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Title: Proposed new work item on "Requirements and functional architecture of IoT based metaverse service"

Contact:	Chao Ma CAICT China	Tel: +86-18612866101 E-mail: machao@caict.ac.cn
Contact:	Cheng Chi CAICT China	Tel: +86-15210000965 E-mail: chicheng@caict.ac.cn
Contact:	Yi Xie China Mobile	Tel: +86- 13910866107 E-mail: xieyi@chinamobile.com
Contact:	Minshi Chen China Mobile	Tel: +86- 13911773802 E-mail: chenminshi@chinamobile.com
Contact:	Jie Cheng China Mobile	Tel: +86- 13811723151 E-mail: chengjiewl@chinamobile.com

Abstract: This contribution proposes to initiate a new work item on Requirements and functional architecture of IoT based metaverse service.

1 Background

Virtual world technology has gained insane popularity recently, especially after Facebook rebranded itself as Meta Platforms to strengthen its hold in the developing industry. Metaverse technology is growing into a full-fledged business domain with active participation from global business entities, which will have tremendous potential to fundamentally transform the ways we work, learn, play, and live our lives. However, this expansion is not possible by itself, and this is where the importance of IoT gets involved.

The Internet of Things (IoT) could give a robust digital network of interconnected physical devices we use every day. It bridges our physical and virtual worlds and enable metaverse to analyse and interact with the real world. With IoT, billions of tech devices, such as cameras, sensors, wearable devices, etc., are connected, through wired or wireless channels, to share information, interact, and access data resources. Only when enabled by IoT can metaverse incorporate massive data from the real world to achieve digital twin and virtual simulations, and establish an entirely integrated digital content feedback into the physical environment to make metaverse feel real. IoT is an important pillar of the metaverse infrastructure, which can unleash its maximum potential. The combination of IoT and metaverse will likely open new opportunities for industrial domain, individual needs, and social requirements.

2 Discussion

2.1 The Metaverse service

Metaverse service is basically a computer-generated virtual environment that enables the users to enter networked extended reality - a virtual space. The Metaverse service refers to the combination of both virtual reality, augmented reality, and mixed reality resulting in an extended reality or XR. It is generally accessed via smart solutions & gears like Oculus headsets as shown in Figure1. It is a realm developed or is being developed by experts with the aim to make users hang out with friends, play games, watch movies, go on a shopping spree with them in recent days, or even fulfil more professional industry requirements in the future.

Figure 1 examples of the metaverse service

Simply put, the metaverse service is a networked extended reality or XR in which human and automated entities can interact and connect with each other for multiple purposes.

2.2 IoT based metaverse service

- **Use Of smart solutions and devices**

To the infusion of Metaverse service with the real world, IoT-based smart solutions and devices must be utilized. The IoT devices will help in the efficient entrance of the users into the Metaverse service that is close to reality. It will be the perfect recreation of the scenarios we encounter in the real world. Since IoT is about the interconnectedness of multiple devices with the physical world, it will aid in the complex integration and collaboration of hybrid data with digital cloud systems. This will pave the way for an advanced interactive virtual simulation world for vivid experiences for the users.

- **Integration digital content into the physical world**

IoT innovation will help the metaverse service integrate digital content into the physical world. For users, to access, experience, and interact with things in the metaverse service while actually being in the real world, IoT will help in this collaboration between these two worlds. For instance, it will provide the groundwork for physical users to access digital content while using augmented and virtual reality technology and tools. Plus, it will play an important role in providing advanced interoperable systems to the users for interacting with automated digital entities. This will, in turn, generate a real-time control system that will give the users a realistic sensation-felt experience, like the way a person acts and reacts in the real world.

- **Ingestion and extraction of data**

Another important aspect that people must acknowledge is the importance of data in the current world and the integration of the metaverse service in it. It provides information value to a digital realm like the metaverse service. Likewise, IoT innovations are tools and technology that will help incorporate the metadata and physical data from the real world. For instance, consider the metaverse service a blank canvas in an online forum that needs to be filled with content extracted by the IoT-powered smart solutions. To put it simply, mass ingestion or extraction of real-world data through IoT devices will ensure successful integration and a strong connection between the real world and the Metaverse.

- **Secure connection between the virtual world and physical one**

IoT will play a fundamental role in the secure connection between the metaverse service and the real world. It will not only assist with its smart solution but also ensure the support of its technological infrastructure needed to form a responsive and uninterrupted link between its smart physical devices and the metaverse service. Moreover, it is also a fact that cloud technology is required to form a strong bond between the metaverse service and IoT. Without this technology, the required processing power will fall short of incorporating data collected by devices for the metaverse service. The foundation of IoT and data analytics will assemble on top of cloud technology support, ensuring a real-life experience for the users in the metaverse service.

2.3 The architecture of IoT based metaverse service

The metaverse service has great prospects in the real world's future. It is considered to be the next big thing. Especially after the Covid-19 pandemic, the importance and need for a digital world have significantly increased. This will also increase further advanced technological development or upgradation of IoT devices, networks, and its smart solutions around us. The interlinked prospect of the metaverse service and IoT will transform the real world around us, but it also brings a lot of requirements in the metaverse service as shown in Figure 2, future study on the requirements will be provided.

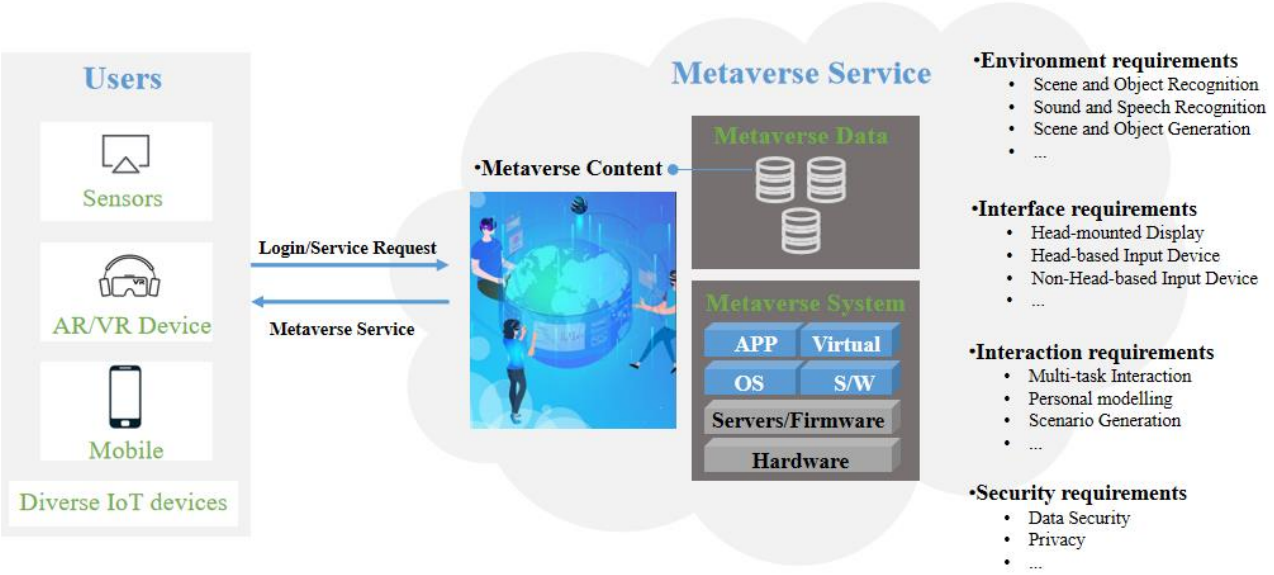

Figure 2 – The example requirements of IoT based metaverse service

Figure 3 gives an initial functional architecture of the IoT based metaverse service. This architecture shows the main functional entities and the interaction with different layers. Further study on the functional architecture including more detailed functional entities and related logic flows will be provided in the future.

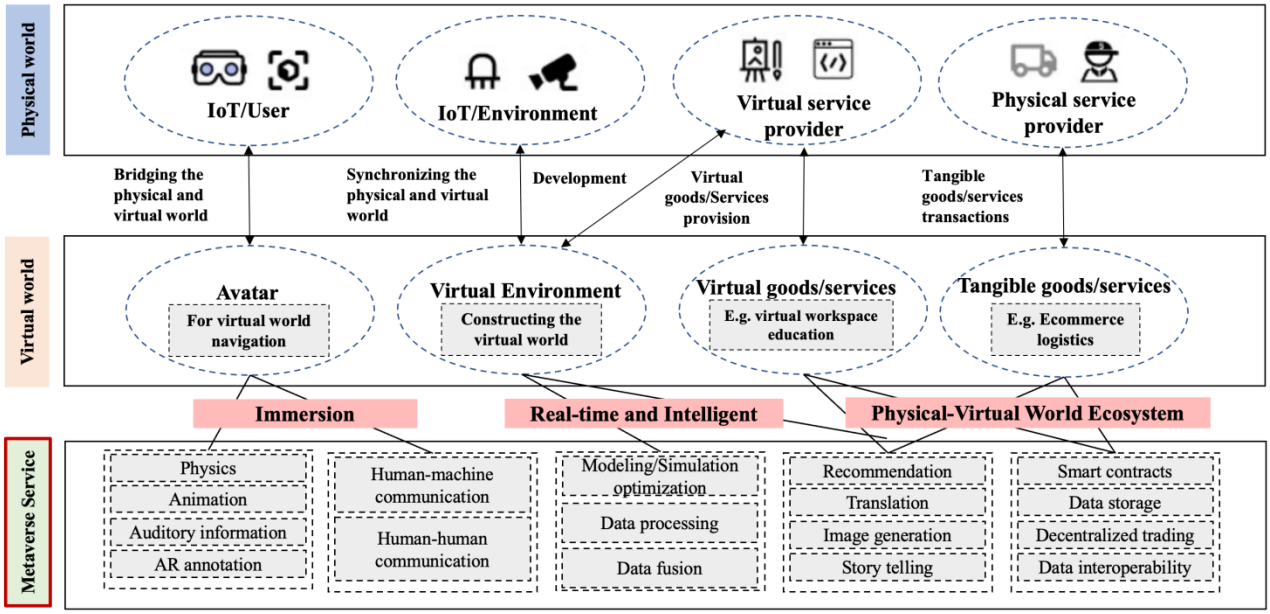

Figure 3 – The architecture of IoT based metaverse service

3 Gap analysis

The following table briefly shows the gap analysis for the proposed new work item.

Table-1 Gap analysis inside ITU-T related to Metaverse service in the IoT

SDO	Numbering	Title	Analysis results
ITU-T	Y.4000	Overview of Internet of things	This Recommendation provides an overview of the Internet of things (IoT). It clarifies the concept and scope of the IoT, identifies the fundamental characteristics and high-level requirements of the IoT and describes the IoT reference model. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Y.4100	Common requirements of the Internet of things	The common requirements of the IoT specified in this Recommendation are classified into the categories of non-functional requirements, application support requirements, service

			requirements, communication requirements, device requirements, data management requirements and security and privacy protection requirements. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Y.4113	Requirements of the network for the Internet of Things	This recommendation describes the common requirements for core network, access network and IoT area network. In this document, it mainly focuses on the requirements of the network for the IoT with smart meters and sensor as devices. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Y.4401	Functional framework and capabilities of the Internet of things	This Recommendation provides a description of the basic capabilities of the Internet of things (IoT), based on the functional view, the implementation view and the deployment view of the IoT functional framework described in this Recommendation, in order to fulfil the IoT common requirements specified in Recommendation ITU-T Y.2066. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	H.430.5	Architectural framework for immersive for live experience (ILE) services	This Recommendation identifies the architectural frameworks of Immersive Live Experience (ILE) services, including the high-level functional architecture, and provides some candidate technologies for the functions required for ILE. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	H.430.1	Requirements for immersive live experience (ILE) services	This Recommendation identifies general requirements and high-level functional requirements for Immersive Live Experience (ILE) services, in

			order to clarify ILE services. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	H.430.5	Reference models for ILE presentation environment	This Recommendation provides three reference models for the Immersive Live Experience (ILE) presentation environment, in order to reproduce highly realistic sensation or immersiveness on par with the experience of audience at the event site, and to reduce the design and set-up time of ILE viewing sites. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	F.740.2	Requirements and reference framework for digital representation of cultural relics/artworks using augmented reality	This Recommendation describes the requirements, application scenarios and reference framework for digital representation of cultural relics/artworks using augmented reality, which is known as augmented reality cultural service system (ARCSS). The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Y.dtf-infoex	Information exchange model for digital twin federation in smart cities and communities	This Recommendation defines the requirements of digital twin federation.The information exchange model among the components of the digital twin federation, which are the digital twins, the registry and the connection broker, is required to define for digital twin federation based on the requirements. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	F.DHAI	Framework and Requirements of Digital Human Access Interface	This under study work item describes the general access interface framework, including interface module description,

			application scenarios etc. It defines unified access interface requirements of digital human services for the developers to integrate the capabilities of digital human into different applications.The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	F.DH-PE	Requirements and evaluation methods of digital human platform	This under study work item provides the requirements and evaluation methods for the digital human platform from the aspects of function, compatibility, reliability, scalability, time response, and ease of use. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Y.IMT-2020-DTNMO	Digital twin network - Management and Orchestration	This under study work item specifies the management and orchestration aspects of Digital Twin Network and puts forwards the necessities and value of research on IMT-2020 network and beyond. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Y.DTN-CapLevel	Digital twin network - Capability level and evaluation methods	This under study work item specifies the capability level and evaluation methods of digital twin network system. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ITU-T	Focus Group on metaverse (FG-MV)		Not touch IoT based metaverse service
ITU-T	SG16-CG-Metaverse		Not touch IoT based metaverse service

Table-2 Gap analysis with work of other identified SDOs

SDOs	Numbering	Title	Analysis results
ISO/IEC	18038:2020	Computer Graphics, Image Processing And Environmental Representation - Sensor Representation In Mixed And Augmented Reality	This document defines the framework and information reference model for representing sensor-based 3D mixed-reality worlds The requirements and functional architecture of IoT based metaverse service hasn’t been mentioned. Further study on this topic needs to be developed.
ISO/IEC	23000-13:2017	Multimedia Application Format (MPEG-A) - Part 13: Augmented Reality Application Format	This document specifies mechanisms to connect to local/remote sensors and actuators and remote resources, such as maps and compressed media. It also details description elements for representing AR content and mechanisms to integrated compressed media (image, audio, video, graphics). The requirements and functional architecture of IoT based metaverse service hasn’t been mentioned. Further study on this topic needs to be developed.
ISO/IEC	23488:2022	Computer Graphics, Image Processing And Environment Data Representation - Object/Environmental Representation For Image-Based Rendering In Virtual/Mixed And Augmented Reality (VR/MAR)	This document specifies an image-based representation model that represents target objects/environments using a set of images and optionally the underlying 3D model for accurate and efficient objects/environments representation at an arbitrary viewpoint. The requirements and functional architecture of IoT based metaverse service hasn’t been mentioned. Further study on this topic needs to be developed.
IEC TC110	TR 62341-2-1	Generic introduction of holographic display	This document is intended to gather technical information on holographic displays and to identify optical measurement items that would be required to characterize their performance. The requirements and functional architecture of IoT based metaverse service hasn’t been mentioned. Further study on this topic needs to be developed.

IEEE	1589-2020	Augmented Reality Learning Experience Model	This document proposes an overarching integrated conceptual model that describes interactions between the physical world, the user, and digital information, the context for AR-assisted learning and other parameters of the environment. Specifically, it defines two data models and their binding to XML and JSON. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
IEEE Metaverse Standards Committee	P2048	Standard for Metaverse: Terminology, Definitions and Taxonomy	This document will define the vocabulary, categories, and levels of a metaverse in order to establish a common ground for ongoing discussions, facilitate the sustainable development of metaverse-related activities, and promote the healthy growth of metaverse markets. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
IEEE Metaverse Standards Committee	P7016	Standard for Ethically Aligned Design and Operation of Metaverse Systems	This document will provide a high-level overview of the techno-social aspects of metaverse systems, and specify an ethical assessment methodology for use in their design and operation. The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
3GPP	TR 22.856	Study on Localized Mobile Metaverse Services	This TR document focuses on locally relevant, persistent, shared content accessed by both onsite and remote user, The requirements and functional architecture of IoT based metaverse service hasn't been mentioned. Further study on this topic needs to be developed.
ETSI			Not touch IoT based metaverse service.
oneM2M			Not touch IoT based metaverse service.

Conclusion:

Regarding to the proposed new work item, gap analysis has been fully done based on investigation of ITU-T and other SDOs. The result of gap analysis is that the proposed new work item has no duplication with ITU-T and other SDOs.

4 Proposal

4.1 It is proposed to initiate a new work item on “Requirements and functional architecture of IoT based metaverse service”.

4.2 It is proposed to use the following text as the baseline document for meeting discussion.

Draft new Recommendation ITU-T Y.IoT-MS

Requirements and functional architecture of IoT based Metaverse service

Summary

This Recommendation provides the requirements and functional architecture of metaverse service based on IoT, including general requirements, high-level functional architecture and use cases of IoT based metaverse service.

Keywords

Metaverse service (MS), functional architecture, Internet of things (IoT)

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8 High-level functional architecture of IoT based metaverse service**Error! Bookmark not defin**

9 Use cases of IoT based metaverse service in the IoT ..... **Error! Bookmark not defined.**

A.1 justification for proposed draft new ITU-T Y.IoT-MS "Requirements and functional architecture of IoT based metaverse service" 17

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Draft new Recommendation ITU-T Y.IoT-MS

Requirements and functional architecture of IoT based metaverse service

1 Scope

This Recommendation provides the functional architecture of metaverse service based on the Internet of things. The scope of this Recommendation includes:

– Requirements of IoT based metaverse service

– Functional architecture of IoT based metaverse service

– Use cases of IoT based metaverse service

2 References

[ITU-T Y.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of Internet of things.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Internet of things (IoT) [ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.2 Terms defined in this Recommendation

TBD

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

IoT Internet of Things

5 Conventions

In this Recommendation:

– The keywords “is required to” indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

– The keywords “is recommended” indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

– The keywords “can optionally” and “may” indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor’s implementation must provide the option and the feature can be optionally enabled by network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Introduction

Virtual world technology has gained insane popularity recently, especially after Facebook rebranded itself as Meta Platforms to strengthen its hold in the developing industry. Metaverse technology is growing into a full-fledged business domain with active participation from global business entities, which will have tremendous potential to fundamentally transform the ways we work, learn, play, and live our lives. However, this expansion is not possible by itself, and this is where the importance of IoT gets involved.

The Internet of Things (IoT) could give a robust digital network of interconnected physical devices we use every day. It bridges our physical and virtual worlds and enable metaverse to analyse and interact with the real world. With IoT, billions of tech devices, such as cameras, sensors, wearable devices, etc., are connected, through wired or wireless channels, to share information, interact, and access data resources. Only when enabled by IoT can metaverse incorporate massive data from the real world to achieve digital twin and virtual simulations, and establish an entirely integrated digital content feedback into the physical environment to make metaverse feel real. IoT is an important pillar of the metaverse infrastructure, which can unleash its maximum potential. The combination of IoT and metaverse will likely open new opportunities for industrial domain, individual needs, and social requirements.

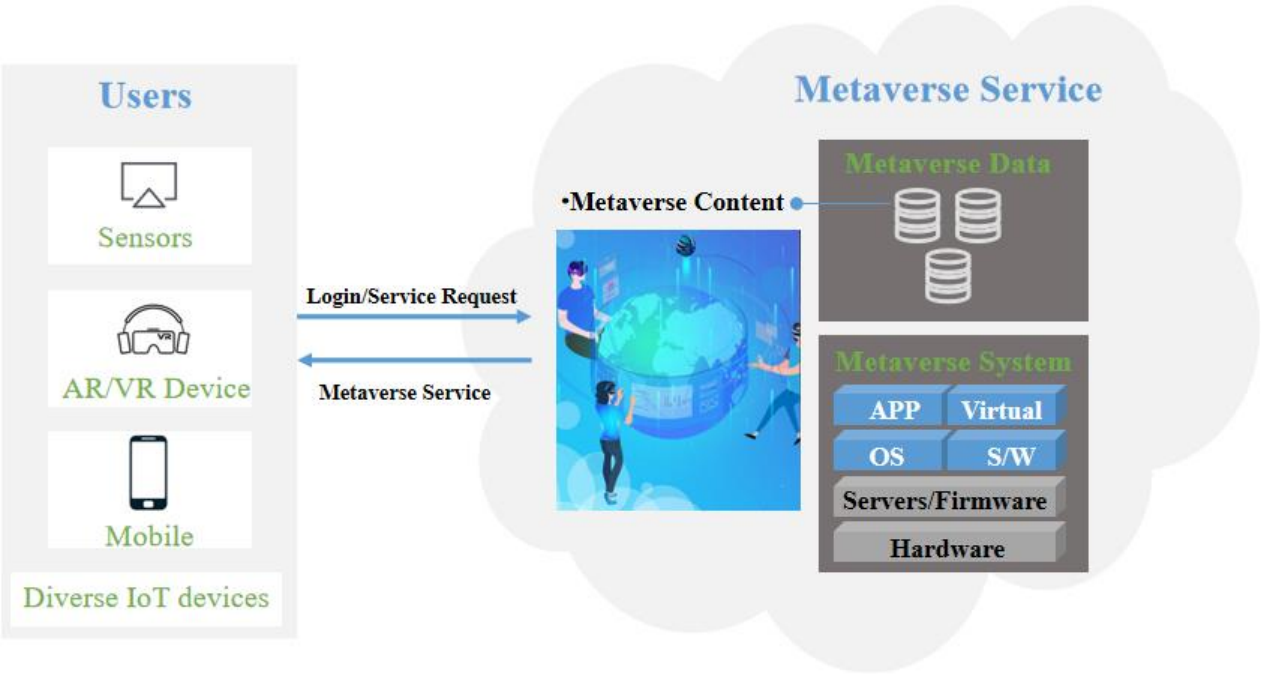

Figure 1 – The overview of IoT-based metaverse service

The metaverse service has great prospects in the real world’s future. It is considered to be the next big thing. Especially after the Covid-19 pandemic, the importance and need for a digital world have significantly increased. This will also increase further advanced technological development or

upgradation of IoT devices, networks, and its smart solutions around us as shown in Figure 1. The interlinked prospect of the metaverse service and IoT will transform the real world around us.

7 Requirements of IoT based metaverse service

[TBD]

8 Functional architecture of IoT based metaverse service

[TBD]

9 Use cases of IoT based metaverse service

[TBD]

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A.1 justification for proposed draft new ITU-T Y.IoT-MS "Requirements and functional architecture of IoT based metaverse service"

Question:	Q3/20	**Proposed new ITU-T Recommendation**	Geneva, 30 January-10 February 2023	
Reference and title:	Y.IoT-MS " Requirements and functional architecture of IoT based metaverse service"			
Base text:	TBD		**Timing:**	Q4 2024
Editor(s):	Chao Ma, E-mail: machao@caict.ac.cn Jie Cheng, E-mail:chengjiewl@chinamobile.com		**Approval process:**	AAP

Scope (defines the intent or object of the Recommendation and the aspects covered, thereby indicating the limits of its applicability):

This Recommendation provides the Requirements and functional architecture of IoT based metaverse service. The scope of this Recommendation includes:

– Requirements of IoT based metaverse service

– Functional architecture of IoT based metaverse service

– Use cases of IoT based metaverse service

Summary (provides a brief overview of the purpose and contents of the Recommendation, thus permitting readers to judge its usefulness for their work):

Virtual world technology has gained insane popularity recently, especially after Facebook rebranded itself as Meta Platforms to strengthen its hold in the developing industry. Metaverse technology is growing into a full-fledged business domain with active participation from global business entities, which will have tremendous potential to fundamentally transform the ways we work, learn, play, and live our lives. However, this expansion is not possible by itself, and this is where the importance of IoT gets involved.

The Internet of Things (IoT) could give a robust digital network of interconnected physical devices we use every day. It bridges our physical and virtual worlds and enable metaverse to analyse and interact with the real world. With IoT, billions of tech devices, such as cameras, sensors, wearable devices, etc., are connected, through wired or wireless channels, to share information, interact, and access data resources. Only when enabled by IoT can metaverse incorporate massive data from the real world to achieve digital twin and virtual simulations, and establish an entirely integrated digital content feedback into the physical environment to make metaverse feel real. IoT is an important pillar of the metaverse infrastructure, which can unleash its maximum potential. The combination of IoT and metaverse will likely open new opportunities for industrial domain, individual needs, and social requirements.

Relations to ITU-T Recommendations or to other standards (approved or under development)**:**

ITU-T Y.4000

Liaisons with other study groups or with other standards bodies:

SG16, FG-Metaverse

Supporting members that are committing to contributing actively to the work item:

State Grid Electric Power Co., Ltd., China Telecommunications Corporation, China Unicom, MIIT, China Information Communication Technologies Group, ZTE, Beijing University of Posts and Telecommunications