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Design of a Peer-To-Peer Network Framework for the Metaverse

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Abstract: This study aims to work out a peer-to-peer (P2P) network framework for real-time communication in the metaverse. The P2P network framework is designed specifically for the needs of metaverse launching on ordinary personal computers (PCs). It takes advantage of the P2P protocol to distribute data transmission, processing, and analytics on both client and server sides. The primary features of the solution can provide low-cost, high-quality, and decentralised web connections among multiple users. The innovative solution fulfils the needs for (1) scalability, (2) telecommunication, and (3) comprehensive data analysis in the metaverse. Future work is to deploy the framework in a practical context and progressively optimise the connection quality according to the activity specification of metaverse activities.

Keywords: A peer-to-peer (P2P) network framework, metaverse, telecommunication, data analytics, decentralised web connections

1. Introduction

One of the key features of the metaverse is to enable synchronous connection among multiple users synchronously (Tang et al., 2022). The client-server network framework heavily depends on the web server which may cause server overload and unstable connections. Nevertheless, the network frameworks are hard to scale up due to their high cost and the limited capabilities of servers (e.g., Queries Per Second, Transactions Per Second). The peer-to-peer (P2P) network protocol is widely applied in the online game industry to achieve a higher quality of synchronous and stable web connection (such as the Unity Multiplayers tool) (Kanazawa & Takami, 2018). However, currently, many metaverse platforms have adopted traditional client-server network frameworks, consisting of a server and many clients, such as Gather town, Minecraft, Roblox, VRChat, and World of Warcraft. There are fewer platforms in the metaverse industry making use of the P2P network framework in the metaverse. In view of this, this study aims to develop a P2P network framework as a low-cost, synchronous, and decentralised solution for the metaverse. It can support (1) scalability (2) telecommunication, and (3) comprehensive data analysis in the metaverse.

2. The P2P network framework

2.1 Design of the P2P network framework

The P2P network framework consists of server and client-sides to realise low-cost, high-quality, and decentralised web connections among multiple users (refer to Figure 1). Data transmission, processing, and analytics are designed to be distributed on both server and client sides. On the server side, a web server with Laravel platform in PHP script will be provided as the processing centre for comprehensive AI behaviour analysis. On the client side, the Unity Multiplayer tool as the P2P framework is adopted to realise the decentralised and real-time telecommunication among clients.

The Unity Multiplayer tool framework provides automatic optimisation to maintain the quality of telecommunication among users. Mainstream metaverse platforms adopt the client-server framework to let web servers act as coordinators. All data streams will go through their web servers to update the status of virtual worlds. However, If the connection between a client and the web server is unstable, it may cause the failure of display or interactions. The P2P framework enables each client to be the node in the routing map regarding their connectivity to each other. A client with good connectivity with others will be the node to collect and upload data of multiple clients and submit it to the server-side for comprehensive analysis. The system can automatically identify the best routing solution to build real-time connections among all the participants.

The server performs timely processing, and the processed files will be sent back to the host through files with timestamps, and the host will then send the processing results to other members through the P2P network. In addition, using the P2P network framework, users own their behavioural data and analysis results.

The analysis results will be stored on the user's device by default, and the user can access them locally. Also, if a client agrees to submit his or her tracking data to the server, the users as nodes can submit the raw behavioural data to the server each 10 minutes interval. If the client agrees to share their behavioural data for comprehensive analysis, a copy of the data will be sent to the server. After the data analysis is completed, the system will delete users' data from the server. Also, the client can open the dashboard to view the latest analysis results or historical records at any time.

Additionally, this framework is decentralised and stored on the client side as default. Users can decide whether the data will be shared and what data will be uploaded to the web server. Compared with the traditional client-server network framework, the P2P framework gives clients choices in advance to protect their privacy.

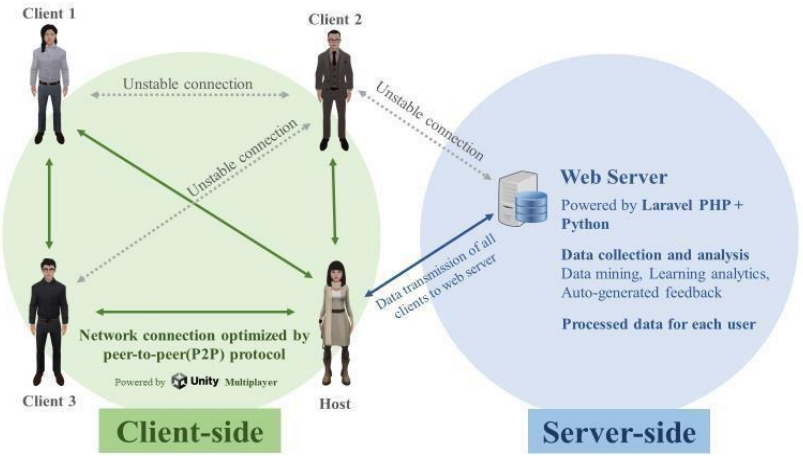

Figure 1. Design of the P2P network framework

Users can create public or private virtual spaces. (Refer to Figure 2). In the same virtual space, each user synchronises data through the P2P network (such as name, avatar image, location information, avatar pose information) (Refer to Figure 3).

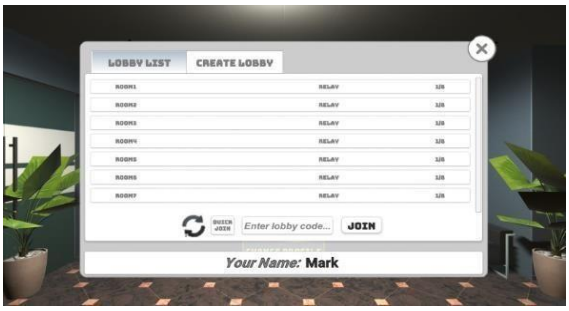

Figure 2. The interface of a multi-user lobby.

Figure 3. An example of P2P network framework-supported interactions among clients in the same virtual space.

2.2 Features of the P2P network framework

Using the P2P network framework has advantages over the traditional client-server network framework regarding (1) its low cost without a large amount of data processing on the web server; (2) supporting flexible routing rules to optimise the connection quality among multiple users automatically; and (3) decentralising the design so that users can obtain the ownership of their data and data sovereignty lies with users.

3. Advantages of the framework

The advantages of the framework can be summarised in three aspects. First, the solution can lower the threshold of the deployment of an analytics system, making real-time analysis possible. Second, the solution protects users' data privacy. The solution enables users to use the platform using the P2P network framework anonymously. Third, the solution protects users' data ownership. Data ownership refers to the possession and responsibility for data (Hummel et al., 2021). The solution allows users to decide who can be entitled to access and use the user data.

4. Future work

Currently, the P2P network service is mainly designed for video or audio chat with a uniform and consistent data flow to transmit among clients. In a metaverse context, various activities may happen randomly with different combinations. Simply and frequently conducting a global refresh will cause high consumption of system resources, which may affect the performance of the metaverse. Thus, finding an efficient and flexible data processing and packaging solution is vital to realise partial (not global) refresh in the metaverse. Future work is to deploy the framework in a practical context and progressively optimise the connection quality according to the activity specification of metaverse activities.

Acknowledgments

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