Draft new Recommendation ITU-T Y.4246 (ex Y.ACC-IoTMV)

Accessibility requirements for metaverse services supporting Internet of things

Summary

This Recommendation specifies accessibility requirements for metaverse services supporting IoT, complementing ITU-T Y.4204 by addressing issues specific to immersive and digital twin environments. It identifies three key areas: sensory perception, spatial navigation, and communication/action. The text requires alternative representations of visual and audio information, support for assistive technologies, personalization of virtual objects and audio characteristics, and clear notification when adaptations such as size scaling, contrast adjustment, colour change, or sound modification may distort real-world information. Its aim is to ensure that persons with disabilities and users with specific needs can access, understand, navigate, communicate, and interact effectively in IoT-supported metaverse services.

Keywords

Assistive technology, communication accessibility, digital twin, Internet of Things, metaverse accessibility, sensory perception, spatial navigation, user personalization

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Accessibility requirements for metaverse services supporting Internet of things

1 Scope

This Recommendation provides accessibility requirements for metaverse services that support the Internet of things (IoT).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Technical Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Technical Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

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

[ITU-T Y.4204] Recommendation ITU-T Y.4204 (2019), *Accessibility requirements for the Internet of things applications and services.*

3 Definitions

3.1 Terms defined elsewhere

3.1.1 accessibility [b-ITU-T F.791]: The degree to which a product, device, service or environment (virtual or real) is available to as many people as possible.

3.1.2 accessibility feature [b-ITU-T F.791]: An additional content component that is intended to assist people hindered in their ability to perceive an aspect of the main content.

3.1.3 assistive technology [b-ITU-T F.791]: Piece of equipment, product system, hardware, software or service that is used to enable, maintain or improve functional capabilities of individuals with disabilities.

3.1.4 metaverse [b-ITU-T Y.4238]: a collective virtual environment where physical and virtual worlds converge, that enables users to interact with shared digital spaces, objects and services.

NOTE – A metaverse can be virtual, augmented, representative of, or associated with the physical world.

3.1.5 person with age-related disabilities [b-ITU-T F.791]: A person with cognitive or physical disabilities caused by the aging process. Examples are impaired eyesight, deafness in varying degrees, reduced mobility or cognitive abilities.

3.1.6 person with specific needs [b-ITU-T F.791]: Includes persons with disabilities (PWDs), persons who are not literate, those with learning disabilities, children, indigenous people, older persons with age-related disabilities and anyone who has a temporary disability.

3.1.7 specific needs [b-ITU-T F.791]: This replaces the use of the term ‘special needs’. This term refers to a wide range of categories including women, children, youth, indigenous people, older persons with age-related disabilities, persons with illiteracy, as well as persons with disabilities (PWDs).

3.1.8 universal design [b-UNCRPD]: The design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. "Universal design" shall not exclude assistive devices for particular groups of persons with disabilities where this is needed.

3.2 Terms defined in this Recommendation

This Recommendation define the following terms:

None.

4 Abbreviations and acronyms

These Recommendation use the following abbreviations and acronyms:

AAC	Augmentative and Alternative Communication
AR	Augmented Reality
IoT	Internet of Things
MR	Mixed Reality
UX	User experience
VR	Virtual Reality
XR	extended Reality

5 Conventions

The following conventions are used in this Recommendation:

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

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

6 Overview of accessibility user problems in the metaverse supporting IoT

[ITU-T Y. 4204] provides general accessibility requirements for Internet of things (IoT) applications and services. Basically, these requirements are essential for ensuring accessibility of IoT applications and services for persons with disabilities. In IoT applications and services that apply an immersive environment, such as the metaverse, the requirements specified in [ITU-T Y.4204] alone may lead to distortion and misinterpretation of information expressed in these applications and services. Additional requirements for the metaverse supporting IoT are needed to prevent such distortion and misreading. This Recommendation defines additional requirements to be considered when applying the requirements presented in [ITU-T Y.4204] to secure the accessibility of the metaverse supporting IoT. Digital twin technology, built from data collected via IoT, creates an identical virtual world of the real world. The digital twin can be used to digitally replicate the real-world geographical and temporal environment to monitor various information, conduct complex experiments, or plan future events.

The metaverse extends the digital twin by providing an immersive, interactive interface that enables intuitive user experiences. While digital twins serve as the technological backbone for real-time monitoring and analysis, the metaverse leverages this data to facilitate simulation, collaboration and policy experimentation in virtual spaces. Together, they create a synergistic relationship that bridges the physical and virtual worlds across various domains such as smart cities, industrial environments and healthcare.

One example is the use of metaverse technology for urban planning, where new city spaces can be envisioned and presented to citizens as prototypes (e.g. [b-Allam] and [b-Hudson-Smith]). Immersive extended reality (XR) technologies, such as augmented reality (AR), virtual reality (VR) and mixed reality (MR), can be used to enhance the user experience (UX) in this virtual world. The virtual world, based on real-world data collected through IoT technology and using XR technology for UX, is collectively referred to as a metaverse supporting IoT. The metaverse, supported by IoT, can provide services across various fields, such as remote medical services, smart factories, smart agriculture and simulation-based education.

The metaverse is a virtual space where people can interact with other people or objects, which can be any “thing” on the IoT. It is also a means of communication. The metaverse has a spatial concept that participants can recognise. In addition, through the metaverse, users interact and communicate with each other within this virtual space. For a person to participate in the metaverse, they must first recognise this virtual space and any objects in it (whether human or virtual), and interact in various ways. For example, persons with sensory disabilities may have difficulty recognising this space and communicating within it.

Another technical issue that may affect accessibility in the metaverse supporting IoT is size scaling. When physical objects are replicated in virtual environments such as the metaverse, the size ratios of the same objects between the real and virtual worlds may not always match accurately. This discrepancy arises because, in virtual environments, certain small objects may become difficult to recognize or interact with if their size is preserved exactly as in the real, physical world. Conversely, some large objects may dominate the virtual world, limiting effective interaction. Therefore, intentional adjustments to the size ratios of objects in the metaverse may be necessary to enhance visibility, recognition and usability for users, including persons with disabilities and those with specific needs.

The metaverse interface must be designed to remove barriers for persons with disabilities and those with specific needs. Thanks to IoT products and services, personalization will be possible in the metaverse; hence persons with disabilities, such as visual disabilities in reality, may be able to experience sight in the metaverse, or they may be able to use the metaverse by utilising the other senses to experience an otherwise invisible reality.

However, persons with disabilities who cannot fully use sensory channels (e.g., visual, auditory, tactile) connected to XR's immersive environment may not be sufficiently stimulated to feel the metaverse's presence. As a result, everyone, including persons with disabilities, may not experience sufficient immersion in the environment and users may have difficulty achieving immersion in the environment.

In order to ensure accessibility in the metaverse, barriers must be removed, which can sometimes be achieved through appropriate assistive technologies. In this case, users with disabilities can fully participate as if they exist in the real world with a sense of immersion, thanks to assistive technologies or personalization.

Since metaverse services built on IoT platforms are composed of a virtual world based on information collected from the real world, the metaverse must be configured to accurately reflect the core elements of reality that are needed by all users, especially persons with disabilities.

To maximise the expected benefits of metaverse services when persons with disabilities use XR devices, supporting IoT and accessibility, accessibility must be guaranteed by reflecting the sensorial, spatial and communication methods of persons with disabilities in the real world, as appropriately as possible.

Figure 1 summarises the areas of accessibility user challenges in the metaverse supporting IoT.

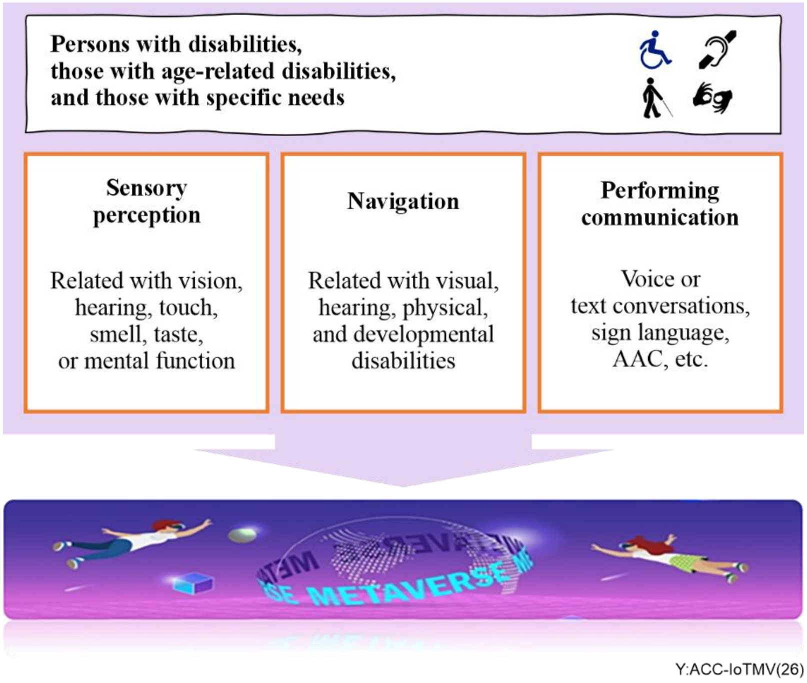

Figure 1 - Three areas of accessibility user challenges in the metaverse supporting IoT

The user challenges of the persons with disabilities, those with age-related disabilities and those with specific needs in each area are as follows.

6.1 Sensory perception

Sensory perceptions can vary in scope depending on the type of user experience (UX) the metaverse service provides. A metaverse service based on XR may utilize one or many senses, such as vision, hearing, touch, smell or taste. Specific users who have difficulty with these senses may be less immersed. When presenting alternative technologies to users, persons with disabilities may want to project real-world difficulties into the metaverse to maintain a "normal sense of reality" or, if possible, avoid them there. For example, some persons with hearing disabilities who have cochlear implants can actually hear to some extent in the metaverse. Still, some prefer to turn off the transmitter in favour of an inaudible environment. They may prefer an alternative representation of sound rather than hearing it even in the metaverse.

6.2 Navigation

People experience virtual spaces in unique ways. These experiences can vary based on a number of factors, such as age, exposure to digital media, trust in technologies and individual needs or preferences. The way users perceive and interact with virtual spaces is shaped by diverse personal circumstances and contexts. While virtual spaces may appear uniform on the surface, subjective engagement with them is highly individualized and multifaceted. The practice of recognizing space may or may not be the same as those without disabilities. The method of recognising and using space varies depending on disability type, such as visual, hearing and physical disabilities.

This area also concerns the accessibility of navigation through the virtual world. This is important for accessibility services. Subtitles, captions and sign language must be flagged with directionality through icons such as an arrow. Where to position these services in the metaverse is also a challenge. For example, persons with visual disabilities who do not recognize space by sight utilize different senses and memories, using tools such as a cane to identify areas and mentally reconstruct space.

6.3 Performing communication/action

People communicate in various ways: languages, modalities and formats. The means of communication for persons with disabilities such as sign language, subtitles or captions or audio description and augmentative and alternative communication (AAC), in addition to the means of communication for persons without disabilities, such as voice or text conversations, may also be considered for the means of communication for all and especially for those with disabilities.

As in the case of sensory perception, persons with disabilities may want to bring real communication methods to the metaverse as they are or use methods that were not possible in real life. For example, a deaf person who uses sign language may prefer to appear as if they are not using sign language in the virtual world by relying on sign language-to-speech translation. Conversely, they may wish for their use of sign language to be faithfully represented in the virtual world as it is in real life.

This area also concerns manipulating virtual objects and controlling the virtual environment, including powering on/off, volume control and settings. For example, a person with hearing disabilities who uses sign language as their primary communication medium may want to use it in the metaverse, even if the metaverse service supports voice communication for users with hearing disabilities.

As another example, people with or without disabilities may want to see digital twin objects in larger sizes to improve visibility and recognition. Figure 2 shows that while a briefcase object in the real world has a specific size ratio to a person, in the metaverse, the briefcase may be intentionally enlarged to mitigate difficulty perceiving small objects. In the context of metaverse factories, this size scaling concern is particularly relevant. While precise size scaling is important for design and manufacturing purposes, maintenance workers interacting with digital twin objects of equipment may encounter difficulties in recognizing small components when displayed in exact physical dimensions. To address this, metaverse services should consider adopting a balanced approach, preserving accurate size scaling for engineering applications while providing appropriate visual adjustments, such as enlarging small parts, for better recognition and usability in maintenance and operational scenarios.

NOTE – [b-ITU-T Y4238] introduces, in clause 7.2.4, a service scenario of remote maintenance assistance where metaverse-based virtual worlds support the physical world of a factory. In this context, the size-scaling concern is explicitly addressed to enhance usability and recognition.

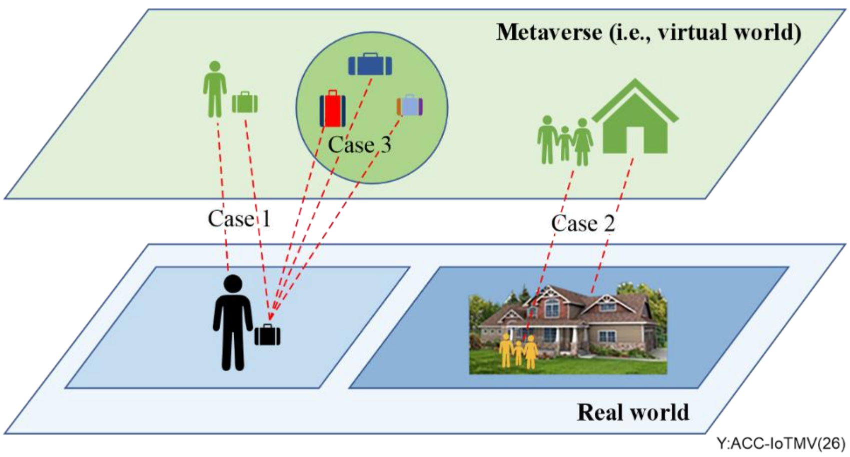

Figure 2 – Examples of size scaling concerns in the metaverse

Figure 2 illustrates examples in which the size ratio between real-world objects and their virtual representations in the metaverse differs intentionally to enhance visibility and usability. It shows examples of how small objects, such as briefcases, are scaled up in the metaverse to support user recognition, especially for persons with disabilities and those with specific needs.

7 Accessibility requirements for metaverse services supporting IoT

Digital twin technology makes real-world objects into “twin” virtual objects in the virtual world and virtualizes and simulates the real world within the virtual world.

Although it is called a digital twin, it is unnecessary to reflect the real world 100% in the virtual world. Substituting real-world information into the virtual world does not fulfil the purpose of virtualizing or simulating digital twins. The purpose of the digital twin is to test and verify which real-world information becomes a parameter, and how a change in some parameters results in a specific outcome through the virtualization or simulation of the real world.

Accessibility problems in the real world can be overcome through digital twins using the metaverse. However, this can lead to distorted information when virtualizing and simulating the real world through digital twins to observe specific results. Providing accessibility through digital twins and the metaverse requires proper control and notification of such distortions.

This section lists accessibility requirements for the metaverse supporting IoT. The requirements are divided into three subsections: sensory perception, spatial perception and performing communication/action.

7.1 Accessibility requirements on sensory perception

When implementing digital twins through the immersive environment of the metaverse, the following accessibility requirements for sensory perceptions must be considered.

1. When the information to be virtualized or simulated with a digital twin is visual information, a metaverse service is required to provide a function for the virtual object to be magnified, expressed in high contrast or adjusted brightness, according to the user's cognitive ability.

2. A metaverse service is required to provide an auditory or tactile alternative means to visual information.

3. When expanding or reducing virtual objects, a metaverse service is required to notify a user that a distorted perception of texture, volume and depth may interfere with the user's information acquisition.

4. When a specific colour is changed and expressed for a colour-blind user, a metaverse service is required to notify that distorted perception of colour and texture may interfere with the user's information acquisition.

5. When a high contrast function is used to increase visibility, a metaverse service is required to notify the user that a distorted perception of shape, colour and texture may interfere with the user's information acquisition.

6. When contrast is adjusted, a metaverse service is required to notify the user that distorted perceptions of shape, colour, texture and depth may interfere with their information acquisition.

7. When audio content description is provided as an alternative to visual information, audio content description is required to explain the shape, colour, texture, volume and depth of the virtual object so that the user can obtain information equivalent to that of the user who visually acquires information.

8. When providing an alternative means of and recognising visual information through tactile information, a metaverse service is required to provide information on the shape, texture, volume and depth of virtual objects through tactile information, and colour information is required to be provided through separate audio information.

9. When the information to be virtualized or simulated with a digital twin is auditory information, a metaverse service is required to provide functions that allow the user to change the virtual object's loudness, pitch and tone according to the user's cognitive ability upon the user's discretion.

10. When the virtual object's loudness, pitch or tone is changed at the user's discretion, a metaverse service is required to notify the user that the distorted perception of the changed audio may interfere with the user's information acquisition.

11. For users who do not recognise the direction of audio, a metaverse service is required to provide a function that visually expresses this direction.

12. When assistive technologies such as hearing aids and cochlear implants are used, a metaverse service is recommended to provide the means to adjust the size, height, tone and direction of the virtual object's audio so that it is not distorted. Also, a metaverse service is required to notify the user that the virtual object's audio characteristics (e.g. size, height, tone and direction) may be distorted and interfere with their information acquisition.

13. A metaverse service is required to provide a visual or tactile alternative means to audio information.

14. A metaverse service is recommended to adjust virtual representations of digital twin objects based on predefined metadata profiles within its virtual world, ensuring better visibility, recognition and interaction for users. Such adjustments may include size, colour, shape, material/texture, transparency, animation behaviour, physical simulation, sound, position/orientation, interaction and lighting/sunlight response.

7.2 Accessibility requirements on spatial perception

When implementing digital twins in the immersive metaverse environment, the following accessibility requirements regarding spatial perceptions must be considered.

1. A metaverse service is recommended to provide appropriate visual and tactile information elements to assist spatial recognition of persons with visual disabilities.

2. When visual and tactile information elements for spatial recognition are provided, a metaverse service is required to clearly indicate whether they exist in reality or whether they are supplied by the metaverse.

3. A metaverse service is recommended to utilize auxiliary means, such as tactile paving and braille information panels, that persons with disabilities use to recognise and move through space in the real world.

4. A metaverse service is required to provide the function of moving to a specific location as a reference.

5. A metaverse service is required to provide information on the location and direction of the space of the persons with disabilities using appropriate information boards, audio guidance, AACs, etc.

7.3 Accessibility requirements for performing communication/action

When implementing digital twins through the immersive environment of the metaverse, the following accessibility requirements for performing communication or action must be considered.

1. The metaverse service is required to provide sign language interpretation and speech-to-text conversion functions for voice conversations.

2. A metaverse service is required to ensure compatibility with accessibility devices such as hearing aids and cochlear implants.

3. A metaverse service is recommended to provide the direction of audio information to help persons with visual disabilities locate the other party.

4. The metaverse service is recommended to provide a real-life mobility experience to users who use mobility aids such as white sticks, wheelchairs and electric wheelchairs.

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