an ephemeral team often prefers not to show their face or to remain silent for fear of saying something incorrect, so they may remain a complete stranger, even if they belong to the same team for weeks or months. In the metaverse [26], it is certainly easy to feel like you share the same environment and belong to the same group in a place where the user's body language, gestures, and posture all become part of communication. Additionally, blockchain technology can help manage team membership and identity[12]. However, the need arises to measure the quality of communication in virtual environments and the, so to speak, well-being of individuals who act in teams for a common purpose, helping participants to become aware of unhealthy conversational patterns (related to engagement, empathy, politeness, and conversational balance) and potentially correct their behavior.

3 Interactive 3D-2D interface for the near-real time evaluation of the conversation in virtual meetings

The proposed system aims to study the impact of virtual tools and 2D interfaces to overcome communication obstacles between members of a team who meet remotely in virtual collaboration and improve psychological safety. It integrates a blockchain-based 3D collaboration environment with real-time affective and conversational analysis tools to enhance communication quality among remote software development teams.

3.1 Proposed architecture

The architecture is conceived to provide a feedback loop that continuously captures, analyzes, and visualizes the emotional and conversational state of the team together with the current state of the project and the work done. Having many visual elements on screen and near real-time feedback may increase mental effort, distract people during Agile meetings, or encourage over-monitoring and overly self-conscious behavior among participants. To reduce these risks, the system design must focus on showing aggregated, team-level information instead of individual data so that no one feels

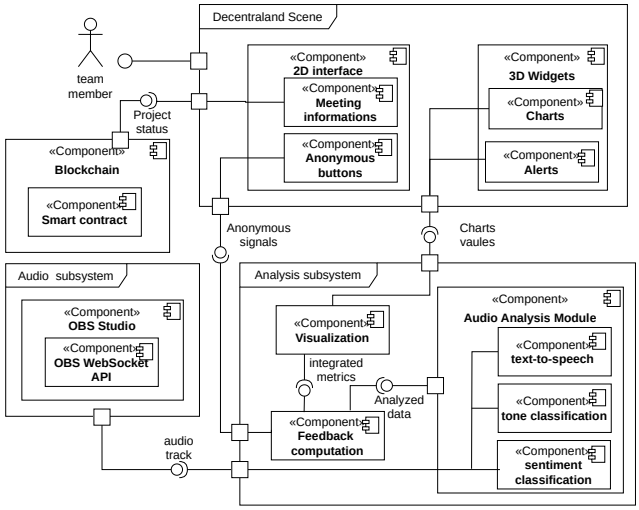


Figure 1: UML component diagram of the architecture.

Figure 2: A preview of the 3D-2D interface.

The 2D interface describes the current status of a project and the team member assignments. It also includes a button for expressing discomfort during the meeting. The 3D interface includes elements demonstrating the development process and the quality of a conversation, updated automatically and in real time.

singled out or judged personally. Emotional and conversational metrics are updated in such a way as to avoid excessive reactivity and moment-to-moment scrutiny. It is composed of four subsystems: the 3D Scene including the 2D interaction interface, the audio capture component, the conversation analysis subsystem, and the blockchain component. Figure 1 represents main components of the architecture and their interconnections.

Decentraland 3D Scene: The collaborative workspace is implemented using the Decentraland SDK[1]. It serves as the shared virtual environment where avatars interact naturally—speaking and can collaborate around visual artifacts such as Kanban boards, project dashboards, and emotional radar charts. The elements in the scene update dynamically to reflect the current tone and engagement levels of the conversation. For example, a collective drop in empathy or a rise in tension is instantly shown through color changes or shifts in the radar chart. A 2D interface consists of a persistent overlay that appears within each user's view. This interface provides personal and team state indicators (e.g., role progress, contribution balance) and interactive controls for direct input, including an anonymous "discomfort" button, which lets users signal unease without disclosing their identity. Figure 2 represents a view of the 3D-2D interface during an Agile meeting.

Audio subsystem: Conversations within the scene are captured in real time using dedicated open-source software such as OBS Studio, configured with the OBS WebSocket API for automated data streaming. The audio of all active avatars is transmitted to the analysis back-end.

Analysis subsystem: It includes components to perform the analysis of the conversation and manage scene elements in near-real time. Audio Analysis Module to perform speech-to-text conversion and tone and sentiment classification with transformer-based models. This subsystem calculates conversational metrics (turn-taking, dominance, and politeness) and produces feedback data (emotional metrics with anonymous discomfort signals).

Blockchain subsystem: The blockchain subsystem supports persistent digital identity, verifiable and traceable project information, access control, and privacy guarantees within the shared virtual environment. Identity and project traceability are secured using blockchain technology. Each team member is associated with a decentralized identifier, stored on a compatible blockchain such as Ethereum and Polygon. Smart contracts manage project information, updates, and verifiable records of collaboration without exposing personal data. This layer ensures trust and data integrity across work sessions.

3.2 System workflow

The workflow is based on the following steps.

(1) Interaction in Decentraland: Team members meet and interact as avatars within the 3D scene resembling a workplace. The integrated 2D interface displays project progress and data related to the single participant. The participant uses the interface to send direct feedback, such as anonymous distress signals.
(2) Audio Capture: The audio stream is securely transmitted to the analytics backend in near real time.
(3) Analysis: emotion analysis, distress signals and interaction data from the 2D interface are synchronized and processed to calculate composite "conversation state" metrics.
(4) Visualization: Aggregated metrics are sent back to Decentraland to update the emotional charts and project dashboards in quasi-real time. The integrated 2D interface adapts dynamically.

3.3 Proposed Experimentation

The experiment phase aims to elicit answers for our research questions. In particular, which elements of the scene and for which conditions the following hypotheses are supported:

[1]The chosen 3D collaborative environment is Decentraland (https://decentraland.org/), a metaversal system based on blockchain technology.

H1: Agile teams using the system show improvement in communication satisfaction and psychological safety.

H2: The emotional charts and radar in the scene reduce the persistence of negative conversational tone during the meeting.

H3: Anonymous feedback from the 2D interface corresponds with measurable downturns in sentiment, validating their role as early indicators of team discomfort.

The study will involve 3 to 5 Agile software teams, each comprising 5-9 members. During the experimental phase, selected teams will conduct their regular meetings within a specific configuration of the experimental environment. Participants will first complete standardized questionnaires that serve as a baseline for the evaluation. At the conclusion of the experimental phase, the same set of psychological safety and communication surveys will be re-administered to all participants. Psychological safety will be assessed using consolidated tools, such as Edmondson's Team Psychological Safety Scale [21]. Additionally, questions aim to capture qualitative insight regarding:

- Perceived improvements in emotional awareness.
- Comfort and trust in anonymity features.
- Usefulness and interpretability of the elements in the scene (tone graph, emotional radar, and more).
- Cognitive load and usability of the system

4 Conclusions

This paper presents the conceptual framework and preliminary results of the research on a 3D-2D interface to support distributed Agile team collaboration via immersive virtual environments. The proposed system integrates metaverse interaction and blockchain-based identity management to improve team communication quality and psychological safety. The architecture incorporates dynamic 3D scene elements that deliver near-real-life feedback on conversation tone and project progress. These are automatically rendered by the scene engine based on input from the analysis subsystem, which uses audio tracks and text analysis. The study demonstrates the importance of emotional awareness and trust-oriented collaboration in Agile teams. The findings suggest that such interface design and integration can pave the way for effective and trustworthy remote teamwork practice within the next-generation virtual software development environment.

Acknowledgments

This work was partially supported by the project SERICS (PE00000014) under the MUR National Recovery and Resilience Plan, funded by the European Union–NextGenerationEU. This work was partially supported by project AISAC, Italian Ministry of Enterprises and Made in Italy (MIMIT), within the "ACCORDI PER L'INNOVAZIONE" (2021–2026) under Grant CUP: B29J23001120005 – COR: 1607797

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