Metaverse Use Cases

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[DTF]

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Executive Summary

This document provides possible use cases utilizing the Metaverse as a virtual representation of an environment, a space to enable communication and interaction, as well as a virtual space to run simulations. This document focuses on several use cases which are not included in the AIC and CPS use case documents [IOWN GF AIC] [IOWN GF CPS] published at the end of 2021 from IOWN Global Forum. These use cases are Virtual Co-working Space, Simulation of Smart City, and Retailing in Metaverse. Virtual Co-working Space enables remote collaboration from several physical locations. Simulation of Smart City demonstrates potential benefits of a better city planning under different conditions. Retailing in Metaverse realizes commercial trade by enabling interaction and transactions between users in the virtual world. This document also clarifies fundamental gaps and key requirements which need to be studied in IOWN Global Forum in the near future.

1. Introduction

The term "Metaverse" is becoming very popular within the technology industry and around the world. However, multiple definitions of the term Metaverse exist [Chowdhury, Swaptik.] and [Mystakidis, S.], so a true consensus on its meaning has not yet been decided. Referring to existing publications, the IOWN Global Forum (IOWN GF) defines the Metaverse as a virtual space to connect people, environment, objects and machines (e.g., a computer, a sensor, a robot, a smart phones) for communication, interaction, and new immersive experiences. The Metaverse provides an environment for virtual services, including work collaboration, personal entertainment, and social interaction by creating appropriate virtual spaces with the necessary digital content. This often includes digital twins of physical objects, digital humans/avatars, and sensory information. Virtual entities such as imaginary creatures and futuristic cities can be provided in the Metaverse if they are desired/required for a worthwhile user experience.

2. Scope

Different Metaverses are virtual spaces where users can perform actions to communicate, interact and experience new immersive experiences. Some Metaverse use cases have been included in published IOWN GF use case documents [IOWN GF AIC] [IOWN GF CPS] and were closely related to digital twins. However, these Metaverse use cases did not include several types of applications. Therefore, missing Metaverse use cases need to be collected. In addition, the network performance requirements for the Metaverse need to be clarified due to the evolution of avatar technology and the synchronization of the real world with the virtual worlds of the Metaverse. Since Metaverses might be constructed by many different types of digital twins, the requirements must cover all of them.

The scope of this document is to collect and define additional Metaverse use cases and to clarify the gaps and requirements for the missing use cases from the existing use case documents in IOWN GF.

3. Metaverse Use Cases

3.1. Types of Metaverse Use Cases

There are several types of Metaverse use cases for its purposes/services. In other words, Metaverse is a platform that implements many types of sub use cases in different industries. As shown below, Metaverse provides a wide variety of use cases from gaming to smart cities. Virtual spaces in these use cases can be experienced both in a full virtual environment (virtual reality) and a hybrid-environment (augmented/mixed reality).

Table 1 Types of Metaverse use cases

Types	**Metaverse use cases**	**Description**	**Related IOWN GF Use Case**	**Section, document**
Public event in virtual spaces	Virtual music concert	Audiences to join a Metaverse to interact with an artist and other audiences.	Interactive Live Music	Sec 3.1.1 [IOWN GF AIC]
	Interactive live sports	Distributed audiences to join a Metaverse to cheer their favorite team with other audiences	Interactive live sports	Sec 3.1.2 [IOWN GF AIC]
Virtual collaboration	Virtual co-working space	Co-working in a Metaverse for team activities and team building	N/A	
Gaming via virtual spaces	Virtual online game	Online game content such as RPG and battle-royale, exploring a virtual world, breeding live animals, creating own rooms or objects in a Metaverse (e.g. FORTNITE, and MINECRAFT)	Cloud Gaming	Sec 3.1.3 [IOWN GF AIC]
Visualization of simulation	Simulation for smart city	Simulating traffic, energy consumption, flow of people, then integrating these representations/outputs of simulations into a Metaverse	N/A	
Operation through virtual spaces	Remote operation of factory	Remotely operating a factory through Metaverse providing visual and non-visual information of remote factory	Smart plant	Sec 3.3.1 [IOWN GF CPS]
Virtual retail	Retailing in Metaverse	Virtual store to trade digital goods, meet and chat with other people through avatars, and NFT trading using blockchain (e.g. Decentraland, Horizon World, The Matrix, VR Chat) in a Metaverse.	N/A	
Digital human in virtual spaces	Digital representation of human	A digital representation of human including some of features of a human such as personality and knowledge in a Metaverse.	Another me	Sec 3.4.2 [IOWN GF AIC]

There exists a wide variety of designs and implementations of Metaverse systems. Most Metaverses, however, consist of several major functions such as virtual space generation, avatars/digital twin creation, and communication management. The virtual space is a virtually created space on a computing system to accommodate various types of digital objects, digital contents, digital creatures and digital human (these are sometimes called digital twin). Virtual spaces created by different software platforms, which are recognized as different types of virtual spaces, often have common features such as three-dimensional coordinates, functions to allocate digital objects in their virtual space with necessary meta data (e.g., identifier, location, and behavior), and interfaces to other systems to control / monitor the virtual space. For example, a game engine as a software platform provides a virtual space as a dynamic three-dimensional space for characters and environments such as buildings, foliage, and vehicles. A Metaverse needs to be a convergent virtual space including many types of digital objects and content from different providers. Thus, entities of a Metaverse are decentralized and distributed in nature.

In addition, several Metaverses can be connected via a link between them which may create hierarchical architectures. These connections provide a more complex virtual world, which is called the multi-Metaverse concept. In this concept, some virtual spaces have corridors to another potential destination to travel between worlds that have different themes (e.g., gaming, music, co-working).

ccording to the use case and nature of the system design shown above, creating a Metaverse apparently requires large amounts of data transmission with low latency, as it needs high resolution data for real-time rendering transferred among decentralized ICT systems. Moreover, the Metaverse concept should provide many opportunities for cross-industry/domain/company data exchange. Many data included in digital objects used in a Metaverse needs to interact with each other to form a unified virtual space. This requires a mechanism to securely share data provided by different stakeholders.

In this section, DTF-TF focuses on three use cases; Virtual co-working space, Simulation for a smart city, and Retailing in the Metaverse. Regarding others, the corresponding use cases are described in AIC/CPS documents.

3.2. Virtual Co-working Space

3.2.1. Description

A virtual co-working space is one popular use case of the Metaverse. Many companies provide solutions for co-working space in a Metaverse [Sourceforge.net]. Workers can collaborate with their colleagues and clients using the co-working space. The scale of this collaborative working space may vary. It can be anywhere from a private room or a large-scale science laboratory with intricate equipment.

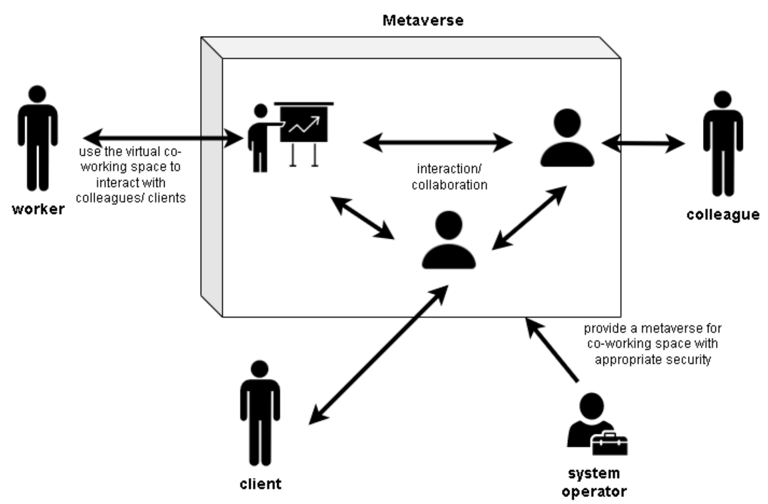

Figure 1 Overview of Virtual Co-working Space

The following Personas appear in this use case.

- Worker: People uses the co-working space in a Metaverse for her/his work with colleagues/clients.
- System operator: Person, group or company organizing the co-working space in a Metaverse.

3.2.2. Key Feature Set

3.2.2.1. Persona #1: Workers and Client

As a worker, I want to;

- work effectively within the Metaverse

1. Operate business apps that are equipped with 3D UIs
2. Observe digital models, including digital twins and 3D models
3. Drive multiple systems that are connected to the Metaverse

- and interact with other colleagues and clients

1. View colleagues/clients and their behavior in real-time
2. Communicate with colleagues/clients verbally and non-verbally

So that I can have a seamless collaboration with colleagues as if I were at the real office.

- Utilize office applications to interact/collaborate with colleagues and clients

1. Interact with objects within the Metaverse at the same time with colleagues and show the result of the interaction
2. Manipulate digital models to create an output with colleagues
3. Control a digital twin within the Metaverse and show changes in the physical world

So that I can have an enough capability to share my idea with my colleagues as if I were at the real office.

3.2.2.2. Persona #2: System Operator

As a System Operator, I want to;

- provide a virtual space service for the workers and clients (Metaverse)

1. Create / modify / delete a virtual space for co-working
2. Control / manage accesses from workers
3. Customize the digital space, to have it tailor-made based on the user demands/requirements.

So that I can have a capability to provide a Metaverse for co-working space with appropriate security.

- monitor the state of the Metaverse

1. Manage capacity of resources for seamless collaboration among workers
2. Configure data quality (e.g., video, audio) for workers
3. Monitor security related alert

So that I can have a capability to manage a Metaverse for co-working space with appropriate quality.

3.2.3. Service Gap/Requirements

Service gap and service requirements of virtual co-working space are the followings:

- Virtual space synchronization: Since the virtual co-working space is a social collaboration, requesting everyone to participate in the activity, in contrast to a video meeting, the number of synchronizations increases in addition to the increase of the network load. In the case of interaction among workers/clients, low latency is critical to synchronize multiple workers.
- Scale of co-working space: If a co-working space accommodates dozens of workers, network and computation infrastructure are required to be scalable. As converged data from worker's physical premise to a virtual space needs to be synchronized and rendered, it requires higher performance computation and computation, as well as more effective distribution mechanism than is possible today.

3.3. Simulation for Smart City

3.3.1. Description

A simulation for smart city could be an expanded usage of a Metaverse. A Metaverse of smart city, which could be a replica of real city (digital twin) or a virtually created space of a new fabricated city scape, can be used for simulation to predict future situations under certain conditions.

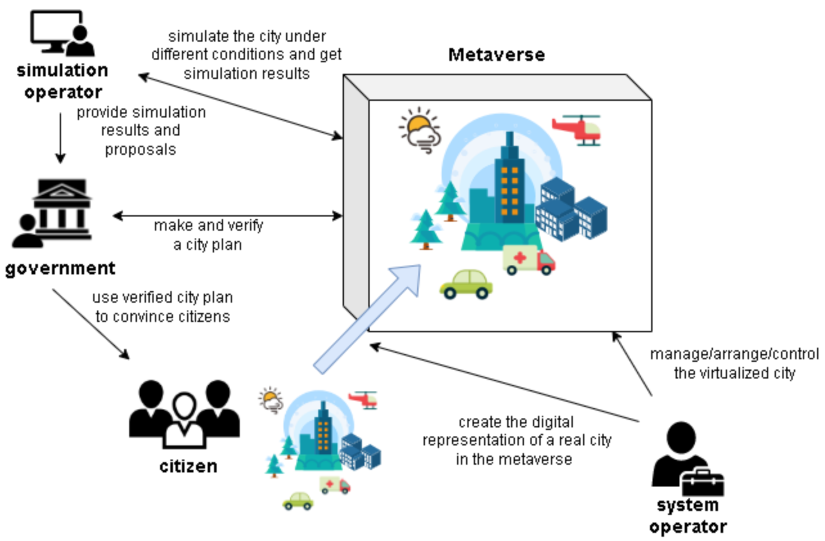

Figure 2 Overview of Simulation for Smart City

The following Personas appear in this use case.

- Simulation operator: The organization that uses the virtualized city in a Metaverse for the desired simulation.
- Government of a city: The organization that analyzes the output of the simulation to make a reliable and effective city plan.
- System operator: Person, group or company managing the lifecycle of the virtualized city used for simulation in a Metaverse.

3.3.2. Key Feature Set

3.3.2.1. Persona #1: User of simulation

As a user of simulation, I want to;

- execute simulation in a Metaverse

1. Run simulation in a Metaverse where the target city is replicated
2. Visualize simulation result with associated effects for city assets
3. Adjust configuration of simulation to achieve desirable status of the target city

So that I can have a visualized result of city simulation in a Metaverse.

3.3.2.2. Persona #2: Government of city

As a government of the target city, I want to;

- show outcome of city plan

1. View simulation result with impacts to city infrastructures through a Metaverse
2. Analyze the result to consider a measure
3. Reflect the measure to a Metaverse to evaluate its effects for city activities
4. Convince citizens and relevant parties regarding the implementation of city plans by showing visualized outcome in a Metaverse

So that I can plan a policy and execute necessary measures to improve city infrastructures and activities.

3.3.2.3. Persona #3: System Operator

As a System Operator, I want to;

- provide a virtual space service for the simulator operator (Metaverse)

1. Create / modify / delete a virtual space for users of simulation
2. Control / manage accesses from users
3. Customize the digital space, to have it tailor-made based on the user demands/requirements.

So that I can have a capability to provide a Metaverse for smart city simulation with appropriate security.

- monitor the state of the Metaverse

1. Manage capacity of resources for simulation and visualization of smart city
2. Configure data quality (e.g. video, audio) for smart city simulation

So that I can have a capability to manage a Metaverse for smart city simulation with appropriate quality.

3.3.3. Service Gap/Requirements

Service gap and service requirements of simulation of smart cities include the followings:

- Computing power/chip capability: executing multiple simulations requires high performance computing (HPC). In the case of a large-scale city simulation with detailed granularity (e.g., road traffic, weather, and flow of people), it requires HPC infrastructure with high performance chips.
- Memory and data volume: creating a Metaverse and executing simulations on it multiple times requires tremendous data volumes. It requires high speed data transactions between a database and a chip, networks, and user devices.
- Lack of standards: there are no existing standards to ensure interoperability of the Metaverse. Some missing standards include data formats for digital contents, protocols and interfaces. This situation creates a complicated issue, in that a Metaverse needs to be generated for each city in a different way. Establishing standards is necessary to create a fluid and seamless experience within the Metaverse.

3.4. Retailing in Metaverse

3.4.1. Description

Retailing in a Metaverse should have a virtual store to trade digital / real goods where people can meet and interact with each other through avatars and commit a purchase. A retail site can vary from a personally owned store or gallery to a large-scale facility, such as an expo or even an entire department store.

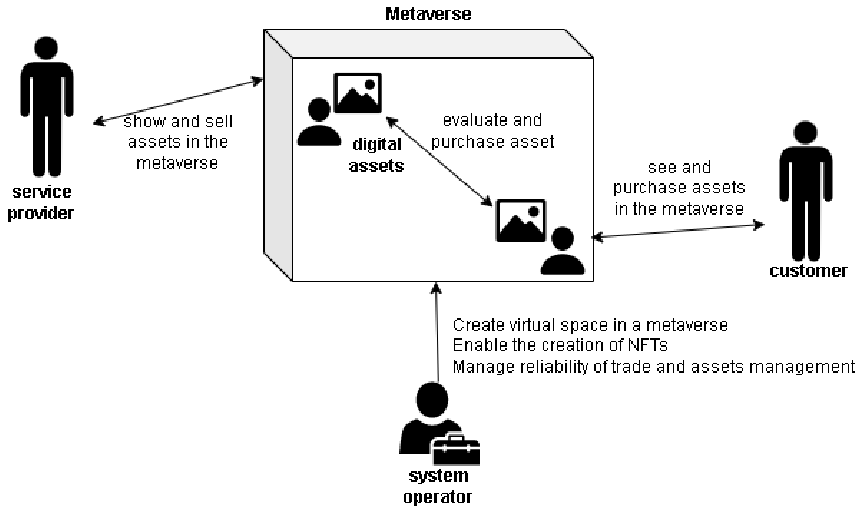

Figure 3 Overview of Retailing Metaverse

The following Personas appear in this use case.

- Customer: A person or an organization that purchases assets in a Metaverse.
- Service Provider: A person or an organization that provides her/his digital assets in a Metaverse.
- System operator: Person, group or company organizing the virtualized space used for business like digital assets retailing in a Metaverse.

3.4.2. Key Feature Set

3.4.2.1. Persona #1: Customer

As a Customer, I want to;

- purchase a digital asset in a Metaverse

1. See digital assets in the Metaverse with attributes to evaluate its value
2. Communicate other Customer(s) and Provider(s) to exchange information of assets
3. Purchase an asset, which may involve NFT trading

So that I can purchase preferred digital asset with reliability and trust

3.4.2.2. Persona #2: Provider

As a Service Provider, I want to;

- exhibit my digital asset in a Metaverse

1. Show digital assets in a Metaverse with attributes including NFT
2. Communicate with Customer(s) to exchange information to trade assets
3. Sell an asset, which may involve NFT trading

So that I can sell my digital asset without risk of forgery.

3.4.2.3. Persona #3: System Operator

As a System operator, I want to;

- provide a virtual space service (Metaverse)

1. Create / modify / delete a virtual space for digital asset retailing
2. Control / manage accesses from Customers and Providers
3. Customize the digital space, to have it tailor-made based on the user demands requirements

So that I can have a capability to provide a Metaverse for digital asset retailing with appropriate security

- monitor the state of the Metaverse

1. Manage capacity of resources for visualization and trading of digital asset
2. Configure data quality (e.g., video, audio) for communication between Customers and Providers

So that I can have a capability to manage a Metaverse for digital asset retailing with appropriate quality.

3.4.3. Service Gap/Requirements

Service gap and service requirements of retailing in Metaverse are followings:

- Reliability of Metaverse infrastructure: trading assets within the Metaverse, including when NFTs are involved, requires reliable network and computing infrastructure in terms of capability and security. As a Metaverse for digital asset retailing could include a large amount of value even if the Metaverse is a relatively small virtual space, robust and secure infrastructure is necessary to provide reliable environment for this use case.

4. Requirements

Metaverse use cases involve connecting people and machines within a virtual space. Similar to the requirements set in the AI-Integrated Communication use cases [IOWN GF AIC], a Metaverse can also adopt the concept of data volume, data velocity, scalability and elasticity to express the necessary requirements.

Key requirements can be expressed along with the following workflows.

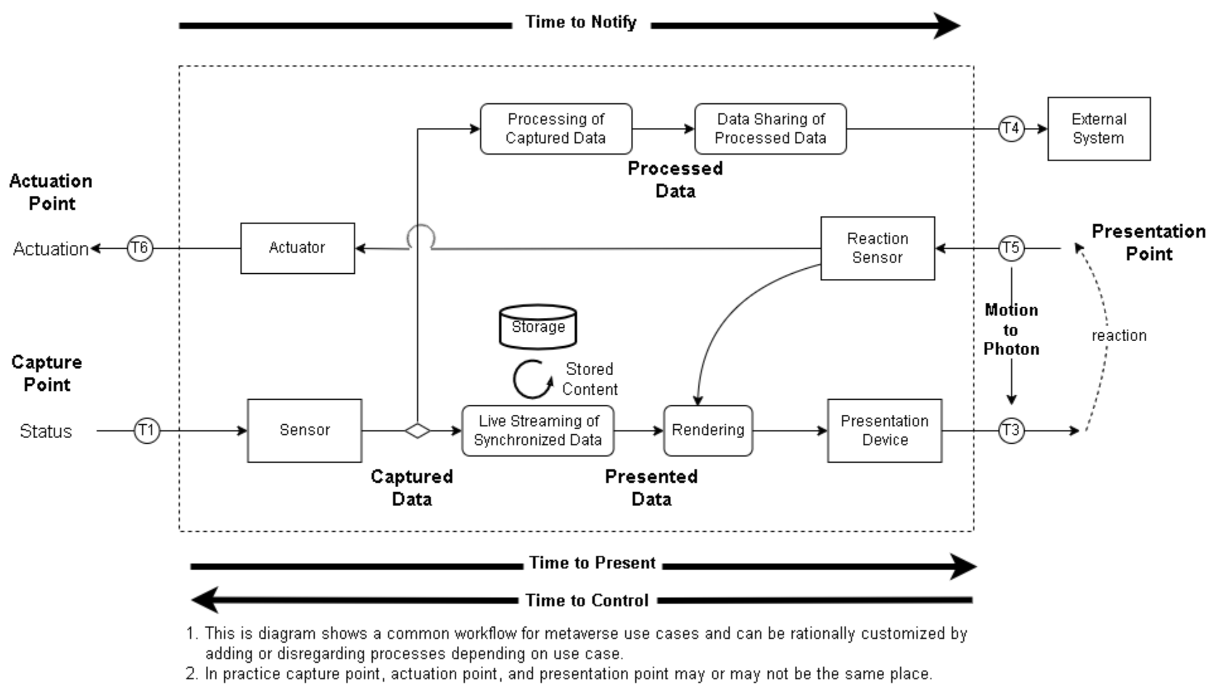

Figure 4 Common Workflows and Key Requirements for Metaverse use cases

Data Sharing (T1 to T4): "Processed Data" are made available to "External Systems" through "Data Sharing of Processed Data". The end-to-end delay for this flow is named "Time to Notify (TTN)".

Remote Live Monitoring (T1 to T3): "Captured Data" (e.g., images, voice, and haptic data) are transferred to "Presentation Devices" in remote sites for remote live monitoring via "Live Streaming of Synchronized Data, which are used for the creation of enriched contents from multiple streams of "Captured Data." The end-to-end delay for this flow is named "Time to Present (TTP)."

Motion to Photon (T5 to T3): The data captured by "Reaction Sensors" are reflected the presented view on the person's "Presentation Device", which provides, for example, a personalized view of a free viewpoint video. The end-to-end delay for this flow is named "Motion to Photon (MTP) ".

Remote Control (T5 to T6): The data captured by "Reaction Sensors" are directly dispatched to "Actuators" at remote sites, which enables, for example, remote motion control of specific machines. The end-to-end delay for this flow is named "Time to Control (TTC)".

Given the above workflows, the following aspects will be key requirements for Metaverse use cases;

- **Data Volume**: Metaverse UCs require a minimal delay. Therefore, deep compression cannot be expected. Even when the data are compressed, the rate would at least be in the other of hundreds of Gbps. It is expected that the use of next-generation display technology such as Holographic display would require delivery and computation of several hundred Gbps to a few Tbps of “Presented Data “.

- **Data Velocity**: As described below, some Metaverse use cases require less than 10 ms “MTP, which will be the most critical requirement. Using 1ms for capturing (posture-eye motion) and 2 ms for displaying leaves only 6ms for networking and computing.
- **Scalability and Elasticity**: Some Metaverse use cases, will enable a vast number of users to share the same remote experience via the network. The network needs to support scalability and elasticity to support varying user demand. An example might be a sporadic surge in communication at a goal scene of a football match.
- **Other Aspects**: Wireless connectivity at the user device is a common requirement for most Metaverse use cases.

4.1. Key Requirements and Assumptions

The Metaverse use cases presented in this document have similar characteristics despite serving different scenarios. It can be demonstrated that these use cases have virtual spaces controlled by system operators. Users, which may be the service providers or customers, can then participate and/or manipulate the space according to their respective purposes.

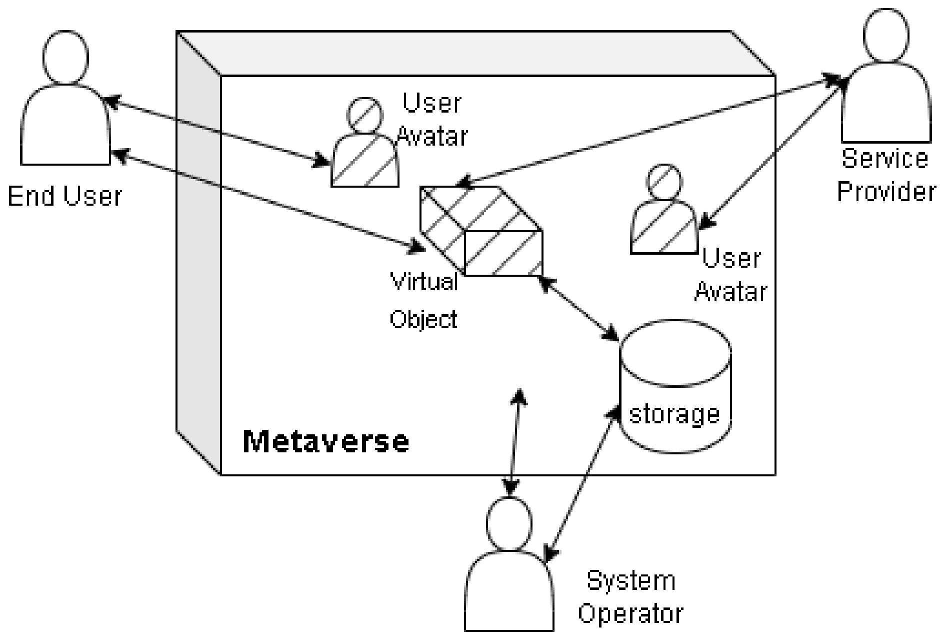

Figure 5 Generalization of Metaverse use cases

4.1.1. Key Requirements

- Data Volume:
  - Captured data
    - video stream (uncompressed) from Capturing Device: 14-230 Gbps per virtual object (total up to 2 Tbps)
      - number of virtual object: up to 8

    - (in case of live updates from the physical world) from sensors: 100,000 sensors per square km, each of which is updated every 1-to-10 seconds
  - Video stream to Presentation Device: 48-230 Gbps
- Data Velocity:
  - TTN: less than 1 minute
  - TTP: 70 ms
  - MTP: 10 ms
  - TTC: 100ms
- Scalability:
  - automatic scaling of network and computing resources is required according to the number of users
  - processing of captured data:
    - around 200 TFLOPS per application per building

4.1.2. Assumptions

- **Capacity-Geographic:**
  - total users of up to 100,000
  - latency requirements applicable to users up to 1,000 km distance
- **Data Velocity**
  - Video stream throughput calculation consider virtual objects that are represented in the Metaverse and presented to the users' devices. It is assumed that up to 8 objects will be within the user’s focus at any given time.
  - Most objects within Metaverse will be presented from stored content data.
  - TTP in the Metaverse may refer to either the act of recording and presenting a physical object, or the act of giving motion input for 3D model manipulation.
  - TTN in the Metaverse sense refers to the time a simulation is triggered until user is notified of the simulation completion
  - TTC in the Metaverse context is calculated when an event occurrence in Metaverse is perceived by the user, to the actuation caused by user’s reaction

5. Conclusion

This document provides Metaverse use cases, Virtual Co-working Space, Simulation of Smart City, and Retailing in Metaverse. These use cases have similar behavior, where users are able to reproduce objects within virtual spaces and manipulate spaces or the objects within a space.

To deliver these services, the following service requirements need to be fulfilled:

- Creation of a standard data model to ensure interoperability of data and assets
- Low latency event synchronization between users
- High performance computing, memory and storage to enable fast large-scale simulations
- Adaptive resource scaling to accommodate changes in the number of users within the space
- Reliable and secure infrastructure, especially for assets transactions

Quantitative requirements based on analysis of these Metaverse use cases are also provided, and they are similar key requirements with AIC and CPS use cases. This document highlights the importance of fulfilling requirements shown in AIC and CPS Use Case Document, as it is required for a wide spectrum of applications.

Definitions and Abbreviations

Definitions

For the purposes of this Reference Document, the following definitions apply:

Virtual Space	Virtually created space on computing system to accommodate various types of digital twins. Although there are several types of virtual spaces created by different software platform, it basically has three dimensional coordinates, functions to allocate digital twins in their virtual space with necessary metadata (e.g. identifier, location, and behavior), and interfaces to other systems to control / monitor the virtual space. For examples, a traffic simulator provides a virtual space as coordinates with locations of cars and pedestrians, and a game engine provides a virtual space as dynamic three dimensional spaces for characters and environments such as building, foliage, and vehicles. [IOWN GF DTF]

Abbreviations and acronyms

For the purposes of this Reference Document, the following abbreviations and acronyms apply:

3D: Three dimensional

AI: Artificial Intelligence

AIC: AI-Integrated Communication

APN: All photonic network

CPS: Cyber physical system

DTF: Digital Twin Framework Task Force

E2E: End to end

HPC: High performance computing

IDH: IOWN Data Hub

IOWN GF: IOWN Global Forum

MTP: Motion to Photon

NFT: Non-Fungible Token

RIM: Reference Implementation Model

TTC: Time to Control

TTN: Time to Notify

TTP: Time to Present

VR: virtual reality

References

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History

Revision	Release Date	Summary of Changes
1.0	March 3, 2023	Initial Release
1.1	June 7, 2023	Minor Editorial Revisions

