Deriving Improvement Plans through Metaverse Technology and Implications

Jeonghee Hyun[1], Hanyong Choi[2], Jaesaeng Kim[3]

*Abstract-*Metaverse-based technology and its service area become wider through online environment and virtual reality. In the Metaverse space where the virtual I and another virtual person can interact each other in the virtual reality, we are already playing games and performing education and presentation, etc.. To enable such VR activities, converged ICT technology is needed. Something in common between Metaverse and Virtual reality is to experience in the VR environment. The main characteristic of virtual reality is the experience in the perspective of first person and that of the Metaverse is that there is interaction each other in the perspective of diverse persons. As it is being extended to X-Metaverse where the boundary of Metaverse disappears expanding to diverse fields, in this paper, it is intended to suggest ideal Metaverse construction method and improvements through major technologies and characteristics in building X-Metaverse and diverse application fields and cases.

Keywords: Metaverse, VR, AR, Platform, AI

1. Introduction

Recently, as the non-face-to-face service becomes important by the COVID-19 pandemic situation, Metaverse is caught attention. In the real world, the virtual world appeared as IoT and cloud technologies were being developed, and as Big Data and AI technologies were developed, automation and AI were developed. In here, as the extended reality is added, Metaverse appeared. Metaverse is the compound word of Meta (virtual, transcendence) and universe and refers to 3-dimensional virtual space [1]. This term appeared in 'Snow Crash', American SF novel' by Neal Stephenson in 1992 for the first time [2]. Recently, as the non-face-to-face conference, work from home, non-face-to-face education become routine, new Metaverse ecosystem is formed such as production of digital contents, profit creation, asset transaction, etc. in the meta-space. In the Metaspace, we are already experiencing various games, education and presentation, etc. that the virtual I and another virtual person can interact. To experience Metaverse VR activities properly, ICT technologies such as the computer performance, communication technology, Bog Data, artificial Intelligence (AI), cloud,

security, etc. should be developed converging each other. In addition, as Metaverse platform requires powerful constraints on the user experience, high speed network, response time and delay time, to materialize them, diverse technologies are required. The something in common between Metaverse and virtual reality is to experience in the virtual reality environment. Metaverse is being developed applied to diverse fields such as manufacturing field, medical care, interior, education and national defense, and diverse technologies and platforms are competing. Therefore, as Metaverse platform is extending to diverse fields such as marketing, game, education, medical care, etc. and X-Metaverse where the boundary of Metaverse disappears, in this paper, the major construction technologies and platforms required to be extended to X-Metaverse are examined and the application cases in diverse industrial fields will be contemplated.

2. Concept and Policy of Metaverse
2.1 Concept of Metaverse

Metaverse is the compound word of Meta, which means 'transcendence and beyond that,' and the universe, and

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[1]*Kimpo University, Kimpo, Korea*
ORCID: 0000-0002-6660-905X

[2]*Shinhan University, Uijeongbu, Korea(Corresponding author**)*
ORCID: 0000-0002-7207-299X

[3]*Kimpo University, Kimpo, Korea*
ORCID :0000-0002-9125-7711

[2]*Corresponding Author E-mail: hychoi@shinhan.ac.kr*

refers to the virtual world transcending the reality. The term 'Metaverse' appeared in 'Snow Crash', the American SF novel by Neal Stephenson in 1992 for the first time. As a concept appeared for the first time in this novel, Metaverse in the novel 'Snow Crash' is a virtual computer world and contains the contents that make the impossible rule and life possible in Metaverse including all the lifestyles in the real world. In the meantime, recently, it is defined as a world where the virtuality and the reality are coevolved interacting each other, in which the social, economic and cultural activities are made creating the value and is defined as an 'Extended virtual world' emphasizing the virtual converging technology (XR: extended reality) like virtual/augmented reality (VR/AR) [3]. In addition, as shown in Table 1, Metaverse is defined differently by each author, and although there is slight difference depending on the author, it has something in common in the fact that the activities possible in the real world are connected and are influencing each other in the virtual world, too.

Table 1. Various definitions for Metaverse [4]

A space for various cultural, artistic, social, and economic activities such as games, communication, and commerce through avatars
Augmentation and utilize objects in real space. or, Virtual space where you can do activities related to reality through avatar
3D virtual space that combines virtual space with reality
Virtual space where the boundaries between the real world and the virtual world have disappeared
A life type, game type virtual world where virtual world and reality world coexist in various fields(e.g politics, economy, society, culture) of the real world
Expanded reality space that aims for human communication and allows you to enjoy real and unrealistic experiences

That is, Metaverse can be considered as new converged form of world made by combining the space in reality with the immersive technology. Metaverse as a derivative reality has interoperability, continuity that the diverse actions can be made through one avatar, presence that is made without physical contact, simultaneity that multiple users are connected and the characteristic of goods-based economic flow at the same time [5]. In addition, Metaverse is recognized as new platform beyond the virtual world as it is engaged with the diffusion of COVID-19, distribution of 5G, extended technology (XR), etc. simply in the functional perspective based on the basic concept of internet which integrates each service.

2.2 Major Policy
At this point, the reasons why the interest in Metaverse is increased and spread to various fields are as follows.

First, as the technologies such as virtual reality (VR), augmented reality (AR), 5G, blockchain, etc. are being developed, the ability to materialize the virtual world is improved rapidly. Especially, it is important that not the technology is advanced but also the service in the form that they are converged appears earnestly. In terms of concept, the concept of immersive economy3 is getting spotlighted as new economic trend in 2019. As the importance in utilizing the virtual space through Metaverse is being increased, the investment and the service to improve the technology related to Metaverse are being accelerated by country. Among then, XR technology is, basically, the core technology that provides the interaction. XR is the mixed technology that calls collectively VR, AR, etc. and converged with Metaverse most actively. For the development of XT technology, which is the foundation of Metaverse, the future development plan is suggested by the country through the active support policy and the major contents are as shown in Table 2.

Table 2. Major XR-related Policy by Country [6]

Country	Description	Details
Korea	Organization of Metaverse Alliance	- Started as follow-up measure of Virtual Convergence Economy Development Strategy (Dec 2020) - Share technology trend, review legal system maintenance plan, discover and plan Metaverse platform
	Metaverse Hub	- Joint discover and plan the inter-business tasks related to Metaverse - Select the strategic Metaverse area and support the growth of business - Support virtual convergence service production, test and demonstration
	XR industry support and Promotion of XR convergence	- Direction to foster the private driven virtual convergence economy development foundation
United States	Utilization of public sector's XR support accomplishments	- Support and Utilize diverse XR technology development - Support XR-based education and training program development in the fields of national security, social and safety fields around Ministry of National Defense, Department of Homeland Security, Ministry of

		Education, etc.
Great Britain	Mid- and long-term XR technology development	- Designate XR as 4 big digital core technology - Promote the immersive technology through local cluster support and the XR industry development through creation of local industry synergy
China	Fostering XR industry customized for local government for creation of new industry	- Central Government: XR expansion policy to foster strategic emerging industry - Local government: XT industry fostering policy (Utilize XR for technology development strategy such as digital economy development, educational innovation, 5G, Big Data, etc.)
Japan	Develop and Utilize XR technology for realization of Society 5.0	- Include AI, IoT, VR · AR technology in 'Society 5.0' Strategy - Support AR · VR R&D cost and contents production business and prepare the technology Utilization guidelines

3. Major Metaverse-based Technology

For the most basic element technology among diverse basic technologies to construct Metaverse, it requires the diverse technologies such as reality-related technology like VR/AR/MR/XR, platform, network, etc, the characteristics of each technology will be examined in each clause.

3.1 VR/AR/MR/XR [7]

Virtual reality refers to the case that the virtual object exists in the virtual environment realized by computer and is to enter into a new world being immersed in it by blocking the surrounding environment of user. User equips the display device on the head and uses the contents blocked from the real world. Virtual reality technology includes software development kit, game engine, 3D scanning technology, etc. 3D design engine can develop the visual elements through the game engine or animation tool, etc. Augmented reality is the technology that allows viewing the digital data such as voice, image, text, etc. overlapped on the screen through the devices like special glasses and smart pads. It is the technology to create the space where the actual reality and virtual reality interact by synthesizing the virtual object or information using the GPS device, which transmits and receives the position information and geographic information, and the gravity [7]. Augmented

reality is materialized mainly by smart phone APPs or through See-through devices having form of glasses such as MS HoloLens, Varjo XR-3 HMD, etc. Varjo XR-3 can combine the real world and the virtual world exquisitely using video pass through method having low delay time. Mixed reality refers to the intermediate stage between virtual reality and augmented reality. It is the technology combining only with the advantages of AR and VR and it materializes the better virtual world by converging the information of reality with the vituality. For example, in the virtual world of user, it converge the human five senses information such as sense of vision, sense of touch, sense of smell, auditory sense and can interact. Extended reality (XR: eXtended Reality) refers to the combination of real-virtual worlds and human-machine interaction by the computer technology. As a concept extended from MR, it allows touching the virtual object in the real space with hand by reinforcing the interaction between reality and virtuality. For example, there is a case that putting the conference data on the digital space and sharing that information when non-face-to-face conference. It can be utilized when simulating in the education or training, medical care, manufacturing, and defense industry. If "XR-3 HMD", the device exclusive for AR and MR, is used, user wearing HMD can experience the 3D contents with higher sense of reality and immersion level.

3.2 Metaverse Platform

Metaverse platform grants the immersion as if the users can communicate freely without separate procedure, can develop his/her own contents (avatar) without difficulty with good user interface and communicate actually with people [7]. Since Metaverse platform requires the powerful constraints on the user experience, high speed network, response time and delay time, to materialize it, various technologies are required. In terms of infrastructure, 5g or edge computing are the most important technology. No matter what device the use uses in Metaverse such as smart phone, PC, VR devices, etc, it should make all users to see and feel the same world at same time. Metaverse platform appears in diverse professional fields such as 3D game industry, entertainment industry, manufacturing, distribution, finance, real estate, education, etc. Metaverse platform currently used the most is Roblox, Zepeto, Minecraft, Mesh, etc. [8]. As shown in Figure 1, Roblox allows the user to make a routine life through the game and avatar in the game and the communication within Metaverse and the user can develop the game contents easily. It is the platform where the user can create 3D virtual space by himself, enjoy Metaverse in real-time and can develop and sell Metaverse items, and the virtual currency "Roblox" is being used [9]. Zepeto, which is made by

Naver Z, possesses 300 million subscribers as of 2021 and the members of 7 ~ 18 years old, the Z generation, are 80%. It has contents that user can play diverse culture, business and daily life as game and can communicate with other member in Metaverse. It allows creating the profits by the goods sales, contents processing and production activity, etc and investment and collaboration with the global fashion company and domestic entertainment company are possible. This platform is the 3D avatar-based social network service and the user can produce the items by him/herself [9]. Gathertown is the video conference platform for the virtual space communication made by a startup in the United States. It provides the virtual office environment and video conference function and generates the avatar for the user and performed the conference using tools in Metaverse space. It links the video conference system reflected with real image, collaboration tool, multimedia, etc. Besides them, diverse platforms by industrial field such as Minecraft, Mesh, Omniverse, Starline, Horizon, etc. are being developed.

3.3 Network and High Speed Computing Technology

To share the information in the remote working environment, the super high speed network technology like 5G having the characteristics of super-high speed, super-low latency, hyper-connectivity, etc. is required. 5G network has higher data transmission speed than 4G LITE cellular network, its latency time is reduced greatly and the range to transmit and receive the information between the terminal and the base station was expanded to remote area. These characteristics can process Big Data quickly, allows the multiple users to participate at the same time and can provide large contents. In addition, it became main technology to make Metaverse age earlier together with the non-face-to-face environment due to COVID-19. Amazon announced 'Wavelength', the edge computing service, which can provide the 5G super-low latency transmission application and Microsoft and AT&T provide 'Network Edge Compute' (NEC) service to the corporate clients [11].

3.4 Security Technology

If Metaverse is commercialized and the users are increased, the users in Metaverse environment generate new types of information such as habit, activity pattern, etc. During the Zoom meeting, user account information leakage, microphone or web-cam hacking, zoom meeting screen seizure (Zoom bombing or Zoom trolling) occurred. The security control technology against such information leakage is required. Among the activities made in Metaverse environment, the most important activity is economic activity. As the contents having

economic value in the economic activity are gradually being increased, the contents, which become the security subject, will be increased than the real world. The contents security can be classified mainly into authentication and the security for contents information. In Metaverse, the security is required to protect not only the user information but also to protect the virtual ownership of the user. As all the information in Metaverse is stored in the authentication information, the security for personal information is important [11]. Diverse security technologies on the combination of non-fungible Token (NFT) technology and Metaverse are essential. Since NFT is important transaction asset linking block chain technology with Metaverse and real world and refers to the technology granting the ownership to the digital contents such as music, image, drawing, etc.

3.5 Cloud Technology

In the IoT, the equipments generate Big Data exchanging the data each other through the sensors without human intervention and Big Data are processed in real-time through Cloud service. The business assigns the information asset to Cloud operator without storing them by itself and can use them through network if necessary. As such, as all the data are concentrated in Cloud, Metaverse is being developed rapidly [12]. Netflix, which launched <Squid Game>, transferred all the data to Cloud-based datacenter of AWS to provide the video service to the people around the world without traffic congestion. As a result, the number of streaming service members was increased 8 times and the amount of TV viewing for 8 years was increased 1,000 times. Microsoft introduced Cloud Azure Digital Twins, which connects the real world and virtual world to the IOT-based technology and can manage and develop the product by tracking diverse environment variables. Doosan Heavy Industries & Construction is operating wind power generation environment having optimal efficiency by recording and tracking the climatic environment systematically including wind and temperature. Besides them, domestic cloud businesses such as KT, NHN, etc. are competing in the public cloud services.

3.6 Internet of Things (IoT)

As the non-face-to-face remote working environment is being expanded due to COVID-19 since 2020, The Great Digital Leap Forward, which AR/VR-based Digital Twins utilizing IoT was converged with existing traditional industries, occurred. The industrial sites are meeting with mixed world that can monitor and control in real-time in the real world and virtual world by connecting the products and the system with IoT. IoT

model can be classified into connection type, intelligence type and autonomous type. Connected the objects to internet, in the connection type, the objects can monitor surrounding environment and transmit its results and control the objects remotely through monitoring information. In the intelligence type, objects transmits the surrounding information to the cloud and can analyze, diagnose and make decision intelligently. In the autonomous type, the objects communicate and collaborate each other autonomously having intelligence and can perform the tasks with minimum human control.

3.7 Artificial Intelligence (AI)

In Metaverse virtual world, the new world where the technical potential of AI can be exerted freely can be made freely and the new value can be created by augmenting Metaverse. In the virtual department store or store, AI-based agent that identifies the preference of client can recommend the must-have item (space) to the user. AI agent can inform the client of recent new products or recommend the clothing for client's avatar. Interacting diversely with AI engine in Metaverse, the user can expand the lifestyle. Omniverse is 3D collaboration tool and 50 thousand users such as engineer, designer, etc. already perform diverse collaboration projects. For example, if Al design agent can make the user to prepare the design proposal quickly or can support the cartoon aspirant to make animation production easier, the opportunity to perform the project effectively and efficiently is increased [13]. NFT is the asset of Metaverse but can be extended to intelligent NFT through the advanced technology of AI. Alethea (AI) launched the intelligent NFT Robert Alice (image), which replies when asked. Furthermore, as the conversation between two NFT is possible, it will be caught great attention only with new type of podcast [13].

3.8 Big Data Analysis and Utilization Technology

In Big Data analysis and utilization technology, the text mining is the technique to analyze the unstructured data composed of text. Representative analysis methods are word cloud analysis, topic modeling analysis, time series analysis, etc. Topic modeling analysis is the algorithm that identifies the relation among the words in the document and analyzes what keywords are there. This is the method to extract new issues and online review analysis, and is applied to diverse fields such as user experience identification [14]. Connected with Lifelogging closely, Metaverse 'Lifelogging' stores its routine or experience or put on record and uploads it on Facebook, Twitter, Instagram, Vlog on YouTube, etc. In the medical field, by lifelogging the heart rates, blood pressure, activity level, etc. of the wearer with smart

watch every hour continuously, the health condition of wearer is identified and predicted, through which the user can receive the prescription by sending accumulated data remotely to the doctors. In Instagram, user can make the pictures posted constantly as Big Data and send the advertising customized for user, and teenage user can analyze the teenager trend based on the data lifelogged constantly by teenage user. Unmanned store 'Amazon Go' records the behavior pattern of consumers from the beginning to end through AI monitoring camera and stores as Big Data. Big Data gathered as such can be learned by AI or utilized for other fields.

3.9 Blockchain

Blockchain and NFT (non-fungible Token) in Metaverse perform the role of digital currency. In Metaverse, the blockchain technology is the technology that does not store the transaction details in the central server but stores the transaction details in the computer of the clients by distributing it. At the same time, it increases the security by applying the encryption technology and to prevent the forgery and alteration, it should guarantee the ownership and transparency of the transaction. The user owns the item or contents within platform linked with cryptocurrency utilizing the NFT technology and can transact freely. Since blockchain technology records and store all these data permanently, the property of the user can be kept even the game would be disappeared. 'Smart Contract' of blockchain is the technology to perform the transaction automatically when it satisfies the specific condition without intermediation. The game company can earn the users' trust through blockchain technology and the user can convert the virtual asset (cryptocurrency) grafted with blockchain technology to legal tender in Metaverse. [15]. Second-hand trading platform 'Durian' proceeds all the transactions through blockchain and accumulates 0.1% of the transaction amount to the seller and buyer as Durian point, which can be changed into cash by selling then in the exchange where MACH token is listed. The blockchain cryptocurrency 'Chiliz' provides the contents related to the sports and the entertainment including e-sports by converting it to NFT.

4. Metaverse Utilization Case

Currently, Metaverse is being extended to diverse fields including manufacturing, medical care and education as shown in Table 3 [6]. There exist fields that reached to the level utilized enough in the field work from the experimental fields yet. As such, diverse Metaverse utilization cases are deemed to be expanded to all fields without limitation of Metaverse utilization method and application range depending on the growth and construction method shown in Chapter 2.

Table 3. Metaverse Utilization Field and Application Case [6]

Description	Major Detail
Manufacturing	- Improvement of job efficiency and safety protection of field worker - Facility operation, location guidance, provision of disaster and safety management information, AR remote collaboration service, etc.
Education	- Provision of safe and immersive education experience - Virtual campus, VR mock interview, XR utilization experiment and practice, etc.
Medical Care	- Medical training and rehabilitation treatment support -Attending remote operating room, medical training solution, VR rehabilitation treatment solution, etc. - Operation of smart operating room (identification and simulation of operating position by realizing the patient condition virtually)
Distribution	- Online product promotion and provision of shopping information customized for client - Establishment and operation of cyber branch - Arrangement and option change of AR products, immersive space solution utilizing VR, etc.
National Defense	- Save training cost and secure safety - AR·VR-based virtual training system building

4.1 Manufacturing Industry Field

'Digital Twins' technology that copies the physical objects and real space to 3D digital world is to install the twin manufacturing factory same as automotive manufacturing factory in real world in the 3D virtual space. Hyundai Motors introduced the 'Meta-factory' concept and made diverse virtual scenario tested anytime and anywhere even though the user does not present in the manufacturing site. Unity Software Inc. and Hyundai Motors announced to build 'Smart Factory' in the real space, which is the digital virtual factory 'Meta-Factory', in the real-time 3D Metaverse platform through the strategic business agreement entered in CES 2022 [16].

4.2 Medical Field

In the clinical care, Metaverse makes 3D virtual patient by materializing the patient information with VR and AR technologies. In the psychological disorder area, the patient receives the addiction or depression treatment drawing a picture and playing the play in the environment that he/she would come to the hospital in Metaverse space. In the eye treatment area, Metaverse analyzes the data of the patient wearing 3D virtual reality device using AI analysis and test algorithm, judges the eye health condition and provides the customized eye care service with the solutions such as Metaverse game, etc. Seoul National University Bundang Hospital performed the smart operation for lung cancer operation using Metaverse technology. The attendees establish their avatars and enter to operating room like playing game. They can see the operating surgeon and operating nurse as same as real through the $360°$ -8K-3D camera and can see all the environment of operating room as much as they want. In Metaverse, the environment that the attendees are in actual operating room is provided [17].

4.3 Interior Field

Archisketch Inc. launched the 3D Interior Recommendation Service "SEESOOP" grafted AI with Metaverse. It provides the service that can arrange the furniture and home appliances in 3D in advance utilizing the digitalized home drawing in the virtual reality. People can arrange diverse furniture and appliances in virtual space. AI recommends appropriate design and interior props by indentifying the preference of the client [18].

4.4 Education Field

The non-face-to-face education utilizing 3D virtual space due to COVID-19 increases the immersion and the learning effect using the XR (eXtended Reality), immersive contents visualization technology, high quality contents, etc. In 2021, Soonchunhyang University held the virtual entrance ceremony for the first time in the world by materializing the 3D virtual stadium with Metaverse map. The user enters into social world of Metaverse platform 'Jump VR', established the customized personal avatar and participated in the entrance ceremony [19]. Mammo6 developed the solution for non-face-to-face education 'Galaxity: School' in 2021. This solution shares diverse educational materials such as video, document, etc. online and allows interaction between learner and teacher through voice chatting [20].

4.5 National Defense Field

KAI (Korea Aerospace Industries) developed the system that materializes the aircrafts or satellites (fighter plane, helicopter, satellite, unmanned airplane (VTOL), etc. in 3D actual size when the user accesses the cyber space after wearing VR goggle and VR gloves in Metaverse experiencing zone. It allows not only just seeing but also touching directly the virtual image trough virtual gloves.

Hancom Frontis disclosed the flight training of air force fighter and army Apache attack helicopter, tactical firing exercise simulation, etc. to the public. It converges the technologies such as meta game, virtual tactile technology (haptic), Big Data, 5G, etc. to the troop maneuver training, commanding exercise of each level commander and assistant chief of staff for operation, etc. To do that, Army is developing 'Game-based online platform' to implement the VR military exercise realistically [21].

5. Conclusion and Improvement Plan

In the results of examining Metaverse technologies and application cases in the main body, the advantage of Metaverse is that it can bring the reduction of time and cost by performing the business, education, etc. in Metaverse-based virtual environment. In addition, it can provide the higher service adding the interactive functions to the service provided by existing virtual reality and augmented reality. The disadvantage of Metaverse is that since the online activities are very easily accessible than the offline activities and the contents exposure is very easy, it is difficult to control the harmful contents and privacy invasion and security problems exist. To overcome the disadvantages and the problem of Metaverse, it is intended to suggest following considerations.

- Expand Metaverse from professional domain to the daily life domain together with the improvement of problems such as XR device weight, picture quality, etc.
- Enable the communication that can express even the facial expression and behavior by grafting with AI technology.
- Produce economic value in the virtual world, too.
- Expand the flexible business activity and communication in the Metaverse world linked to reality.
- Develop smooth communication, collaboration tool and visualization technology in online non-face-to-face environment.
- Provide the job and implement the population decentralization policy by overcoming the geographical limitation according to the change by the decentralized business environment.
- The function of means of social connection is emphasized due to pandemic. Therefore, diverse platforms that can satisfy Metaverse users according to the purpose and type of service and the contents utilizing platforms should be produced constantly.
- It is necessary to converge the policy related to XR, which is the ER technology suggested by country, with diverse industries. Virtual convergence technology project promoted currently through major authorities of each country needs to be extended and integrated with X-

Metaverse so that its creation of value can be linked to economy in reality.
- Besides, the talents having expertise by the acquisition of information and learning on new technological environment of Metaverse should be fostered

Besides these considerations, currently, Metaverse technology and market need the policy support for the contents development, fostering professional manpower and Metaverse ecosystem building. At this moment, the cases utilizing Metaverse present the expected effect and the needs in the positive aspect and it is expected to be generalized as a means of new communication. In addition, the connection method among diverse businesses, between countries and Metaverses is required together with institutional support by that. Therefore, in future, it is necessary to prepare for such problems with the policy and legal systems.

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