




The Research of Metaverse Application in Intelligent Railway Passenger Station

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Abstract. As an emerging concept, the metaverse has received a lot of attention and is now being researched for applications in many fields, including industry, education, healthcare, cultural tourism, and the construction industry. An enhanced intelligent passenger station architecture is proposed in China for railway passenger stations, which promoting the development of the metaverse application in Intelligent Railway Passenger Station (IRPS). To provide a theoretical support for the development of metaverse application in IRPS, the technology architecture of the metaverse railway intelligent passenger station is proposed, and the metaverse application in IRPS is designed, which lays the cornerstone for further intelligent development of China's high-speed railway.

Keywords: Metaverse · Intelligent railway passenger station · Intelligent railway · Application design

1 Introduction

In the novel 'Snow Crash' [1], the Metaverse concept was first proposed, which is a parallel world in information space aligned with real space. In the Metaverse, people build their playmaker, Avatar, that creates value that can circulate in the real world. In recent years, the COVID-19 pandemic has enormously impacted people's lives, and the metaverse makes it possible to solve the problem. For the features of the Metaverse, such as permeation, interactivity, anytime, anywhere, low latency features, and so on. It enhances the traditional industries' evolution. In this paper, based on the previous studies of Intelligent Railway Passenger Station (IRPS), the technology architecture of the Metaverse in IRPS is proposed. The metaverse application in IRPS is designed to promote the intellectual development of IRPS in information space that extends the temporal and spatial scale of Intelligent Railway.

The Metaverse is a technology gathering that includes 5G communications, cloud computing, digital twins, artificial intelligence (AI), blockchain, and expanded reality

technologies [2, 3]. The signature of the metaverse is immersion, interactivity, any-time, anywhere, and low latency. A virtual environment of the metaverse based on the actual physical world that incorporates real-world economic, social, and entertainment activities and allows for multi-user participation in its creation [4].

The Metaverse advances industrial automation [5]. BMW is building a virtual factory with Omniverse to pre-build digital models before building cars. Production efficiency by about 30% [2].

The combination of metaverse and education [6] can enhance physical practices in the schooling process, improve the efficiency of participatory activities, enhance daily sensory experiences, and provide technical support for the construction of virtual learning communities, gamification, and personalization of teaching and learning, contributing to revolutionary changes in education.

Metaverse is exploring applications in the medical field [7], emerging in several aspects of medical prevention, diagnosis, treatment, and medical education. The health metaverse is one of the innovative solutions to address the global healthcare challenges that usher in a profound digital transformation of the worldwide healthcare system.

Metaverse is highly consistent with the genes of cultural tourism activities, cultural tourism development needs, and development paths [8]. During the COVID-19 pandemic, the metaverse will promote the development of film and animation, game experience and interaction, performing arts content and presentation effects, digital operation of large festivals and exhibitions, protection of cultural and tourism resources, intelligent tourism, and other aspects.

The potential application scenarios of a metaverse in the construction field [2]. In the design stage, the metaverse can provide a space for communication in the virtual world, build a virtual design plan model, and break through the space limitation of communication; in the construction stage, preview the construction process and complete the verification and adjustment of complex engineering construction plans; in the operation and maintenance stage, use the metaverse virtual space to expand the functions and operation and maintenance; and conduct virtual construction transactions in the virtual area.

Even though the metaverse application is exploratory, the current research results show that the metaverse technology can promote the progress of many fields. The metaverse technology lowers the cost, promotes efficiency and precision rate, expands the spatial scale for many domains, and provides interaction beyond time and space. With the development and maturity of metaverse technology, it is bound to carry a new qualitative leap in many fields.

2 The Technology Architecture for the Metaverse of IRPS

In China, the IRPS concept was first proposed in 2017. Meantime, the “1 + 4 + N” master plan was constructed [9], where “1” means a brain, “4” includes passenger service, station management, safety, and green, and “N” means numerous applications in the railway station. Development until 2021, the concept of an enhanced intelligent railway passenger station was proposed by the continuous research of cyber-physical and digital twin technologies in IRPS. The Enhanced IRPS realizes the convenient travel of passengers [10], Seamless self-service, an efficient organization of production, secure real-time

monitoring, green and eco-friendly, through building the fully interconnected physical station and fully mirrored digital twin station for physical-information mapping fusion, total sense simulation, real-time monitoring, precise diagnosis, deducing the state of a predicted physical entity in a real-world environment. The analytics platform layer of The Enhanced IRPS's overall architecture compose by the platforms of data aggregation and sharing, controlling and collaboration linkage, intelligent service, cloud computing, digital twins, internet of things, big data analysis, and other platforms.

The metaverse incorporates various new information technologies such as 5G communications, edge computing, digital twins, artificial intelligence, blockchain, and virtual/augmented reality [11]. The metaverse forms a virtual world in information space that is identical and independent of the real world [4]. The railway metaverse covers the entire society-physics- cyberspace of railway transport and makes rail transport transcends the limits of time and space, which advances the opening of the railway with additional socioeconomic advantages.

The basis on the platform of the enhanced IRPS, Metaverse technology can be realized in railway passenger stations, and The Technology Architecture for the Metaverse of IRPS is as follows (Fig. 1).

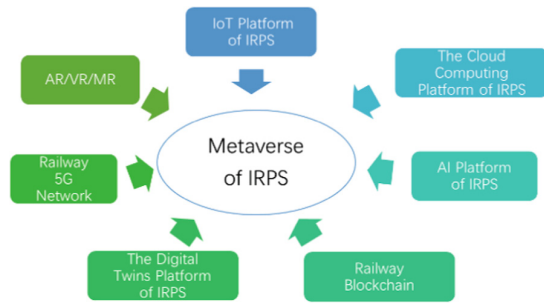


Fig. 1. The technology architecture for the metaverse of IRPS

The IoT platform of IRPS collects information from the real world, which supports connecting the virtual world IRPS and the real world IRPS. The cloud computing platform of IRPS provides powerful computing capabilities, which make the end devices lighter. The AI Platform of IRPS includes big data analysis and AI algorithms, which determine the metaverse application in IRPS and how smart it is. The Railway blockchain supports the metaverse application in IRPS economic system, ensuring the safety of the virtual identity and assets of metaverse users and ensuring the legitimacy of transactions. The digital twins Platform of IRPS establishes a digital mirror of some railway station, realizes the full mirror of the real world to the virtual world, and provides a basis for the virtual primary metaverse, the virtual-real symbiosis, and the virtual-real linkage of the railway intelligent passenger station. The Railway 5G Network is a channel for the metaverse to provide low-latency, high-speed, and large-scale access, providing users with a more real-time and smooth experience. AR/VR/MR technology offers an immersive metaverse experience, allowing users such as travelers and staff to interact with virtual objects.

3 The Design of Metaverse Application in IRPS

Many digital twin stations have been preliminarily constructed in IRPS. On this basis, the application of the metaverse in IRPS is designed, including Virtual Humans, passenger service, passenger transportation, Safety & emergency response, energy management, comprehensive transportation hub, and so on (Fig. 2).

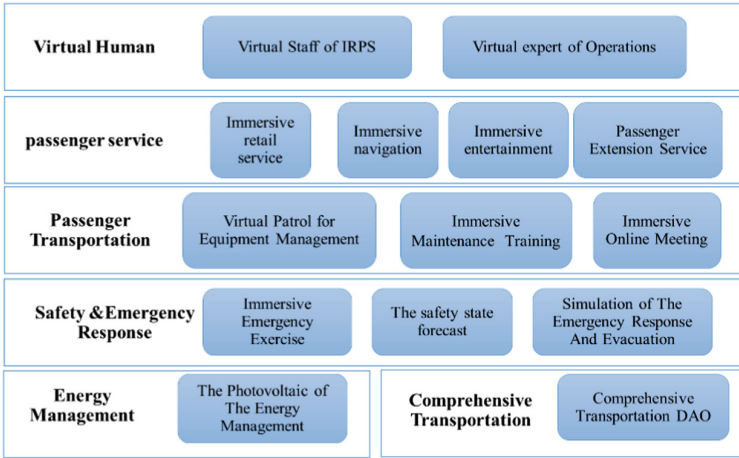


Fig. 2. The design of metaverse application in IRPS

3.1 Virtual Human

Virtual Staff. The virtual staff in IRPS can provide passengers with inquiry, ticketing, and other services through an intelligent inquiry machine, ticketing-integrated service terminals, station-integrated service desks, and other equipment. When passengers encounter problems at the station, the virtual staff in IRPS can provide remote assistance. To ensure safety, the virtual staff in IRPS also offer services on the platform, such as the location service of the train compartments and intruder alarms. The Virtual Staff in IRPS can also provide uninterrupted 24 h of service, with high stability, concurrency, and work efficiency. With the development of a front-projected holographic display, the service for locating train compartments may be replaced by this one to make the sign clearer and more prominent (Fig. 3).

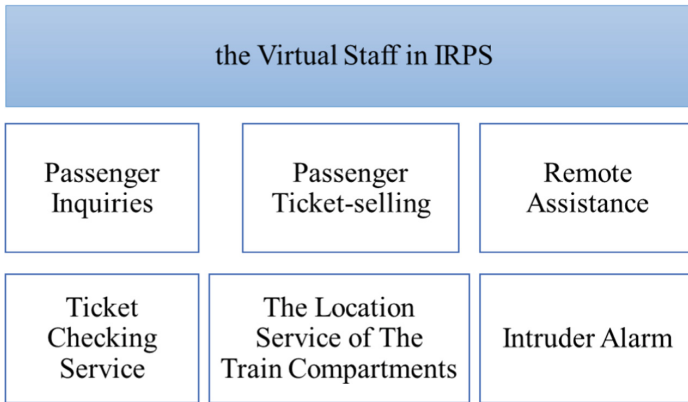


Fig. 3. The virtual staff in IRPS

Virtual Expert. The Virtual Expert of Operations in IRPS provide service that includes technology consulting, system diagnosis, regular check, failure detection, operating maintenance, automatic backup, and so on. The Passenger Service and Production Control Platform is the core of IRPS. For the knowledge base management system, the Virtual Expert of Operations provides 24-h uninterrupted maintenance services for platform users (Fig. 4).

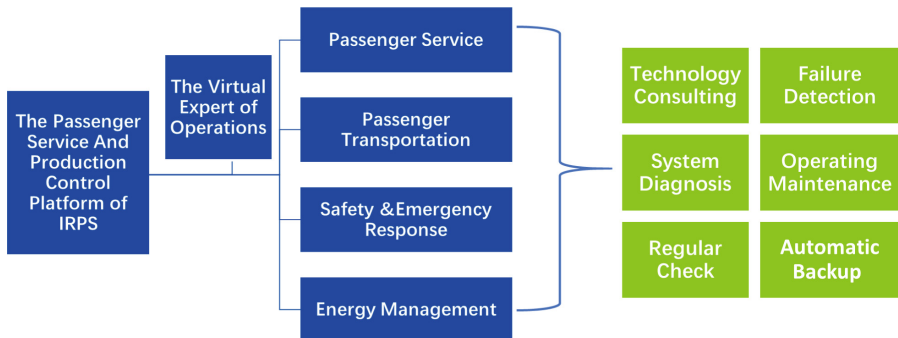


Fig. 4. The virtual expert of operations in IRPS

3.2 Passenger Service

The Passenger Service in IRPS provides Immersive navigation so that users can faster grasp the environment information, such as retail store service desk, restroom, and ticket barrier. Virtual Retail offers a new channel for buying specialty products without physically entering a store while waiting. Immersive entertainment provides interactive e-books, immersive movies and animations for children in the Baby Care Room station. Passenger extension services include cloud tourism, digital collections of railway

stations, railway cultural and creative products, station sandbox games, management games, and online station exhibition galleries.

3.3 Passenger Transportation

The Passenger Transportation in IRPS consists of virtual patrol for equipment management, multi-professional joint inspection, remote control and operation and maintenance of equipment and facilities, immersive training, and online meetings. Virtual patrol for equipment management offers a new channel for inspection equipment without physically walking through the station and provides multi-disciplinary maintenance and remote control of the equipment. Immersive training places staff in an interactive learning virtual environment to teach particular skills such as train scheduling and fire-fighting. Immersive online meetings offer a cyberspace room for anyone anywhere, such as a station, train, or bureau. Participants can get their facial expressions during the conference through the avatar as if they were communicating face-to-face.

3.4 Safety &Emergency Response

The Safety &Emergency Response in IRPS consists of an immersive emergency exercise, the state prediction of security, and simulation of the emergency response and evacuation. Immersive emergency exercise offers a new way for participants to practice their skills by handling a pre-created virtual disaster such as widespread delays, fires, floods, earthquakes, or some other disasters. The participants are able to rescue passengers in the disaster after completing each step as planned. The safety state forecast shows the dynamic outcome of changes in rail transport. Immersive emergency response and evacuation simulation can improve emergency response capabilities at passenger stations.

3.5 Energy Management

By retrofitting existing station canopies and roofs to allow for photovoltaic power generation. Use blockchain technology to record proof of electricity generation and consumption. We are enabling the management of the entire lifecycle of the station's photovoltaic power resources based on multi-party consensus and tamper-evident nature. Promote carbon neutrality at railway stations. Issuance of a station passenger carbon neutral token exchange service, which rewards different amounts of tokens depending on the amount of electricity consumed, to be exchanged for more welcoming station train services.

3.6 Comprehensive Transportation Hub

As the value of digital assets continues to emerge, railway passenger stations, as data generators and holders, rely on their strengths to form station data industry ecologies. It can create a Decentralized Autonomous Organization (DAO) together with subway, air, bus, and taxi. We research the user portrait within the organization to provide accurate and personalized services.

4 Conclusions and Future Works

Based on the previous studies of Intelligent Railway Passenger Station (IRPS), we analyze the commonalities between the metaverse technology and the development direction of IRPS, and the technology architecture of the metaverse in IRPS is proposed. And we designed the metaverse application in IRPS, including virtual humans, passenger service, passenger transportation, safety & emergency response, energy management, comprehensive transportation hub, and so on. in information space to extend the temporal and spatial scale of Intelligent Railway, the metaverse technology promote the intelligent development of IRPS. But the research of the Metaverse technology is just getting started, especially in the security protection of information. We will focus on it in the follow-up study.

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