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ITU-T STUDY GROUP 16

WORKSHOP ON METAVERSE AND MULTIMEDIA

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>> NOAH LUO: Hello in I think that we have only one minute until 1:30. I think our workshop will begin on time, so I would urge and invite everyone to take their seat in the room, and for those who are online, be ready.

>> NOAH LUO: Okay. It's already 1:30 Geneva time, so I think online people are joining from different time zones. It's a good gathering here and also more online from different regions of the world.

So with great pleasure, I announce the opening of our workshop on the subject of multimedia and Metaverse.

Today, we will have 10 different speakers from various backgrounds, and they will speak to us in two groups. Each group has five. We organization the workshop in two sessions to separate by a coffee break. But quite importantly, we have the pleasure and honor to be able to invite Dr. Bilel Jamoussi who leads our Study Group Department in the T Sector, so he's supposed to give us an opening speech. Let's welcome with applause to Bilel Jamoussi's opening speech.

(Applause).

>> BILEL JAMOUSSI: Thank you very much, Chairman. Good afternoon to all the leagues here in Geneva and welcome to sunny Geneva today, and also greetings to all the colleagues online joining us from around the world.

It's a pleasure to be back here in Geneva after a while for me, and to be able to welcome you at this workshop on the Metaverse. Certainly Dr. Chaesub Lee sends his regards and he's on Mission to Indonesia for a workshop organized with ISO, IEC and WTO so he's not able to join us here today for this Opening Workshop and I'm pleased to be here with you.

The concept of the Metaverse, quite an interesting word and topic. We have seen it at WTSA, we had an exhibition. Many of you who were here in March at WTSA, have seen and heard on the Metaverse, and of course participants in Study Group 16, had this topic on their radar since January.

Certainly a topic that is attracting quite a bit of public interest, and a lot of our members are trying to understand it. The correspondence group that Study Group 16 has established has started to progress the understanding of this topic, and I think they produced a nice paper that could perhaps be published as a technical report from Study Group 16. I think that would be a useful input, not only to SG16 but all the other Study Groups in the ITU who are trying to understand this new concept and understand how to use it.

The Times Magazine has published an article online in August on this topic, so there is quite a bit of interest in it and trying to understand it. Of course, for us in ITU, we're trying to understand what are the elements that could be standardized, and certainly this is not something new for Study Group 16, given that it has already been working on standards for augmented reality, extended reality, AR, VR, virtual reality, et cetera. So we already have some expertise and some knowledge and some output in Study Group 16 that we can build on.

And this is a wider topic, I think, than Study Group 16 on multimedia. Certainly, there are security aspects that maybe Study Group 17 will be addressing. Many applications for, perhaps, Smart Cities and Communities that Study Group 20 might be interested in.

I was shopping for a kitchen last week while I was on vacation, and I thought it was very interesting to see that in the shop, they had, you know, these AR and VR masks and you can design your kitchen with the mask on, and imagining where all the cupboards are going to go and where the electronics will go and so on. It was something that the consumers are already playing with and facing, so it's important to see how we as the technical community can put together some standards to facilitate interoperability in exchange of equipment and devices and network connectivity worldwide. That's our scope of focus, and I think that it is very much a pleasure to be with you today in this workshop to kind of kick off this broader discussion.

So I'd like to also take this opportunity to thank Huawei for hosting the reception this evening at 6:30, and I wish you a very successful workshop, and I hope that not only SG 16 will benefit from the outcome of this discussion but all the other Study Groups in the ITU that are interested in this topic. Thank you, Chairman.

>> CHAIR: So, yeah. Once again, we would like to give our thanks to Dr. Jamoussi for his very exciting opening speech. He gave us a lot of guidelines and information on -- and I think now I give you quite a brief talk. I didn't prepare a slide to help me, but I will use only one slide. Yeah it will be shown on the screen. This is not the beginning of my story. I want to show you a book. This book is really interesting. It's a nice one. One of the most recent technical and business best sellers. Yeah, it's called *The Metaverse* by author. I just want to read one sentence from the book jacket. The term Metaverse is suddenly everywhere from the front pages of a national newspaper and the latest fashion trends to the plans of the most powerful companies in the future. I think this sentence just describes what is going on. So what is the Metaverse, it is -- we need to be very careful, but one thing is quite certain that people are just working together to build a understanding, including definition and scope for such a very grand thing.

I remember an old Indian fable with 6 blind men poaching an elephant because they don't have eyes, they can onlynd the animal through the touching and so each touch a different part of the elephant and they try to form a whole picture, but they have great difficulties. So we don't need to laugh at them. Human beings are doing the same thing when we are facing something as great and fresh as the Metaverse thing.

A great effort has been conducted everywhere, including in our ITU-T. What we are doing is we try to contribute to add to this process for human beings to build an understanding of a Metaverse and its values and implication to the human societies. I think we, for this purpose, we have been working quite hard since March -- since February of this year, when we decided to create this correspondence group, and now through the whole process we've held many workshops, today's workshop and to quite a great scale. I mean we have a gatherings of guests from different sectors, industry, academia, hopefully someone concerned with the regulatory and policymaking. You are all welcome to join us for the common target that we can contribute to a better understanding of Metaverse.

I just want to use this slide to show the basic idea because you ask different people and they have different notion about the understanding of Metaverse. A's understanding is not necessarily the same as B and C. So this understanding may have something in common. If there is any commonality that will serve in the common underlying statement for Metaverse, in my understanding maybe looks like this. Metaverse may mean or might look like this forest of different trees. Each tree probably represented from

the application service, but underground there must be some fertile soil to enable the tree to grow in the forest. So probably ITU-T is especially understanding what we are doing here may help with this kind of purpose to provide the healthy growth of this forest with some very fertile soil. We try to instill the fertilizers and nutrients into the soil to make it very fertile and to make such growth sustainable. So, we will contribute from many technical perspectives.

So this is my perspective, it is my vision for what can be done from the point of view. I think just like Dr. Jamoussi's side we want to be part of the global effort to makes things happen. That's the purpose of today's workshop. I think some people are writing books to popularize their ideas. What we are trying to do is meet people and gather people together to have brainstorming. Okay. This is also our contribution. I stop here. I sincerely hope we can have a very productive and very thought-inspiring meeting today.

So, we have 10 speakers from different backgrounds, and also they are grouped in two sessions. I with great pleasure, I invite my colleague, distinguished scientist from actually Korea Dr. -- so I will chair and be the moderator for the first session and Dr. Kang will take a turn it Chair the second session. We also will provide a coffee break for people to get refreshed.

Okay. Thank you very much. Let's begin our formal session now. Yeah.

I think just like Dr. Jamoussi mentioned, the joint efforts among different study groups of the ITU-T -- between ITU and other SGs will be quite a desirable thing. I mean a study on Metaverse has been conducted in different study groups in the T Sector and 16 is one and 17 to my best knowledge is also doing very well, so they are a specialized domain in security and privacy. I would like to invite the Chairman of Study Group 17, Professor Heung from Korea to share his views and the information from Study Group 17's side. I will check if Dr. Heung you are already online in.

>> HEUNG-YOUL YOUM: Yes, I am here. Thank you, Mr. Luo, Noah for inviting me to this workshop. I will start my presentation. So, my name is Heung Youl Youm and I am Professor at Soonch (?) University in Korea. Currently mentioned by Study Group 16 Chairman and my colleagues, Chairman of Study Group 17. It's my great pleasure to join this workshop virtually and I think for this, including Study Group 16 Chairman for inviting me to this workshop.

The title of my presentation is Metaverse: Security and privacy. Consent is as follows from the definitions to the references. So, next slide, please.

Actually, there is -- there are no definitions on Metaverse in ITU and ISO, but according to the wikpedia, Metaverse is defined as a high-process iteration of Internet as single universal immersallable virtual world that is facilitated by the use of virtual reality and augmented reality headsets.

Study Group 16 discussed the terms of Metaverse at our last Study Group 17, our September Study Group 17 meeting, and we identified this Metaverse is registered as a trademark, so we may need to use another alternative term. Alternative term immersive virtual universe. So it is now being proposed by Study Group 17 for use when we send a liaison statement to TSAG and the potential established focus group on Metaverse.

So there are two instances I found in ISO, OBP as of today. Next slide, please.

Actually, we are very interested in many use cases in Korea, but I pick up only two. My university had a ceremony in March 2021 by using Metaverse. A virtual-reality space is used for entrance ceremony because at that time we could not hold a physical entrance ceremony due to the pandemic. So, new freshman can interact with other people with a computer-generated environment, and this was supported by SK Telecom and Soonchunhyang University freshmen attended the virtual ceremony welcoming as avatars through an app.

Then another is created by Korea Tourism Organization, a virtual space that simulates Seoul's tour of the attractions and introduced tourists to visit by utilizing we have a portal NAVER's so called a ZEPETO platform, that is a Metaverse platform in Korea.

Next slide, please. Areas for Metaverse use cases are many, as follows. Firstly, game areas we can use immersive entertainment or Internet gaming services, business operations, for example in Korea Sinon Bank one of the second largest banks also has a (?) financial institute in the country with Metaverse platforms. And then also there are many other areas with improved education and training and enhanced customer experience, work meetings like the Zoom platform here, and advertising, branding, and marketing opportunities, digital locations, selling digital goods and services, more connected work experiences, and others are many that you can imagine. Next slide, please.

What are the key technologies for Metaverse? Blockchain and Cryptocurrency I would like to mention. And then another is AR/VR technology and 3D modeling and artificial intelligence, and Internet of Everything, IoE, and digital humans. Next slide, please.

So, assets to be protected for Metaverse services. I believe that we need to protect the user profile data, such as authentication credential data, financial data, behavior data such as the user profile, sensitive biometric data because some use cases, we use biometric data. And the data for Crypto assets such as Cryptocurrency and digital goods and assets, including non-fungible tokens and then systems for providing services and application. That is to say we need to consider to be protected as an asset. Next slide, please.

What are the examples of security risks in so first thing is identity theft is one of them. So malware attacks -- if various

security is not adopted, theft in Metaverse can be even more easier. The next one is malware attack such as ran someware so if malware is installed on the platforms, so I think they collect the data and then they try to put your data through the deep Internet. Then the third one is theft of virtual data and collect data using social engineering attacks and then sell the data on the deep Internet. Sometimes there is a shared space so if you use a shared space, there is a risk from using the shared space. And then we can use use deepfake for Bocus information and then the bogus information could be delivered for other purpose. And then theft of virtual assets of Cryptocurrency and digital goods and assets could be used in the Metaverse services so theft of asset such as currency and digital goods and assets, including non-fungible tokens is one of the key security risks.

Next slide, please.

What are the privacy and social risks? So be thankful if you use collecting unauthorized data about individuals is one of the examples as a privacy risk, and then if you can see ISO and IEC 29100 so they define 11 privacy principles, so if example consent starts from consent of choice. So if one of the privacy principles is compromised it could be one of the examples of the privacy risk. And then the other thing is a kind of social risk that is harassment and cyberbullying, so those are other issues.

Next slide, please.

Example of security and privacy measures. Actually, there was a ITU Plenipotentiary Conference meeting, and for the discussion of Resolution 130, Resolution 130 is a building competent security in the use of ICT, very high-level and overarching resolutions, so we discussed the issues. We agreed to take -- we asked every Member State to take very exclusive measures.

So we mitigate security and privacy risk, so we may need security measures such as using of a strong password, multi-factor authentication, robust identity management and software updates and anti--malware software. So that could be examples of security measures.

And then Metaverse-specific security and privacy measures needs to be developed, taking into account security measures to prevent security risks, which are described in ISO/IEC 27002, such as access control, identity management, supply chain management, Cloud computing security, response to security incidents, et cetera.

And then recently in 2020, I believe, ISO published a new standard, ISO/IEC 27701 provided a complete set of privacy controls for data controller and processers, so we need to consider those to develop a Metaverse-specific security measures and privacy measures.

I know we in ITU context, use of the privacy measures is a very sensitive one. We discussed those issues, and we discussed a Resolution 130. So in Study Group 17, Point W, we define a PIA protection as a security clarity could be used to protect a PII,

so in this context we could consider that augment. Especially compiling of security assurance is necessary to evaluate the integrity of the competence of the Metaverse services.

Next slide, please.

Concluding remarks, so actually when we discuss in the ITU PP Resolution 130, a new term, security by design and privacy was introduced, and I believe that security by design and privacy by design approaches should be considered by the beginning of the Metaverse services, and then we need to use a risk assessment-based approach to develop or identify new security measures. And then, actually as I mentioned, Study Group 17 discussed these issues, Metaverse security issues at our Study Group 17 December meeting and then Study Group 17 needs to augment, needs to convince us that the standardizing work is very critical to provide the interoperability for services, including security and privacy. And then we, actually Study Group 17, send liaison statement to TSAG about our agreement to establish a focus group on Metaverse as a way forward to address the diverse aspects, including security and privacy and also definition of the Metaverse. Because as I mentioned, Metaverse is registered as trademark, so we may need to define a new term, use a new term, or we may need to define terms on new terms of Metaverse.

And then security empty privacy framework, including assurance should be developed. And then is the reference I used when I prepared this slide, and thank you very much for your attention. Again, thank you very much for inviting me to this workshop. Thank you.

>> CHAIR: Thank you very much, Professor Youm. I think you have done an excellent job in convincing people that what has been started in Study Group 17 in relation to Metaverse is quite important, so thank you once again. Also, I think to build a synergetic effort among different study groups in ITU-T, the new trend stemming among them is quite desirable, so you just made your latest contribution and have a mutual understanding. Taw very much once again, Professor Youm.

>> HEUNG-YOUL YOUM: Thank you so much.

>> CHAIR: Okay. So I think so far so good. Just on time. Not even a single minute late. Let's introduce our second speaker, if you please open the page for Professor Yu. Professor Yu Lu is distinguished professor in college of information science and electronic engineer at Zhejiang University and most prestigious University in China located in one of the loveliest cities, and Professor Yu is one of my personal friends and we've known each other for a long time. 2D and 3D representation in her research and in thes those general area of video coding and processing and holds many important positions in a range of organizations including IEEE ISO/IEC, JTC 1 and quite active in our Study Group 16 with a lot of contributions. So, let's welcome professor Yu to have a talk about what's going on from her perspective.

>> LU YU: Thank you, Chairman, for your introduction. I hope I can share my screen since my presentation has a video demonstration. Can I? Can you see my screen? Okay. It's my honor to be here with you in this workshop. Metaverse is a very hot topic recently, and this talk will discuss about things on the immersive video coding, which I believe is one of the key technologies of Metaverse.

So, at the beginning, please allow me to introduce the ISO/IEC JTC 1/SC 29/WG4 MPEG video coding Working Group and our video delivers the essential video coding and low-complexity video enhancement coding which is a layered design for video coding, and most recent delivered work is the neural network compression standard. And this talk will provide a more information about the MPEG immersive video coding which is an ongoing project in WG 4, and we also have some other expiration activities for potential standardization projects, such as Lenslet video coding and implicit neural representation of video.

So, as you know for Metaverse, the visual impressive experience is very important dimension of our experience in Metaverse, so we try to provide environments that completely surround you, to make you feel like you are part of the environment and you can watch the environment from any orientation or position at any moment in time.

And I'm speaking of the virtual orientation, actually there are two categories, one is three-degrees of freedom or six-degrees of freedom. For the first one, so you just turn your head around and it's just as the video demonstrates on the left-hand side. So in this video, the occlusions between objects in the scene would not be changed. But if you go around the scene as the video demonstrates in the right-hand side, the occlusions between objects will be quite different.

So the content providing from 3DoF to 6DoF is actually quite different. So to provide such a 3D visual immersive video, there are different types of representations. Traditionally, we can use multiple view texture and depth or use the multi-plane for image or 3D Cloud or mesh to describe such things. And most recently, there are a lot of research on using overfitting a neural network to represent such a 3D scene.

So, for these different kinds of representations, ISO/IEC and some together with ITU-T to develop different coding standards for those different types of contents. For example, HEVC with extension of multiple-view content, 3D HEVC and in the video coding standard, the 360 video coding is already included. And most recently, WG 4 is working on the immersive video coding. And the simulation with that is the point cloud compression and actually these two standards share the same framework, and I will provide more information about that.

So first of all, let's take a look at the video content, the immersive video content we used for the development activities of MPEG immersive video. Some of the content is captured from nature

scenes by dozens of cameras. The cameras can be set as linearly or along an arch or in 3D array, and those contents can also be synthesized to virtual cameras. So actually even though we have dozens of cameras, if you go around the scene by simply switching between cameras, you will have very different results. So what we expected to have is we can smooth the switching between those cameras, so we have to use view synthesis. And we also tested how the camera settings should be. So for the same scene, if we synthesize from let's say 2 views, then the occlusion issues can happen in those interpolated views. If you use more source views, then the smaller disocclusion issues may happen, so you have to have sufficient source views to provide smooth switching in the scene, to go around the scene. Then this goes to the requirements on the MPEG immersive video coding standards. So the input to the system should be the dozens of input cameras the texture and depths map, and to make the system affordable, we have to reduce the pixel rate significantly to make it affordable and also to provide sufficient coding efficiency for the huge number of data.

And another wish is to if we can use existing video code that would be fantastic. So the design of the MPEG immersive video, actually in the pipeline we include a pre-processing procedure and post-processing procedure, and in between is the -- we can use any existing video code deck.

So let's take a look at a little bit more details about the framework of it. So dozens of input views with texture and depth map are input into the pipeline. And in order to reduce the pixel rate, a procedure named as inter-view redundant to removing is required. So, the key view will be projected to the other views to find out if the projected pixels are quite similar in the target view, then in those areas, the contents should be redundant.

So only those non- redundant areas which are these accrued areas of the target view will be left off of this redundant to remove them for procedure. So those pixels will be merged into patches, and then all the patches in different views will be packed into a so-called atlas, which is a packet of video with texture and depth map. So the packed video will be coded by using the existing video code deck, and by this procedure, about 70% of the pixel rate will be reduce, and we can have a more than 60% bitrate. Then we need to describe the atlas that describes the positions of the atlases as well as in the original source views, so these two bitstream will be multiplexed into the MIV bitstream, and AS a matter of fact, the same framework is also used for the point Cloud compression, so the 3D point will be projected on the bounty box and those pixels will be emerged from the patches and again the same the patches will be packed into atlases.

So there is also video bitstroam and metadata bitstream which will be multiplexed into the V-PCC bitstreams. So considering there are key similarities between these two things, so we decided to define the same framework name as Visual Volumetric kip voido-based Coding, so V3C, so V3C is now standard as the MPEG I

Pack 5 and the Annex edge of that standard actually is the Video-based Point Cloud compression. And then another part of I part 12 is reference to the V3C, the basic framework.

So, in the V3C standard, the syntax and semantics of the bitstreams are defined, and there are two subparts. One is for the parameter sets, including the camera settings and the atlas data. The other part is the video subscreens for the frames of atlases. And, of course, we've needed to extend the basic design of this to describe the information about the flexible setting of cameras, and so on.

So, actually if we define different operation modes, the basic one is the atlas mode, which the patches will be generated and packed into atlases, so this is the basic mode and other than that, there is view mode which is a simplified version. So, for each source view is one big patch in the atlas, so this is a simplified one, and we have another mode named as geometry absent, in which the depth map will not be transmitted in the bitstream, but will be estimated at the decoder side.

And there is one additional mode is the entity mode, and in which the patches are grouping of pixels of the same object. So that in this mode, maybe you can edit the objects, remove or add more objects in the bitstream. And additional to that, we have a frame-packing mode which pack with the texture and depth map in the same atlas.

So, the key features of MIV standards, we can support somewhat sort of flexible camera arrangements, and we support also graphic content or ERP content for omnidirectional videos. And one of the key features that we can reuse the existing video code deck for the compression of MIV content.

So, for the first edition of MIV, our plan is to reach FDIS next week and in the meantime, we are also working on the MIV Edition 2 and we expect to provide more flexible camera settings, for example the camera arrays can be array bl, it's intrinsic and extrinsic parameters, and texture and depth can be captured from the different view positions, and we hope we can have better support for nonLambert ian characteristic content, for example in this picture there is mirrors or highly-reflective surfaces in the video.

And in the meantime, we also try to support the combination of the heterogenous into a simple bitstream.

So in that case if we sample a content object provided with a point Cloud, can be merged together with content of video based. So in this video, actually one of the persons is provided by a point cloud. The others are provided in the video. That's for the MIV.

And the latest new activity in WG 4 is we just start to study on the neural representation of video for both 2D video and 3D video. This is a new topic. We will see if we will define any new standards based on such new representation.

So, that goes to the conclusion of my presentation. There are a lot of challenges. We can have solutions for some of those challenges, like a huge amount of data, a high density of data, that we still need to find good solutions for high-complexity of processing, support more interaction than going around in the scene, and the good news is we have AI technologies and we have good transmission technologies, for example, 6G or semantic communications and so on.

So, I'm glad if you -- if we can have more discussion or communication together with ITU, especially SG 16 for the topic of immersive media for Metaverse. Thank you very much. That's my presentation.

>> CHAIR: Thank you, Professor, Yu for such a excellent overview of what is going on on the impact side in relation to potentially to Metaverse and another number of relevant technologies. Professor Yu is active in both organizations. I mean ISO/IEC, JTC 1 and also (?) and this time she's more and we'd like to encourage more professors from academia and more research from industry work and this model, and also we believe Study Group 16 and MPEG and JTC 1 in general, will continue to enjoy such a collaborative model we have been deploying for more than two decades.

Once we have a clear understanding of about the technical requirements and what needs to be standardized for Metaverse, so I believe us two organizations, we two organizations will launch a new effort just like what we have been doing so far like JVT and other forms of collaboration. Thank you once again, Professor Yu.

>> LU YU: Thank you.

>> CHAIR: Now I think we keep our pace and momentum, so we move on to our third speaker. Yeah. Please open the page for Ms. Yuan Zhang, so please come to the podium and, yes, Yuan Zhang is dependent Director of China telecom And based if Shanghai and co-chair of ITU-T Working Party 3 and also is responsible for originally proposing a new technical domain named video coding for machine, and that's very important subject and impact as well. And also, she Chairs Question 12 for surveillance system and ITU-T Study Group 16.

So, yeah, now we just will listen to her talk. Thank you, Ms. Zhang, please.

>> YUAN ZHANG: Good afternoon, colleagues. Also, good morning and good evening for online colleagues. This is Yuan Zhang from China telecom and my topic is audio and video in empower Metaverse and I'm glad to have this opportunity to present our consideration regarding the audio and video technology and its application in the Metaverse age.

So, several market research institutes have anticipated the global Metaverse market on the basis of the product type, applications, and geography. The results ranging from hundreds of billions of U.S. dollars to trillions of U.S. dollars with the approximate

proposing a generate of 20% to 30%. Crisco has anticipated by the end of this year, we will make up 82% of all Internet traffic.

And in future, in the Metaverse era, the Internet traffic will be dominated by 3D, AR, VR, XR, et cetera, which will grow up to the percentage of 90% and the video data will become the major driving force for the network technology and network economy.

Here I listed several Metaverse scenarios. Some of them are similar to what Dr. from Study Group 16 introduced, developer/creator, virtual workspaces, digital entertainment events, social commerce, smart manufacturing, healthcare, education, and climate change. And the Metaverse presents a large opportunity for content creators to come up with something unique and find a niche for themselves, and the workspace could turn virtual their already products such as Facebook horizon workrooms and also Microsoft Mesh for Microsoft Teams and also the tourism could be made online, and the virtual environment could help host virtual conferences and other events. For example, the creator of a recent organization has released a map for Metaverse offering visitors a chance to experience the cultural heritage site, and also there is an online group named pixel that is aiming to build (?) of the Metaverse.

Regarding smart manufacturing, digital twin technology of virtual representation of the real world physical assets continues to be updated and integrated with video analysis. There are a lot of examples, and one of them is is exploring digital twin. And also in healthcare, early use cases involving healthcare training are emerging, and Microsoft Hollow Lens technology has already been explored in nine operations such as well as surgical cases to provide medical care remotely.

And regarding education, scientists and researchers conduct experiments using digital-twin technologies. And for immersive learning experience to help the students to learn and also enjoy the campus activities. And also for climate change, that there are models, 3D virtual models to reflect the climate change to model, predict, and track it in realtime to build the giant Metaverse of the planet earth. So in conclusion, the scenarios bring up new requirements and opportunities, and the underlying technologies should grow to support and sustain the development and prosperity of the industry development.

So here is to realize the true vision of Metaverse. There are still gaps and challenges. Some of the same as just analyzed by Dr. Yu, that immense investment and progress will be needed in computing power, networking, algorithm, and data at orders of magnitude higher than what we have today.

So the first challenge that is the computing power to support the virtual content creation experienced in the Metaverse. The realtime modeling and interaction with large scale of users requires super computing power.S a the global computing power growth falls behind the growing of data and algorithms. As

predicted by Intel, the Metaverse would require an exa flops which is 1,000 times the current total computing number.

For interactive 4K VR game, 20 flops is required and based on the most 8 to 10 times power growing could be seen in 5 years, so we will require more computing infrastructure, and data center especially with intelligent computing and green computing power.

And also we're needing innovation in semiconductor and more efficient algorithms. And the second challenge would be network. Today's latency-sensitive apps like video calling and Cloud gaming have a roundtrip time latency of 35 to 150 milliseconds and multi-player complex games can go 30 milliseconds. However for the Metaverse to be truly immersive, graphics need to be updated much faster; for instance, single to low double-digit milliseconds. The Metaverse would require more bandwidth than the majority of Internet applications and games today, as mirror needing the Metaverse need to interconnect the diversity of the real world and capture the dynamic changes in realtime involving along with the real world. There is that for every 10 milliseconds increase may be decreasing game latency and the user's game latency decreases by 6%. So regarding network, a super large-scale realtime, interactive and persistent virtual environment requiring a network featuring global coverage, large bandwidth, and almost no delay to continuously provide immersive content and realtime interaction to users.

And the third gap we analyzed is immersive experience gap. The Metaverse is likely to be accessed via a head-mounted display, centimeters away from eye, requiring large-resolution videos well beyond 4K and it needs to provide 3D video, multi-degree of freedom video, and also spatial and temporal video and audio, volumetric video, stereo, audio, video both for human and machine consumption and the computing power and network should be content and semantic oriented instead of decoupled today. So the Metaverse would require substantial improvement in both algorithms and natural and generated data content innovations across the hardware and software.

So the computing and networks and the data and application about them which could promote the application of audio and video technology, and on the other hand the audio and video technology brings new requirements and promotes the development of the underlying network and computing technology. So instead of the decoupled computing network and the content above them, the network and computing mothers age should be content oriented. So based on the analysis of challenges and gaps, the ultimate goal is to deliver and produce more authentic content for better user experience. The Metaverse is a digital world, in which augmented physical and virtual reality emerge. The co-technology driving the success of designing an efficient immersive environment, and among them we can see that here is a technical architecture that we do together in the industry, that video and audio are in building technologies, and I think it's yet difficult to agree on an exact definition of Metaverse, but maybe three things could be

agreed upon now. The first is Metaverse is one of the main development directions and representatives of the next generation of Internet, featuring holographic and Omni-present and the Metaverse is a fusion and virtual space where people live and work, and the Metaverse is an important creation and productivity of future digital assets.

So, the K video and also related technology, and I'm referring to twin technology, includes video coding and processing, some just introduced by Dr. Yu, such as immersive video coding, volumetric video atlas, et cetera, and also digital twin. I'm sorry. Slides are not working. Oh, that's the previous one regarding the technologies. No, next. Next. Next one. Yeah. This is the one. Thank you.

I'm sorry. This pen is not working. So, there are also technology of digital twin and 3D and spatial computing, which can reconstruct the details of digitalization and can create a one-to-one replica with comprehensive information for people, objects, and environments, and it connects maps and couples the digital world and real world with realtime sync, and represents Metaverse in the real world. Next slide, please. I'm sorry, the previous one. Key audio technology. Yes, this one. Yes.

So, many of us first think about the visual component of the Metaverse, but audio is just as important in creating the realistic virtual world, and key audio technology of Metaverse includes audio recognition, audio understanding synthesis and acoustic field reconstruction of virtual stereo and also emotion recognition and audio interaction which could enable the Metaverse to interact through natural language with authentic emotional and unique voice and also immersive audio.

Next slide, please.

So, here are some standardization considerations regarding Metaverse, as well as the co-chairs of Study Group 16, WP3, and WP3 is responsible for audiovisual technology and intelligent immersive applications. It should support the standardization of Metaverse emphasizing on the novel audio and video processing and application. So WP3 has four questions highly related. There is Question 5 on AI-enabled multimedia and also Question 6 for visual audio and signal coding jointly working with MPEG and Question 8 for immersive live experience, and Question 12 on intelligent visual system and services. And there are also related questions of Question 22, 23, 24, 26, and WP1 and WP2 on different aspects.

And also, different study groups should work together among Study Group 11, 12, 15, 17, 20 on the aspect of network computing evaluation, security, and applications, and different SD Os should also collaborate. I learned that some SDOs, different aspects of Metaverse, and I've listed some major ones here, so ITU should collaborate with ISO/IEC, JTC1, IEC, IEEE, IETF, 3GPP on digital twin and digital human and many others. Next slide, please.

And as China Telecom, one of the operators, here are some considerations regarding the role of operator. In the Metaverse

age, a operator can position itself majorly as the constructer of Metaverse infrastructure, taking advantage of the network, Cloud, data and computing resources to promote the integration and collaborative innovation of the ecosystem. And we made three suggestions here to develop the core capabilities of audio, video, AI technology, like I just introduced the 3D coding, rend dering, audio interaction, et cetera. The goal is to provide and operate a platform integrating IaaS and Paas capabilities and design and build applications of business, education, culture Metaverse both to business customers and users, and cooperate and collaborate with the ecosystem in the prospective of technology and industry breakthroughs in chips, AR/VR/MR/XR, wearable devices and naked eye 3D, et cetera.

Next slide, please.

And at last, I would like to briefly introduce some of our practices in China Telecom. Here is the Metaverse digital twin map space system based on 3 dimensional seeing of our China Telecom Research Institute building, the campus, and multidimensional information virtualization with video of different regions such as parks, communities, and business zones and other multidimensional information in realtime. It can display and quickly locate the information point. It adopts our new video coding algorithm and video rendering engine to encode the graphic information to the stream and push it to the front end web system through Web RTC and the multi-dimensional information such as Internet of real cost and mentoring with 3D model is integrated and displayed on the platform to perceived environment. Next slide, please.

And here is an industry Metaverse application we collaboratively developed and it's the integration of digital twin of the steel production line and here is the video if we can play it, and it's the object generation and machine integration and IoT sensors by clicking on the twin for the steel production line, we can actually show the video on the virtual screen and we can see the detection and tracking of the tail of the steel line. Okay. The video is not working. It integrating our algorithm of coding and realtime video tracking and direction, and also smart target detection and content generation. Next slide, please.

And the last one, so we have also developed algorithms of speech-driven lip synchronization, including the temporal and spatial phonome detection and mouth-shape sparing and rendering and it can provide the digital human on rebot with lip sync and expression-driven capability and we also developed speaker identification application, using voice recognition, actually voice-feature recognition generation, and this application has been our China Telecom systems -- next slide.

So it concludes my speech and look forward for future cooperation. Thank you very much.

>> CHAIR: Thank you very much. I think this presentation provides a unique perspective for us to develop better

understanding of what major telecom operators are doing in relation to Metaverse and how they view Metaverse as a game changer, and what are those underlying technologies that will be useful from telecom operators' point of view, and that kind of information to be merged with information from academia, will be driving our work and have some quite enlightening input into our general work on Metaverse and related technology in Study Group 16. Thank you once again, Ms. Yuan Zhang.

Now I think we are just a few minutes behind our schedule, which is good and controllable. We would ask next speaker, Pro spesser Shin-Gak Kang of ITU-T and ITU-T standardization activities as well in standardization. He's from Korea and one of the prestigious National Research Institute well-known, world-famous and graduate in 1984 and joined ETRI and since then has been working in a number of study groups in ITU-T, including Study Group 7, 17, 11, 13, 16, 20, and as well as ISO/IEC, JTC1, IETF, IEEE, NGSON and Rapporteur, convenor, editor and major contributor to those organizations. He's now joinedly leading our correspondence group for Metaverse which was created in February of this year. Okay. I think now let Dr. Kang have the floor to give us a talk.

>> SHIN-GAK KANG: Thank you, Mr. Chair, for the kind introduction for me. So I would like to focus on some Metaverse standardization issues. So, as you know, the Study Group 16 created the correspondence group on Metaverse to study, so we studied several relevant activities on Metaverse, so I would like to briefly share the information and some future direction of the Metaverse standardization.

Okay, so what is Metaverse? The term Metaverse originated in 1992 science fiction novel Snow Crash and there are many different views of Metaverse. I don't want to read this one. You can see. Finally, there is no universally accepted definition of Metaverse. I don't know the 1991 vision of the world.

And there are so many different views. That Metaverse is a space, virtual and reality converge, and people or things interact with each other, and creating economic, social, and cultural values. A lot of important point in the third one, that I think Metaverse can create economic values that is very important for the companies and many people, I think.

These are different characteristics of Metaverse from many experts there are, okay, mentioning some characteristics of Metaverse. Important points the interoperability of the Metaverse, so you can see especially, meta, saying that one of the important characteristics is the interoperability of platforms and work with many study and on the interoperability issues, I think.

Yeah, so there are different kinds of Metaverse scenarios, and they define four different scenarios, you can see augmented realities and others. There is some some distinctive definition. I think currently the meta scenario is evolving into fusion form

of each scenario where the scenarios converge each other so I think there are various types of it.

And, yeah, Metaverse is popular since the 2020 event by NVIDIA, so has told that the Metaverse returns but the Metaverse is not new, but it is new trend again raging again recently. So they say that the Metaverse has already presented so now just returning. So why Metaverse returning in I think there is various background things that first is innovation of the ICT technologies and also change to society and transmission actors to traps fur information across, and the -- focus on the Metaverse.

Okay, so in Metaverse, Metaverse is technologies so contains many different kinds of technologies. Metaverse can be implemented through organic linkage of various ICT technologies, such as XR, AI, data, network, Cloud, digital twin, Blockchain, so on. Because the Metaverse is a combination of various technologies it's difficult to define Metaverse specifically. There are so many relevant groups working on this kind of technologies now days.

So, we can see that there are various standardization activities at no time world, and this is just to show us some cases or issues working on some specific areas. The promotion of the standardization for relevant technologies for Metaverse platform corresponded to the domains for each standards and organizations, so they -- many organizations are working on standardization work related to Metaverse within their scope, and especially from this slide, you can see some recent standardization results from many institutes, emphasis 24 tarred group developed several standards on the relevant issues, and also 21 impact group developed several also tarred on framework proposal to several multiple standards on the impact proposal. And also they developed different kind of some feature of video coding for providing immersive -- and recently also working on some IoMT and this is Metaverse I think. And also another group ISO TC SC9 working on wearable devices and TC 1 3 working on human, developed standard regarding the virtual human body and TC WG6 working on important holographic display devices. Yeah.

Next page, please. Yes. Also, there is IEEE 2888 Working Group working on the interfacing cyber and physical world. Especially working on synchronization and mapping and synchronization issues between the physical world and virtual world. They are working on some relevant issues currently. They are actively studying the relevant issues. And also the other 3079 Working Group is working on human factors for immersive content, and yeah this is another group of the IEEE. Next slide, please.

Yeah. Okay. There is another famous group, Khronos group working on some very important 3D graphic and recently working on XR and VR-related coding, so yeah XR is very famous relatively open standard in many applications. W3C also started working on the Metaverse MICG working on interoperability aspect and focus on find solution for Avatar, and focusing on portability and digital

asset portability, but they didn't when I was there to study at the moment.

Okay, so 3GPP we know very well on mobile communication group, so recently the 3GPP also started work on this Metaverse issues. And recently they had approved new work item on the Metaverse-related issues, and they think about there is some provide timely media to multiple issues, reception to low latency and standardization to enable services based on of objects. Very important, so they work on this issue. Recently 30 companies supported this study item, including many companies in the world.

Yeah. Study Group 16 is also working on digital human related application, developed some standards already.

Okay. Recently, you know that there are important trends, including important changes in the poiser issues and there is Metaverse Standards Forum and this MSF was created in June of this year, and they are fostering the interoperability standard for open Metaverse. They're going to identify some of today's pain points and action to help them with standardization. This is very important activity. Can you see here they are including, SGOs, SDOs, they do not want to develop standard itself but just want to coordinate among the SDOs, it's not clear but very important activities and standardization on the marketplace. And there are related many SDOs that joined this MSF to coordination the Metaverse standardization.

So as Study Group 16, you know that Study Group 16 is working on multimedia and related digital technologies and Study Group 16 covers very different kind of technology issues. You can see here basically the multimedia is one of the common basis for Metaverse. Many questions are already working on or starting to work on different technologies. We have the audio and visual coding groups, and also AI groups are working actively to develop some AI-enabled multimedia application issues, and also we have immersive live experience related to groups and Blockchain groups and accessibility, human factor, digital culture, digital health. So, you can see that Study Group 16 is pretty important standardization group for the future Metaverse work.

Yes. I think the Chair of the SG will present the details about the Metaverse activities. So they established at this SG in January and then after that we are working on actively for the study on Metaverse topics and we have -- we had three e-meeting and developed some report. Okay. Study Group 16 will discuss further at this meeting, especially the terms of reference for the future focus group. And then I think it will be discussed in this Study Group 16 meeting.

Okay, so just about the evolutionary directions of Metaverse. Metaverse maximizes immersion through immersive technologies and it's one of the important directions, so very important. Another second direction is expands the experience of reality through, a vatars and digital human, the digital human is very important component to the future Metaverse platforms and also it enables

collaboration and communication beyond the time and space constraints. Mothers provided some really good quality Metaverse platforms for collaboration activities. And also okay, various digital assets are produced and distributed through the platform. This is another important issue because the digital assets can be used as virtual platform in the future.

Also, Metaverse allows for full interoperability between platforms. You know, there are some different platforms now days so, yeah, we needed to make some interoperation among the digital platform. So based on this direction of Metaverse technologies, and I think we need to work -- think about how to proceed our Metaverse work. I know know of the current Metaverse platforms are very close to closed type and limits the expansion of Metaverse ecosystem through the connection. Building an open Metaverse can expand the Metaverse industry and lower the entry barriers for latecomers, and open Metaverse means all data and functions are distributed and interoperability between Metaverse platforms. So based on this, I think the Metaverse, the multi-versus airo and Metaverse technologies connected and so we need to work on activities and standardization of Metaverse issues. This is maybe last slide, I think. Yeah. Thank you so much. Yeah.

>> CHAIR: Well done, Dr. Kang. So this presentation provides us with I think almost holographic overview about the work related to Metaverse in different SDOs, and probably also shedding some light on the relation between them. Also, good introduction to what's going on on the ITU-D ecosystem and the latest reflection of the programs of correspondence group under his leadership and also of course, another joint convenor couldn't join us online, but I really appreciate if you can spend some time with the discussion under this correspondence group. A lot of fresh material will be reviewed, and hopefully that will lead to some useful conclusions about the way forward. Thank you once again, Dr. Kang.

Now I think, yeah, we are almost on schedule, only a 3-minute gap. So, I think I will introduce our last speaker of this session, Mr. Yuntao Wang who is now joining online. He's based in Beijing China. He's a Senior Engineer, Deputy Chief Engineer of Cloud Computing and Big Data Research Institute of China Academy of Information and Communication Technology, CAICT. He serves on the Deputy Director of Internet Gompance Research Center of AAICT Head of Overall Team of Artificial Intelligence Team of C. A ICT, and Head of Overall Team of Blockchain Team of CAICT and vice Chairman of young experts committee of CAICT and in Study Group 16 his role is the Rapporteurship of ITU-T Question 5 of Study Group 16. Okay. And he has been the Rapporteur for Question 5 since the formation of this question in the year and also he is visible and has activity as well and may provide unique perspective from artificial intelligence view on how they see Metaverse if relation to multimedia. Okay. Yuntao, it's your turn. Thank you.

>> YUNTAO WANG: Okay. Thank you, Noah, for the introductions. Hello, everyone. I'm so glad to join our workshop today, and my topic today will be the gap between reality and expectations of Metaverse. So, I think for today's workshop, we have heard enough of, you know, theories and application, so my presentation today will try to focus more on those data and numbers.

We are trying to find all of those gaps with the evidence of concrete numbers so that everybody can get a better understanding of what's the gap between the reality and expectations of the Metaverse. So, next slide, please.

I have analyzed all those five gaps below, so to summarize my today's presentation, the first gap will be what the users truly want versus what is already provided by the enterprises. So this one will be the first gap. The second gap will be what the companies tell what they are doing right now versus what they actually are doing right now. That's the second gap. The third gap will be, what the government wants about the Metaverse versus what the Metaverse industry really happens. That's the third gap. The fourth gap would be, what technologies are expected for the usage being of Metaverse versus what we have now about the technologies. The fifth gap would be what kinds of standards are expected versus what we are doing right now.

So, the five gaps will be elaborated via numbers, and at each of the gaps, I will be trying to do some gap analysis so that everybody can get a better understanding of why it gap happens and what we should do to bridge all those gaps. Next slide, please.

So all this data actually comes from Statista Statistics and so the first gap would be the user expectations is actually trying to solve this one question of what things would you do in the Metaverse? Just to summarize that from this figure below, I have seen the fact that everybody wants to do in Metaverse, they never do in realtime. So, if they are able to do this work or try this entertainment in the real world, they are never going to do it in the Metaverse again. That's a fact. Why to we see that?

From this statistic, we can see that the share of the respondents expressing their willingness to do all of those kind of things, including try extreme sports like sky diving alter the consciousness with the help of VR and pretend to be someone else and spend a lot of money on collectible clothes, try big game hunting and play games and watch virtual gladiators fight to death, and even more patriot things or not legal things they want to do is what they want to do in the Metaverse.

So, next slide, please.

But we can see that the users are expecting really more than what the technical world could offer. From the perspective of the application realities, we just -- I just used the numbers of the mobile applications referring to the Metaverse together with selected popular keywords as of February 202 2. All of those applications we can get access from the IOS app store or Android app store, here are all of those keywords. The first one is

Crypto. The second one is NFT, non-fungible tokens, and the third is AR and fourth is VR. We can see that there are 144 applications saying they are dealing with Cryptocurrentcys. 118 doing non-fungible token, and 72 AR and 55 dealing with VR. We can see that all of those numbers of mobile applications, they are far from the expectations of what people are allowed to do in the world of Metaverse. Next slide, please.

So, I'm just trying to do a gap analysis of what this really happens. So Metaverse is not just a digital transformation from the real world to the digital world because people always want more. What does that mean? As I said at the beginning that if people can experience the applications in the real world, they will never do it in the Metaverse. Which means at that what we are trying to do now is doing the digital transformation of the traditional world. Actually, what we are building now is trying to do all those real-world things in the virtual world, so the virtual world is just a very simple digital transformation of the traditional world.

What does that mean? It means that now the virtual world, all the Metaverse we have now is highly dependent of the real-world market, the real-world business, and the real-world financial systems, which means that the virtual world is just a copy of the real world.

And the second one is that we can feel the virtual world just as simple transformations of digital economies with digital technologies, so the digital technologies we are using today, we are just using them for the transformation from the real world to the virtual world, and actually we're not creating things that we need to do in the virtual world. So what do people really want in actually, in here, I brought a new wording. It's called digital native world, and maybe someone is very familiar with the word, digital native, which was brought out maybe in the year 2001 to say that they are not digital immigrants but they are digital native born, that they've got used to all of the digital tools as they were born so that includes getting used to all of those digital tools simultaneously while they grow up. The same concept also is available for the digital native world. So what's the meaning of the digital native world? I think the first one is that the digital native world means that it's only for digital content. And the whole process of digital assets in the digital native world can be self-looped in the virtual world, such as the identification, evaluation, and circulation of digital assets. This is very different from the digital transformation of the traditional world because in the real world, we need to rely on all of those central banks, et cetera, to do all of those kind of digital assets circulations. But in the digital native world, actually, we don't have to be dependent on those central world. Also, in the digital native world, we can -- those can be used with the real world through the cross-world trade to meet other needs that cannot be achieved in the virtual world itself, such as food, drink, and transportation, et cetera. In the digital native world, when you are hungry, you go to the cross-world trade center

to do all the trading to between the real world and digital world. That's the meaning of the digital native world. So to my understanding, what people really want is not the transformation of the traditional world, but to build a new digital native world that will not be depend on the real world. That's the gap one analysis. Next slide, please.

For the GAP 2 analysis that in here there are a number of mobile applications with a keyword Metaverse in their name or description as of February 2022 by category. We can see that what are those industries or what are all of those companies providing here? They provide games, they call it Metaverse. They provide financial services, they call them names. They provide social media, they call it Metaverse. And also they provide entertainment books, lifestyle, tools, business, et cetera. These are the applications using the keyword Metaverse they are providing now. Next slide, please.

And also, from the point, from the market capitalization of the Metaverse point of view, we can see that although for this year, we have two very hot topics, the first one would be Metaverse, and the second one would be Web 3.0. And also people say that Web 3.0 are the foundation of Metaverse. But what's the reality here in we can see that only a very small fraction of the Web 3.0 Metaverse were created, so we can see from the market capitalization in trading U.S. dollars here, only 0.03 trading U.S. dollars were forcing the web 3.0 Metaverse scenarios. What are the other applications from the point of view of market capitalization? It's Facebook. It takes 0.9 trillion U.S. dollars, it's gaming and e-sports, it takes 1.98 trillion U.S. dollars, and most of the Metaverse applications were based on Web 2.0 applications and the capitalization, the market capitalization is 14.8-trillion U.S. dollars. Next slide, please.

So, what types of projects does those kind of companies invest in the Metaverse? We can see that although those companies are providing gaming, e-sports, et cetera, but actually they invest heavily in the feels of Cryptocurrencys. We can see that according to the statistics of the Statista, nearly 53% of the companies has invested in the field of Cryptocurrencys and 44% of them invested in non-fungible tokens and only 40% of them invested in working environment and remote work. 30% of them invested in branding and positioning.

We can see that Cryptocurrentcys, non-fungible tokens and branding and positioning are the key areas for the companies to invest in. Next slide, please.

Also, this is a very interesting statistic that although we can see the hot money is flowing into the area of the Metaverse fields, but how, according to the respondents of Statista statistics, only majority of the companies only invest 10% or 20% of their budget to the Metaverse field. Only 17% of the companies take Metaverse as priority investment and it's less than 10% of their marketing and innovation budget were invested in the realm of Metaverse.

So, Metaverse is like some -- it's like some topics that are really hot, but from the perspective of the companies, it seems that they never treat the Metaverse as they're priorities for investments and for future plans.

Next slide, please.

And also, from the perspective of the total users of selected virtual platforms worldwide as of October 2021, we can see that there are real field users of Web 3.0 virtual worlds and it's only 50,000. But for the non-fungible token users, Blockchain users, becoming more and more. Who has the most users? Facebook. Facebook does. Also, where other users lie? They are lying in the gaming and e-sports area. Besides, non-fungible tones and Blockchain gaming and decentralized gaming and Crypto, the rest of the Metaverse users is gaming and Facebook users, that's a fact, but I think this fact is far -- has a deep gap with what we have expected the Metaverse will help us to do in reality. Next slide, please.

So, for this kind of gap analysis, we can see that Crypto is the one making real money under the cover of Metaverse and that's why most of the companies have been doing their work under the cover of Metaverse, but what they're really doing is trying to do all of those Cryptocurrencys. In here I just want to share some numbers on how those real money are worth. The first is that the size of U.S. digital assets has doubled 215 times in just five years. The non-state issued digital assets sored from the 14-billion U.S. dollars in early 2016 to 3-trillion U.S. dollars by November 2021.

The market value of bitcoin, Ether and other token economies has reached nearly 1.9-trillion U.S. dollars and the market size is close to Italys annual GDP and making the Crypto currencies richer than a country.

And also the pandemic triggered a significant increase in revenues made in the Crypto sector with growth of 481% from the year 2019 to 2020.

And we can see that the global Crypto currencies is really the biggest player in the field of Metaverse now, so I think this explains why most of the companies have really invested heavily in the era of the Crypto currencies. Next slide, please.

For the GAP 3, here are some facts. That what the governments want the Metaverse to help others to do, they want the leading benefits of the Metaverse worldwide in the year 2021, they want the Metaverse to help people to do is overcome the obstacles like the disabilities that prevent us from doing something, like enhancing creativity and imagination, traveling the world without moving, increasing technological literacy and skills, connecting with new people without feeling awkward, creating completely new job opportunities, meeting your loved ones whenever you want. Can you see all of those leading benefits are very fancy and it really draws our attention that if any of those leading benefits could be realized by the Metaverse, it will be drawing millions and millions of users to this kind of field, so this is what the

governments want for the Metaverse to help us to do. Next slide, please.

But actually if we use -- we see the statistics from the Metaverse potential consumer expenditure total addressable mark in the United States as of 2022 by segment embedding U.S. dollars, we can see that the users spend their money in the field of Metaverse and what are they really spending on? The first is the other consumer spend. But I think the most important one is real assets. They want to buy real assets in the work of the virtual Metaverse. Also, there are virtual vehicles and parts and home and home-related, apparel, education, and cosmetics. We can see that all of those expenditures from the consumers, the fact is that it's far from beyond the features that the governments want the Metaverse to help us to do. Next slide, please.

So we're trying to do some gap analysis for that. We can see that we are far behind the ideal Metaverse because we have uninvolved the technical problems, we have unsolved the ethical problems, we have unsolved the regulation problems because we have all of those kind of unsolved the problems, and we can not use real technologies, and we cannot leave real ethical lives and we cannot have real-world regulations and cannot really truly live in the world of the Metaverse.

So the significant below is a leading barrier to creating the Metaverse, according to the U.S. Game Developers in the year 2021. We can see that the most concerns about the Metaverse will be the privacy and ethical issues, the cybersecurity issues, the technology availability issues, and the interoperability and standard issues. So, all of those kind of issues remains unsolved, so that we are far behind the real world -- behind the Metaverse world that we are expecting. Next slide, please.

So, actually for GAP 4, what kind of technologies are expected? So just to summarize, we actually what we want for Metaverse, we have two pillar technologies. So the first pillar technologies will be the immersive technology technologies and the second will be distributed systems. For filler immersive interactive technologies, the front end technologies such as XR, and actually the communication network evolution route determine the immersive interaction lubl from if I canned broadband to mobile Internet to broadband technologies and the front and immersive interaction applications can be realized on the user side are becoming richer and richer.

And for the distributed systems, always emphasizes the back end system, oriented to organizational truck chur and this was based on architecture and applications of technologies such as Blockchain.

And the Internet evolution role determines the development of the distributed systems, and as Internet goes from 1.0 with platform, to Web 2.0 with users producers and disseminating content to the new Web 3.0 system with are users have autonomy over data and frims, we can see that Blockchain technologies can enable users to

have more autonomous control over their own identity and wealth. Next slide, please.

So, we can see the fact that the expected features of the Metaverse according to video game developers are access to a variety of gaming activities, opportunities to create and sell content, the markplace for virtual services, and extensive version of social media platforms, et cetera.

Next slide, please.

But what we have right now, for right now we only have the augmented reality gears with no actual content that's supporting the AR applications. We can see that in the year 2021, we have the market size of 27.96 billion U.S. dollars but if the year 2028, it is forecasted that the AR market size will be 252.16-billion U.S. dollars, but I think that the jump from 27 to 252-billion U.S. dollars in AR itself is not enough. It has to be involved with all of those content creation, content dissemination, and circulation of the digital asset behind all of those AR applications.

Next slide, please.

So, for the GAP 4 analysis, we can see that the fusion of different sets of technologies is a key to unlock the door to Metaverse, which we don't have yet. When we're talking about the Metaverse technologies today, actually we're talking about AI, we're talking about Blockchain, AR, and VR separately. But according to the theory of the buckets, we can see that what we are missing for to form the Metaverse buckets, the first is that we can see that the key technologies are missing. Although that we have the game engines required to create an ideal virtual Metaverse, but for now all of those kinds of Metaverse applications are far behind our expectations because we don't have the technology needed for our content creation, for our computer innovation tasks.

Also, we can see that the collaboration between different sites of technology, such as the collaboration between artificial intelligence and Blockchain, the collaboration between AI and AR are far beyond the development needs of Metaverse. The collaborative technology missing means that the leakage may be happening to the Metaverse buckets if we don't tighten all the sites of technologies together tightly. Next slide, please.

So, GAP 5 is trying to do some explanations to the standardizations of Metaverse. We can see if we want to do standardizations of Metaverse, first we need to reach some consensus on Metaverse. We can see that consensus on Metaverse is very hard, even with the definitions we still vary on the definitions of Metaverse. We can see that most of the people see Metaverse as a combination of multiple elements of technologies, but some people see Metaverse as persistent, shared, and 3D virtual spaces in the virtual world. Also someone think that Metaverse just a blending of physical and virtue usually worlds, and some think that the next version of a global Internet would be

Metaverse. We can see that different people have different views on the Metaverse. If we want to do some standardizations on Metaverse, even the definition consensuses are hard to reach. Next slide, please.

So, if we want to see the definition of the Metaverse according to the companies worldwide that help already invested in the Metaverse, we can see that most of the companies see Metaverse as a virtual world, but some -- still some of the companies see that Metaverse is just a Facebook's new name, and it's something that is linked to Web 3.0, and some honestly think that it's just a Cryptocurrentcy container. Next slide, please.

Actually, Metaverse has far more players than expected. It's very different from the traditional technology standardization process. In the traditional technology standardization process, sometimes only one player, a few players were involved in the standardization activities. With we're talking about Metaverse standardizations, actually we need to bring people from the world of computer and IT, we need people from education, we need people from finance, marketing, medical, travel, construction, transport, et cetera. They have far more players than we even expected. Next slide, please.

So, how to do -- how to resolve this kind of gap. Just to summarize that, the Metaverse standardization from my point of view should focus on incremental part of the Metaverse. If we want to try to elaborate Metaverse in the very short creation, we can see that the separate technologies plus the technologies fusion plus all of those vertical industry new players needs maybe form a complete Metaverse. But for the separate technologies, we have already got a very solid background, especially in Study Group 16. But when we are talking about the technology fusion and also all those new players from the vertical sides, we are facing a lot of new challenges, such as Noah has already proposed in his previous presentations the interoperability challenges, the interfaces between different technology interfaces, between different technologies, the content-oriented technologies, the regulation and ethical problems, they are all the new challenges that we need to solve when we are trying to do some standardization work focusing on the Metaverse. Maybe in the future, we need to take full advantages of the solid background on separate technology, but maybe we should focus more on the new challenges about technology fusion and all of those new needs from the vertical industries.

Next slide, please.

I think that concludes today's presentation. I think there are a lot of numbers, but due to time limations, I don't have time to elaborate on them a little bit more. If anybody is interested, please do not hesitate to contact me and I think Metaverse is a really big question and really challenging problem. I think together we could make Metaverse a better place to live in. Thank you. That's my presentation.

>> CHAIR: Okay. Thank you very much, Mr. Wang. I think this is a very good gap analysis. Gap analysis is usually step one in any standardization-related activities.

Having heard your story, it remind me of a little bit this Chinese saying, in English it sounds like the ideal is very sexy and charming and well. Other is always very bony like skeleton. So it's probably true, to some degree it carries truth. However, I think this is still very positive for us to be awakened to the reality and to see the gap between where we are and where we want to go. The journey may be more challenging or long, but we need to get fully prepared and also we need to find, how to say, fellow travelers to join us because that will make the collaboration among different organizations very critical and essential. Also, would like to say from my point of view, this presentation contains too much information for me to digest. However, this abundant information still has a lot, and I suggest people keep a copy of the slides for reference this the future. Okay. Thank you very much. I think it's quite late in your time zone, Yuntao and I offer my appreciation for your hard work to prepare such a thorough document.

Now I think, yeah, so food news is we are already complete the first half. Not too good news is we are 15 minutes behind schedule. So I suggest that we keep our promised break, and then probably we shift this time gap to the second session. However, we reserve sufficient time between this workshop and our reception. Hopefully it's acceptable to you. Then I will also hand over the chairing to Dr. Kang who will lead us and guide us through the second session. Now we have a break for 15 minutes, I think. 15 minutes -- oh, it's 20 minutes, actually. Enjoy your break. We come back at 3:55, please.

(coffee break).

>> Recording in progress.

>> CHAIR: Hello, everyone. Your attention, please. I think we will start, so we will begin the second session.

>> SHIN-GAK KANG: Hello, everyone. Thank you so much for joining this workshop for Working Group 16. It's the second session, of the workshop. As organizer of the workshop I'm happy to be moderate for the second session. So the next we are preparing the document. Yeah.

Okay. Okay. There are some problems in preparing the presentation. I think we have to change the sequence of the presentation. Okay, so next, let me see. Okay. Next speaker is Jisu Kang from Kileon, Korea. Yeah, we have to change the sequence due to some setting issue, so Mr. Kang, could you present first? Yeah. He's not ready yet, so we need a few more second. Yeah.

Okay. So briefly about Ms. Kang from Kileon Korea. Co-founder and Chief Researcher officer from CRO. The presentation, so you can speak. Yeah. Are you ready in okay. So let's continue with the second session. So at this time, Kang already mentioned

Co-founder and Chief Researcher and received degree from (?) Korea majoring in AI. So registered for over 30 in 2022, recognizing leadership, aims to revolutionize communication and special in communication -- okay, so Jisu, could you present your document, please.

>> JISU KANG: Thank you for the introduction. My name is Jisu Kang and I would like to announce with trends and feature trends of technology. This is table of contents. I would like to introduce myself. Jisu Kang. CRO of company, KLleon, responsible for AI technology if my company, and I would like to introduce my company.

So at first my company started with the idea that what if I could make an online lecture with the face and voice of the person I like?

And my company goal became more enthusiastic, and my company's mission and vision is like this. Make digital communications sincere and let everyone become friends beyond the limit of distance. So, my company believes that due to human generation technology, can innovate communication system of digital twin.

I will skip this slide. As I mentioned above, the digital human can solve temporary and spatial limitations, providing an opportunity to communicate with anyone, anywhere, and anytime.

This is an example video of a digital human generated by AI technology.

(no English translation).

As you can see in the video, digital human generation technology is developed really fast and it's hard to distinguish the real human and digital human.

I would like to introduce existing technologies to create digital humans. The first technology is using CGX/VFX-based digital human technology.

To create digital human using a 3D technology, we need 3D engines, like Unreel engine or Unionty, and if we use these engines it we create some really sophisticated digital human but it has some drawbacks.

To generate digital human using CGX-based technology, it took a long time to create a digital human. However, recently unreal company developed Metahuman Creator and it takes less than an hour to create digital human.

Moreover, if you use Motion-capture technology, it's possible to make digital human imitate human behavior. In summary, if you use CGX-based technology to create digital human, there are many advantages and disadvantages, and the first advantage is sophisticated digital human generation and real-time motion generation is possible, and full-body digital human generation is possible. However, it usually takes a long time to make, and it is also expensive to create the desired digital human. And in the

case of the metahuman creator, customization is a little bit difficult.

The next technology is AI-based technology. From ALEX Net in 2012 to now AI technology developed rapidly and can now have creative ability that considered human only has.

In 2018, the fake-based deepfake-based video production has become hot topic and various deepfake videos are spreading on the web.

As can you see in these videos, these videos are digital human and digital humans are generated with deepfake technology, and as you can see, they are really natural.

However, deepfake technology has some limitations, deepfake technology requires a lot of data and a long time to train the AI model. Firstly, a large number of target face images are required to create a new face of the digital human when we use deepface-based technology, and training is required to create a new face, and it takes more than 12 hours to learn.

Recently, face-re-enactment technology emerged and this face re-enactment technology also based on AI technology, but it only requires single image to create digital human face, unlike the deepfake technology which took a long time to collect data, you can now create the face you want with just only one picture.

Then how can face re-enactment technology can create digital human face with only one image? Let's imagine a painter, a painter can imagine a person's profile and various expressions just by looking at one picture because painters have been drawing many faces of people. AI technology is similar that if face re-enactment technology draw out several faces of several people can predict the profile and various expresses just by looking at one picture.

But the question remains, can virtual human created by changing only the face to the digital loop can be called an actual digital human? This material is from Sense Time company and this shows that there are many steps to create a complete digital human. The digital human is a hand-crafted digital human, so we need to take a lot of time to create a digital human. A L2 digital human requires a lot of data to generate a digital human. And level 3 digital humans do not require a lot of data, and it creates automatically by using algorithms. Level 4 digital human has the ability to have conversation with humans, but it can conversate in limited situations. Level 5 digital human is complete digital human that can communicate with a real human anywhere and anytime.

I would like to introduce about our technology and how to -- I would like to introduce how to create digital human using AI technologies. The overall process is like this. The first step is create digital human's face, and the next step is dialogue generation. After dialogue generation, we have to convert the text to the voice, so we have to generate digital human's voice. After voice generation, digital human's lips have to be synchronized with the voice, so mouth generation is required. And the final step is digital human's body generation.

To generate the digital human's face, we need three technologies. The first technology is virtual face generation. Virtual, if you use virtual-face generation technology, we can use digital human face with the loop that the customers want. And the next technology is 3D face generation, and if you use 3D face generation technology, we can convert the digital human's face image to the 3D face, so we can generate many digital human's faces in any angle and expression. The final step is digital human face and body connection technology, and this technology has to combine the face and body naturally.

This is our technology face generation quality, and I will skip this page. And this is TTS text-to-speech and natural language processing technology. After creating digital human's face, we have to generate a dialogue to conversate with the human. To generate a dialogue, we need natural-language processing technology, and natural-language processing technology can be divided into two categories. The first catagory is task-oriented system and the other is open-domain dialogue system. Recently task-oriented dialogue system developed a lot, but it is hard to generate open domain dialogue, so KLleon is trying to develop the task-oriented dialogue system to the open-domain dialogue system.

The next step is text-to-speech generation. After generating the dialogue, we have to convert the text to the voice of the digital human. Recently, AI technology developed a lot, and it only requires only 30 seconds of target voice to create digital human's voice.

The next step is lip sync generation. After generating the digital human's voice, we have to make digital human lip's synchronize to the voice, so we need lip sync generation technology, and I will skip this page.

This is an example of a lip sync generation by using AI technology. No English translation).

As you can see the lips are really natural and it is really hard to distinguish the real lip and digital human's lip.

This is body generation. The next step is body generation. The AI-based body generation technology is in the initial steps, so it's not in the commercialized step, but I think AI technology develops really fast, so the body generation technology will be commercialized in the near future, I think.

I would like to introduce future technology. Future generation of digital human technologies. To create complete digital human, three steps of technology development is required. The first step is real-time generation and next step is emotion-based generation and the last step is memory-based conversation.

The first step is real-time digital human generation, and if we want to communicate with the digital human, then the digital human has to move in realtime to realize realtime generation, three technologies are needed. The first is streaming. Streaming technology is required to produce and transmit long videos in realtime. The other technology is optimization. Currently, the

deep learning technology needs a GPU device, so GPU optimization is required to realize realtime digital humans.

And then multiple deep learning models are used for digital human generation, so scheduling these deep learning models is required.

And lightening the deep learning model is required to enable inference on mobile devices.

I will skip this part.

The next step is conversation with emotion. Humans have emotion and humans can conversate with emotions and therefore digital humans have to have an ability to have a conversation with emotion. For emotion-based conversations, digital humans movement, voice, and dialogue must match the emotion, so for a conversation with emotion we have to develop for technology. The first technology is multimodal AI technology. Face expressions, voice, and facial content must be integrated to understand a human's emotion. The next step is natural language processing, and the digital human has to create conversations that match the talking person's feelings, and then the digital human has to synthesize a voice that matches the emotion of the spoken text. Finally, the digital human should generate facial expressions and actions to generate the conversation.

Multimodal AI technology is a hard issue in research -- in AI research domain. Humans can understand many modalities such as text, audio, and image, but AI does not. The digital human has to understand these multiple datas to understand a human's emotion. Moreover, emotion-based conversation should become possible to have conversations with emotion.

And after the natural language processing, the digital human's voice has to be aligned with the emotion contained in the text. Can you please click the audio? Yes. Yes. Right here. (no English translation).

These four audios have the same content, it's the same text content but have different emotions. If you listen to the four voices, then you can feel the voices are all different. (no English translation).

As you can see, the voice with the emotion is really important.

The last step, the last technology is individually-generation technology. Digital humans have to make gestures based on the dialogue. Every human has different gestures and personalities, so the digital humans have to understand all of these gestures, so it is really hard to develop the video-generation technology.

The last step is conversation with memory. Humans can remember the past dialogues and humans can ceonversate with the memory, so the digital human has to remember the dialogues and generate a new conversation with the memory. Moreover, humans can evolve using or based on the experiment; therefore, digital humans have to have an ability to evolve based on the conversations in the past.

Recently, Facebook AI showed blender bot 2 has ability to remember past dialogue and generate new dialogue based on the memory.

Moreover, as I mentioned above, the deep learning model has to have the ability to evolve based on the new experiences. AI technology has some problems that when the AI model trains with new data, then the AI model forgets the past information. We call it as catastrophic forgetting, and many AI researchers are trying to solve this catastrophic forgetting problem. And if the catastrophic forgetting is involved, then we can create a digital human who can evolve like a real human.

This is all. Thank you for listening. If you have any questions, please send me email.

>> SHIN-GAK KANG: Thank you so much, Mr. Kang. Time is over but we can stop the presentation but as we can see the digital aspect of the human and there are a lot of issues that we need to consider. Due to time limit, I would like to stop here. Thank you so much again. Okay. Let me go to the next presentation. Thank you so much. Yeah. Very impressive. Okay. Are you ready? Yeah. Our next speaker is Mr. Hideke Yamamoto, Vice-chairman of the Study Group 16 and in electric industry and developed so much ITU recommendations on -- and he's editor of many ITU recommendations. He's vice-chair of the Study Group 16 and also he's Chairman of the -- co-chairman of the Working Group 2 Study Group 16 and in charge of e-service issues and human factor aspect in Study Group 16. Chairman of the expert group on multimedia applications, and I stop. Thank you. Please start your presentation. Thank you so much. Please.

>> HIDEKI YAMAMOTO: Can you hear me? Okay. I'm sorry. I'm very sorry to wait so long. Now okay? Okay. Thank you. My name is Hideki Yamamoto. Thank you for the introduction. The title is very long. Metaverse standardization with (?) network. The content is as follows introduction and Metaverse application and so we talk about the digital twin progression in the last. So this threshold in society in 2030, so this is developed by Japan, so Society 5.0 was proposed in the science and technology based firm of the future society that Japan should aspire to, so the main point is cyber system -- cyber testimony, this word means combination of physical space and Cyberspace is very important. In that world, so IoT devices, the IoT devices sensor the real-world data and the data will be accumulated in Cyberspace, and AI is used to analyze such data, and new Cyberspace will be form in regard of the analysis. So to realize 5.0 or beyond I think infrastructure is important and necessary. This slide shows the key features for 5G technologies. As you know, the center of this figure is the 5G and the 5G has three major features. And the direction to beyond 5G, so these three will be extended to with rising capacity and other ratings and other new connectivity.

And we -- in addition to the ordinary 5G extensions, we added four new technical goal, and since we added four, and among four --

>> (Speaking off mic).

>> HIDEKI YAMAMOTO: I'm sorry for the trouble. This slide shows key feature for Beyond 5G, and the blue rectangle means extension of the current 5G technology, and orange rectangle is added to the Beyond 5G, so -- I'm sorry, the blue rectangle means the other focus point to propose the new research project. So, and from now on, I will talk about our research point. Okay. What happened?

Yep, the title of the research prodder is coordinated autonomous network for Beyond 5G and this research project is strongly related to Metaverse, but we noticed that the relationship between Metaverse and our project today, we introduce the relationship of our research project and Metaverse.

So, this slide shows overall architecture to coordinated autonomous network. There are three major technical points. One is autonomous network itself, so this is the extension of the kind of network with AI. So the right table shows the difference between AI network and autonomous network, so network management is key difference between AI network and autonomous. Autonomous network uses evolutionary technology and operational for network and the cost of operation. And regarding the video control, we reduce bi-directional CDN and this is a new CDN and regarding to time now we introduce autonomous mobile robot, and you can see several robots in this figure.

And so we reached, we found or invest new service coordinated autonomous AI network and it includes Metaverse.

The left figure shows the current program. There is an autonomous mobile robot with camera, microphone, speaker, and display, and these kind of robots are used in front of the hotel or office and so on, so communication is not immersive, so people who use it device seem nervous or something. So to solve this problem, we introduced our technologies, and on the right-hand side is the future world, so pink rectangle is the for example in this figure, so two people watch the robot with 360-degree display, and the image will be shared by remote participant, so important point of this figure is the video is synchronized among all participants.

In the real world, so the guest can see the real animals and they can see another animal on the screen, so the screen video is shared and it is synchronized by other people. This is like this.

So we assume a family, or part of family go to zoo and part of family cannot go to zoo, and share the experience of the zoo tour by this technology. So to realize such world so this I show the autonomous network research result. We have already studied the architecture of the autonomous network, and proposed the architecture to focus group in AN and they will start to standardize the architecture in November.

So, important point is autonomous network will reduce the cost of network operation. Next slide is bi-direction CDN and most of the SG 16 experts are introduced in this thread, so we starting this new CDN, so this new CDN can provide the function for cache

control and delay and transfer video for all time and communicate with the AI.

And third one is the autonomous mobile robot, so we invented -- we are studying this type of the robot, so you can see the robot has 360-° camera and direction speaker and spherical display and robot hand and so on.

So, you can see the small video of this MetaPo. We call this robot the MetaPo. So this is the screen and this is the display. So at this moment, the camera captures the room there.

So next is we use this MetaPo as device for Metaverse, so in the display, the virtual space is realized so in robot with 360-degree display on the camera now being developed by us. So regarding the standardization, we have already started to start to standardize the technology of this research. One is to propose new work item to Study Group 16. So Contribution 133 we propose to start new work item for. And we already proposed new work item for Study Group 13 about autonomous network, and also we established new work item to analyze the gap analysis coordinated in APT. So now we introduce the Beyond 5G, our study about the digital -- I'm sorry. Yes, the digital twin. I missed -- okay, digital twin collaboration. So Beyond 5G, so to realize the Beyond 5G world, Cyberspace and the physical space system and service utilized and service enablers and orchestrater. So orchestrater -- orchestrater handles several component of the software. Oh, I'm sorry. All right. Okay. This slide shows a use case for digital twin collaboration based on orchestration so with ghoabal tbroaing awareness of SDG, many cities are interested in transforming themselves into smart and sustainable cities. In order to achieve smart and sustainable cities, smart services across different sectors, such as environment shows traps taition need to be coordinated efficiently and effectively to solve the various problem facing cities in a sustainable manner.

So, some effort is on the way to configure Metaverse for each of these areas using digital twin and to find the best solution individually through various simulations. However, there has been a lack of effort to coordinate this effort. We believe that the absent and effective coordination of individually constructed digital twins via the orchestrater will make it possible to optimize the solution of the intersectional programs throughout the city.

And this slide shows major issue to consider in order to realize the use cases, and the fact is that orchestrate the functions for this is in collaboration, so synchronization and brokering the translation to realize the digital cooperation. And to build the security protocol for interoperability among the digital twin is also important. And high-volume and low-latency is super-diverse inter-digital twin communication technology at the level of Beyond 5G/6G is also necessary.

And the ethical issues associated with the digital twin is also necessary to be studied. For example, Gemini Principles of

information management are studied, and so we are thinking about digital twin component of Metaverse, so someone said Metaverse is almost equal to digital twin, but we don't think so. We would like to difference between digital twin and Metaverse in the future. Thank you.

>> CHAIR: Thank you, Mr. Yamamoto. Very interesting presentation. I think this presentation shows very new fundamental such as autonomous network and various and Metaverse and consent and lastly issues, I think in general the proposed issue is very important to realize the Metaverse in the future. Okay. Thank you so much, Mr. Yamamoto. Due to time limit, I would like to go to the next presentation. Thank you, Mr. Yamamoto.

So, next one is, yeah, Ismael Arribas. Just wait for a second, we need to set up again the presentation environment. We need to change the environment again. Anyway, we still have three more presentations. I will try to, okay make time, but it's a little difficult. Anyway, reception after this workshop, so I hope we can join the reception after the workshop. Yeah. Next presentation is transition from Ismael Arribas. Could you open his audio?

Okay, so let me introduce Ismael Arribas is Co-founder of the company -- he's entrepreneur from Kingdom of Spain, independent conference -- since 2006 and also committee working for -- you can see this. Okay. Committee with the standardization of Study Group 7 and also working for 19 and regional -- also ITU-T and Study Group 16. Founding member of the INA -- standardization ki in INA/DBA and principle advisor for standardization. Proponent of startups -- okay. Let me invite Ismael Arribas?

>> ISMAEL ARRIBAS: Yes. Thank you, Mr. Vice-chair. Thank you all esteemed delegations. Unfortunately, this time I could not be with you in presence, but I will be contributing to this space of the ITU, and I want to remember when I had the opportunity to work in the focus group for the DLT and this picture represents the motivation. And before I got to knowing the transaction and it's very important for our period, and I had in that announcement in 2019 in the Plenary for the Focus Group, we had SG 16 in presence of the technological piece, and we exercised the SDG 17 because of this multi-party environment that we have thanks in other words to the technology itself, and for some video, and one video I go to the slide, and let me check, Mr. Vice-chair if you can see the video? Just 10 seconds, or 9 second?

>> CHAIR: Yes, we can see.

>> ISMAEL ARRIBAS: It's coming. Okay. Thank you very much. I'm very welcome to introduce the Kron World.

Coming to afterwards of the introduction, we understand a new wave of competition which we are deploying as global world and the Cloud computing is focusing on understanding of let's say we can understand our first world where we live and our experience in a real space. In the column of the left side, we have the kind of

relationships between the parameters, between the different worlds. If you go between the first world and the second world, really the experience entering fictional experience with the virtual one where we have a choice with the virtual and the real. And in the third world, which is really the focus of the Metaverse, it is the real fusion of the reality and virtual space world.

The circumstances empower our presence, even give most continuity in different kinds of aspect, in our knowledge, in our experience, even in our whole relationships. But we need to distinguish this kind of circumstances as we were watching during the session of today, it's not really easy to provoke proper identification, but we have technologies that provide the human-centric position with the opportunities of this era that we are living in. This is what we are deploying in the video. You could watch that we are focusing on three pieces. One of them is Owake that we already have on the communication channel in place and in production for me Metaverse. I will introduce you to two major use cases really quick. The other is a conscious for the human to manage e-memory which is our Kron world or Kron, e-memory whereby this will help the human to achieve the interaction between machine and machine, machine to human and human to human. And the other is the pattern which will be to manage the autonomous environment between different devices and focusing in saving mechanism. But going to the layer of the framework of the communication channel that we already have deployed and we will see afterwards, there are like three elemental pillars, and today we are under harmonized understanding of this with different can denominations probably in our work we are doing, but we identify these three human needs to match our presence in a consistent way with the virtual world. And what we call transaction proofing is Prudential policies for compliance. Based on the identity lifecycle, which really this self-serving identity circumstances for a process that could be into human-centric position, it's necessary to know that essentially this human is doing this like in the real world, and we know what we are doing if it is correct or not, but it's not under dependencies of governance or other circumstances that we are not under free will, if your distinguished delegates allow me to say. Based on this environment of the lifecycle, there could be that since in the identity lifecycle, it's called management so if we go to provoke -- hello? Do you hear me?

Okay. If you want to provoke a content delivery network and you are the owner of this content, you can manage and NFT circumstances in this instance and this is how we're moving on to possibilities to reiterate or circumstances to understand what is the case of the Metaverse, and then you could be perfectly in a free business model with a useful omni channel for your avatars in the Metaverse or different environments in the Metaverse itself.

Last but not least, because we are learning by practice, and it's looking for premium business model where we can offer alternative points to reserve policies and everything in realtime and this is the way that we're tackling with the European Telecommunication

Standardization Institute where we are selected with proof of concept and we are doing where here I think I can show, yes, here I will copy this link for all of the audience and name is Timeless in Metaverse Environment based on Edge networks and indeed the exercise represents the way to resolve boxes of concepts for think cases of travel. We call it Meta Travelers and we have a vertical for hospital Metaverse, we have a vertical for university Metaverse, and we have vertical to airport Metaverse itself, but in the use case we're exploring how to solve this, and how meta traveler in tourism case could hire a real traveler and enter in whereby and prove and take a tool for the meta traveler and be paid for the circumstances.

The other use case, which is one of the major use cases for our computing success,s but we are working with the National Council of Scientific and Research of Spain, it is the WISP. It is really a mechanism to provide suspicious transactions to report to different Blockchains or different Metaverse whereby could generate a whistleblower channel to those of them. As you can see, it's anonymous. I can say ITU. I'm sorry, I will enter in here this is the key, the password, and you can enter if I am not there and you just contact myself and we can -- we can talk afterwards that different actions by the main function is this one whereaboutby you transfer your evidence from your device to the device of a authority who could analyze a potential reward or pay attention to investigative situation. There are different integrations here in, but it's enough in this instance to show that these two major use cases allow us to explore the efforts of the Metaverse. In this box that you watch if black, anyone can integrate right now and it's Open Source and whereby could integrate and communication circumstances. And context under the standardization, the circumstances is that we are making within two weeks, finger's crossed with the esteemed Delegation of European Telecommunication Standardization Institute from the declaration with our patent and basic innovation offer the efforts to join the community strongly to work together with crowd computing and help Metaverse, indeed. Thank you very much for hearing me out. It was very quick. I offer you to contact myself and I will connect with the whole group of guardians and explore together how we can help in the Metaverse. In any case, I will continue the contribution in the standardization because as convenor for Working Group 3, I really am committed in different standards development of the organization and I believe if standard for the future of this convergence between regulation and technology and human beings. Thank you very much. Much appreciation for your invitation.

>> CHAIR: Thank you very much for Mr. Arribas for your presentation. I think I understand the work. And working on Blockchain and so I think Blockchain is one of the important components and source of working if some communities presented about recent activities of the Metaverse from the SG committees. Thank you so much. I think we hope to see your further

presentations from your groups for our Metaverse work in the ITU. Thank you so much.

Due to time limit, I would like to go here and invite the next presentation. The next one is Metaverse CG activity progress by Kepeng LI from Tencent China. I will open the boi. The Kepeng LI is co-chairman of the Tencent and ITU-T SG 16 and Metaverse xoar respond ansz group and continued in Metaverse and information security and Blockchain, et cetera, and actively participate in many international standardization activities including ITU-T, SG 16, SG 17, ISO, IETFW3C, IEEE, OMA and served at ITU-T Study Group 17 and co-chair of IETF ACE WG co-chair, OMA CD WG. Are you ready? Could you present, all right in.

>> KEPENG LI: Yes. Thank you. Good morning, good afternoon. Good evening. This is Kepenge from Tencent and also from correspondence group. Next slide, please. The contents include the Metaverse CG introduction, progress, and also we will introduce the Metaverse application scenarios, and technical analysis and standard analysis in the CG report. Now, I will also introduce the future work about the CG. Next slide, please.

So, the correspondence group on Metaverse was encouraged in January of this year under scope and objectives are there where we will carry out the preliminary standardization analysis and we will perform the technical analysis of future standardization directions, potential work items and future coordination needs. And we will also develop a report of CG activities. I think we have achieved these activities based on the previous meetings. The CG convenor is Professor Kang and myself. Okay. Next slide.

So the progress of the CG on Metaverse is that we held three e-meetings in July, August, and September, and the average attendance is around 50, so we have very good participants. We received 29 contributions from 8 entity members, and we have produced consolidated CG report, including use cases, scenarios, technical analysis, standard analysis, and future work suggestions.

Next slide.

So, we received several contributions from ZTE, Oppo, Spain, Huawei, China Telecom, or China Unicom, Tencent and China Mobile and cover use cases and standards analysis and also technical analysis. Next slide.

Yes, we received several contributions from ETRI and several contributions from China Telecom, so the contributions cover standards analysis and also some proposals for the work items and also some change evolutions and standard gap analysis, so it covers technical part and also standard analysis part. So, next slide.

Yes. We've also had several workshops, so basically in May this year, we held a workshop about the AI for Good webinar about exploring AI in the Metaverse. And it was also had one Metaverse workshop in China in May of this year, and then today is the third one with multimedia in the Metaverse workshop. Next slide.

So in the CG Report, we have several Metaverse application scenarios. Let me take game scenario as an example. So in the Metaverse games, we have very strong mutual attraction, and Metaverse brings the real life into the game. The players can own the virtual access like real-world physical access in the virtual games and they can even make money in their game.

A lot of examples is the office scenario, so currently remote work is more common under the influence of the coronavirus disease. The Metaverse enables a virtual office to be conducted in the face-to-face interaction way. The Metaverse can improve the on-site experience and makes our interactions more natural. Participants will be appeared as virtual images through the 3D remote interaction and participants can observe from different angles and make physical or eye contact.

For the scenario, shopping scenario can be created and completed in game-lining experience. We can try the clothes in shopping mall, select products and buy the products easily. We also have other application scenarios like sports, education, events, production, traveling, et cetera.

Next slide, please.

So, in CG Report, we had several application scenarios for Metaverse. One important application is the carbon neutrality. Currently, the online services become the acceleration of the physical world toward the virtual world. Many online services recently such as AR, tourism, digital twin, transportation and digital human. Carbon neutrality is key factor of the innovation along with the development of the Metaverse technology and the application.

Next slide, please. A lot of applications use the digital twin online exhibition hall, so the virtual exhibition hall is constructed by the high-tech VR room, and it supports 360-degree face viewpoint and immersive interactive experience. The visitors feel like standing in the real exhibition hall. Next slide, please.

Yeah. A lot of examples are the virtual digital human. The virtual digital human is the typical usage scenario in the Metaverse to provide enterprise services to the business, for example the customer service guide literature and also provide the nice services to individual customers, for example smart transportation, smart home. Next slide, please. Yeah. A lot of examples are about mobile Metaverse services. The mobile Metaverse services can use the mobile phone to get the inputs from user and give immersive experience to the mobile user. For example, when the mobile user plays the game using the mobile phone, they can get immersive experience, for example they can get smell and taste. The user connections can be connected from the sensor and sent through the server through the 5G network, and the Cloud server can provide better services based on the receipt use and interaction data. Next slide, please.

A lot of use case is NFT, to non-fungible toke season decentralized method based on Blockchain to the digital assets and the transaction of asset many include three phases, asset creation, asset registration, and asset transaction. Firstly, create digital work, for example and secondly the work is registered in NFT insurance platform, and unique identifier is generated for it. After that, the asset can be sold with the NFT transaction platform are and the transactions can be recorded with the Blockchain technology. Next slide.

So, this is about the Metaverse technical analysis. The Metaverse requires 6 main supporting technologies, and there are three underlining technologies including network and computation technologies, AI technologies, and the Blockchain technologies, and above that the backend infrastructure technologies including IoT technologies, interaction technologies, and e-game technologies. Next slide. Please.

So, one key technology is about the digital twins, so digital twins are one of the important methodologies for Metaverse because the Metaverse is large-scale interoperability three-dimensional virtual world rendered in real time. The digital twin technology can be used to construct virtual world and interact with the real world.

So, next slide, please.

A lot of important technology for the Metaverse is extended reality. Extended reality is a term referring to all real and virtual combined environments and how membership is generated by computer and variableses and include representative firms such as virtual reality, mixed reality, and augmented reality. In the any stage, the VR technologies can be used to construct the virtual world. In the middle term, the MR technology can be used to integrate the virtual world into the real world. In long term, the AR technology can be used to mix the virtual world with the real world. Next slide, please.

So there are some other key technologies, for example the Edge computing. The Edge computing can split the large services required for Metaverse computing into small, manageable sub-tasks and distributes these tasks to the edge nodes for processing.

Another one is about the Cloud rendering. Cloud rendering solution is using distributed Cloud, can provide optimal solution for shortening the rendering cycle and accelerate the arrival of the Metaverse.

Another one is modeling technology. It can be used to construct the digital virtual world. The last one is about the video coding, so it includes the low-latency codec modules, used to improve data transmission efficiency.

Next slide, please. In CG report, we also include the Metaverse standard landscape. For example, we have some work and ISO/IEC, JTC, 24, 29, 9, 172/SC9, 110/WG6 and IEE several working groups and IEEE Metaverse standards committee, and IEEE computer society

Metaverse study group, and also Khronso Group, W3C and 3GPP and ETSI also has initial work about Metaverse. Neck slide, please.

Yes, and I want to emphasize that the activities from Metaverse standards Forum, it was alaunched on June 21 this year and it was hosted by the Khronos Group and the founding members include 37 organizations including Adobe, Alibaba, epic Games, Huawei, Microsoft and others. They have made three statements, industry-wide forum to coordinate and encourage Metaverse interoperability. And it's open to all and no participant fee and no NDA and no IP framework. They established coordinated cooperation between industry and SDOs. They want to have three output goals. One is about the agreed industry-wide terminology, and also want to define standards usage recommendations and guidelines. They also will conduct interoperability prototypes, hack-a-thons, plugfests and tooling projects. Next slide.

Yeah. This is about the Metaverse standard gap analysis. This is also from CG Report, so basically we have several interoperability issues. One is the first thing is interoperability among the different Metaverse platforms. The second one is the interoperability between the Metaverse platform and other platforms. The third one is the interoperability between the Metaverse platform and the common client. So need to work on these interoperability issues. Next slide, please.

So about the future work, so there are some discussion about the Focus Group and we will continue the discussion in session 1 and session 2, so you are welcome to join the discussion. There are some possible aspects to consider for the pre-standardization work. For example, we can define the technical requirements for the Metaverse, define the technical framework, work on the interoperability specifications, work on the application interfaces, and also we can define some guidance to use the multimedia related technologies in the Metaverse.

So I think that concludes my presentation. Thank you for your listening. Thank you.

>> CHAIR: Thank you so much, Kepeng Li for your kind explanation about the CG activities. Thank you again to your hard work of Chair of this CG.

I think we already provided so much useful information for the activities and for the being aitive these and CG report you can download the document from the CG Report from Study Group 16. Thank you so much.

Let's go to the last presentation which is our secession Mr. Khizer Khaderi, and as you can see here vast experience so I don't need to introduce all his experience, but basically you can refer, I guess, basically Dr. Khaderi Clinical Associate Professor at Byers Eye Institute at Stanford University and director and founder of the Stanford human perception laboratory and Stanford vision performance center and faculty at the Stanford institute for human-centered AI and Stanford human performance alliance. And the rest of the experience, can you reference this, please.

Unfortunately, Dr. Khaderi presentation, I'm not sure if can share with the rest of the participants. Let's invite Dr. Khaderi for his presentation. Are you ready to present? Hello?

>> KHIZER KHADERI: Yeah. Hi. Hi. It's a pleasure to be here. (Laughing).

>> CHAIR: Yeah.

>> KHIZER KHADERI: Yeah. I'm ready to present. I think I just have to ask somebody to advance the slides, is that correct?

>> CHAIR: Yes. Continue, yes.

>> KHIZER KHADERI: Excellent. It's an honor to be here presenting to the ITU on the Metaverse and standards, so I appreciate the invitation.

My discussion and my topic is around human perception, so perception is reality and the role of human perception and creating an interoperability Metaverse. Next slide.

These are just my disclosure statements and they just relate to patents. This is my bio, go ahead and next slide. We are already kind of went over some of that already so next slide, please. So, you know, a lot of my esteemed colleagues that have already presented probably talked about a lot of the aspects related to the Metaverse. What I'm going to really focus on is when we talk about it there are so many ways to describe the Metaverse and Web3 but when we talk about the evolution of the Internet, it's very much toward immersiveness where our realities are connected whether it's physical, augmented, virtual, some combination of extended realities.

So, with the Metaverse, we're thinking 3D, realtime, synchronous, persistent, and Web3 is decentralized, distributed Blockchain. Next slide.

So I'm going to introduce a little bit about what we've been doing at Stanford and some opportunities as well and some things being done at the global way. Just to give you an overview of the Stanford human perception lab, our focus is really bridging gap between human-machine interfaces and building technologies and tools that can be shared with the overall community. Next slide.

Our approach is reverse engineering the brain via the human senses, which is really focusing on perception and how perception leads to our intent and our decision-making and action, and I'll explain that a little bit more on the next slide.

So, we built a computational perceptual AI engine. So what we're doing is teaching machines how to perceive in a similar method and then as humans. A lot of this has to do with my research and background as a neurosurgeon so my area of expertise is around perception and humans so we're applying a lot of that around how we approach our modeling. So it takes one part computational, applied behavioral sciences, and artificial intelligence. Next slide.

To put simply, you know, humans capture different signals through their sensory system through their cranial nerves. We have 12 of them. And you know in a similar manner, we're you know enabling that process through SDKs and APisms with machine and then we model into behavior and that's the perceptions a aspect and then contextualize with the environment, and when you think about the Metaverse the environments can be quite broad and across different types of realities.

And then the recommended action, so we talked about this future of immersive like presence that can connect us when we go from our physical worlds to our augmented or virtual worlds, but how do we get that? Next slide.

This is basically what I was describing. This is how we see the Metaverse as intuitive, responsive, and contextual. Next slide.

So, you know, where we are today is a lot of, you know, optimization of human-to-machine interfaces, very much task intelligent, and I know this is an old-school Alexa but it's the one I have in my house right now, so (Laughing), this is the one I use. But it's limited to a lot of requests and response, and it's unable to make contextual decisions. When you think about how we all probably perceive, you know, the future, it's about not the human-to-machine interface, but very much more the machine-to-human interface, so an intuitive AI, one that understands and responds to the human's needs and is able to make contextual decisions.

Next slide.

I'll give you a little bit of just short examples of what we're doing at the Human Perception Lab and taking a multimodal approach in creating our tools. One of the ones that's probably not as familiar to most individuals is the psycho metrics, so that's the ability to measure senses and cognition. So when you think about visual acutey, for example, and you're getting an eye test, you know, there could be the 2020 line or 6/6 line depending on what part of the world you live in, and you know my ability and your ability to see that line could be the same, but the quality is subjective. I might be able to see it, but it's blurry for me where it's crystal clear. And so the psychometric part is being able to measure these types of, to quantify some of the certain attributes that have a little bit more of a subjective component.

So, if you could play the slide here, there should be a little play thing at the bottom. I'll just kind of show you how we're doing this through interactive experiences, so this is enabling machines to understand human performance through visual stimuli, and so this is just a regular game and can you play this on our website if you go to Stanford vision performance center under the technology session and hit demos, and by playing a game, you're playing for entertainment, it's not a test, it's actually this is a same SDK we put into Fort Night or Legal Legends or any type of game, and the point of it is to -- it's to enable the machines the ability to, you know, non-intrusively understand the human, and

here you're playing games and you're able to capture the psychometric information and then decode it into human behavior.

What that can do is that can lend to optimizing, you know, your experiences, and in this case you know, we spend a lot of times in front of the screens and this example is just showing how you could use this to actually get the appropriate pair of glasses that could help you with whatever you're doing in this case, gaming.

The next slide. Next slide. We're still on software. So, you know, again, humans are multimodal. We take information from a lot of different places, if we're trying to mimic the same perception to perceive, because our perception goes back to reality going back to the title of my presentation, so it's the same concept here, that the machines if they're able to perceive, they're able to then allow us the type of immersion that we're looking for. Go ahead and play this. This is the same type of multimodal approach but with cameras. And here we're enabling engagement behavior and we're just doing it in a physical environment. We're using Edge computing here from a, you know, keeping in mind the security and safety of the data that's being captured, but this is in a store and we're able to identify how individuals are attentive and what captures their interest. Again, this is now with computer vision, so we went from psycho dt metrics that doesn't involve a lot of hardware but software. And here how to measure engagement and attention. Next slide.

So wearables, so I like to go pragmatically with, you know, under tech and get the proper applications and I think in keeping in the previous presentation was just describing about the applications in the Metaverse which is great and allapplications have to have a ton of sensors and technologies. How do we do this with a wearable that is relatively smart but doesn't have all the bells and whistles? Just to let you know a lot of these tests have been done in the real world and it was just through different industry partners that had questions and wanted to, you know, wanted to see how they could be address, so that's how, you know, we came to some of these use cases.

So go ahead and play this one. Thank you, by the way, for whoever is controlling the.

So in this case it's safe driving versus distraction or attention and fatigue. So in this case, we're perceiving when somebody is tired. So you'll see an individual that's driving, they actually have behind their glasses, there is an actual piece of hardware that's actually an accelerometer gyroscope and you can see in realtime what it's doing in terms of measuring head position. So that camera is just us capturing this, if we didn't have the camera you would have to believe us. The camera isn't doing the modeling, but it's actually all just sensors. What we're trying to do is create a very robust, perceptive AI platform that is able to take multimodal data is and is able to interpret and decode human behavior because that can lead to more intuitive intelligence because then can you create that feedback loop and

recommendation. So in this case it's able to identify that. Can we go ahead and move to the next slide, please.

So when we talk about interoperability, sometimes we look at it from the technical standpoint, but if we really look at it there is a common denominator in terms of interoperability and it's the human. So if we solve for the human I think that's one approach, that's the approach we're taking. So, next slide.

So, Metaverse interoperability, multi-modal signal capture and devoading of human perception. You can use psychometrics, biometrics like sensors, and can you use like a camera. You're never going to be in one environment where you're going to have all of those. You might have some versus the others, and we have to be able to train machines in a similar way, just like sometimes we're in the dark and we can hear things as humans, but we can't see it, but we're still able to operate in that environment. It's just, you know, a little optimization is different. It's the same kind of concept here.

The reason why I'm showing you the game is that this is what really excites me, is you know some of the way that we can develop the tools in terms of interoperability and also understand like, you know, when we're creating standards, the application, we can do a lot of this through gaming because it is highly instrumentive and you have all of these different components there and it creates an ideal setting and environment for this. Next slide. Case in point, go ahead and play the slide, please.

So in this sense, you know, we're just taking data from the camera itself and key points and so this is something that people are doing right now in terms of one mode of capture and if you layer in the psychometric you get two modes. You get the camera and then how someone is actually interpreting the stimuli in terms of the objects on there, on the screen, the decisions they're making from a cognitive psychometric standpoint and then the motor. And what's interesting about that is we can really understand a lot about how humans operate in these environments and how to optimize the experience in their realities in whatever they're doing whether it's work or play or health related.

Next slide.

So this is just appear example of a report that could happen, you know and there is a game score, and then there is a score that's outside of the game that's more related to how this person is interacting with the stimuli, and that's their vision performance index, and then it breaks that down into how they're interpreting everything on the screen in terms of their field of view, their decision-making, which is defined as accuracy, their ability to be attentive to multiple things on the screen, which is their attention, which is multi-tracking, endurance is just you know how well they're able to sustain their level of performance, and detections related to more visual qualities.

But on top of that, we also decoded the same kind of data, including the camera data in terms of emotional state, whether

they're tired or not, how well they're comprehending, so even though we're doing this in a gaming environment, you could see how this could work in the same information could help in education, especially as we go to more online and accessible forms and you know, work upskilling individuals and things of that nature so there are multiple applications, and then there is multiple realities that can explain that because Zoom is one of those that is a web 2.5, right, because technically it's an example of this Metaverse. We don't have to be in a fully virtual environment to consider that a Metaverse experience. Next slide.

Some of the things we're working on in the human perception lab is working with academics and the industry and we're also in the process of a new project that is going to be, we'll be announcing that which will also involve just creators and developers.

We have a human subject aspect to this through our vision-performance center and start with vision but it has a lot of other biometrics that we're also studying there. These are tools and things that we will be open willing up to the community and will be great to work with the ITU in relationship to this. Next slide.

One of the things that we always keep in mind, you know, the human perception lab is borne out of the school of medicine and ophthalmology department and the institute in Stanford is the tenets of context of technology and oath that I took which is making sure we think deeply about this and pragmatically so these are the constructs of our technology. Next slide.

And you know, then the end goal is to build tech that makes sense for humanity and I think that's why we're all here is making sure that we put these kind of safeguards in place, you know, as this area evolves, and the key thing is, and I kind of said it earlier, my presentation is, the human is the center of all of these experiences, so let's solve for human. Next slide.

So when we're establishing the Metaverse standards, you know, I think sometimes we do this in a vacuum, I'm not saying that the ITU or any one group, but just in general and even in science in general, we do a lot of things from a theoretical or a place without really looking at the experimentations a peck. I think one of the things with the Metaverse is the theory of application. It is an evolving area so let's evolve the area with it and I think gaming and e-sports is the perfect way of doing this. Next slide.

So this is, you know, as you know one of my titles, senior advise tore the Global Esports federation and what I love about them is the whole concept of ethos connected around community. What's really good is the tour is inclusive. Next slide. One, I appreciate the values and mission, this all goes around inclusivity, but it also goes into accessibility. They have multiple Member Nations and federations associated with it. Next slide. 123 and counting. Next slide.

And the ITU, you know, they're a member of the ITU as well and where I see this as being excited is that when we talk about some of the theories and standards that we're looking to put into play, you know, groups at the Global Esports Federation are interested in a sense that they have games and tours where some of the other members of ITU and some of the industry members will have potentially a sandbox where we can actually, you know, obviously ethically and responsibly, apply some of these standards and assess it in realtime when you have folks that are interacting in Metaverse-type experiences.

So, we're able to not just create the standards, but we're able to see how well they're working and how to adjust them accordingly in a space before we go ahead and bring them out to the global community. Next slide.

So this is just an example of the tours, and the next slide. The reason why I kind of present this also to the ITU is you know I've spent some time with them in terms of developing out innovation and research centers, and to create nodes around the globe in key strategic areas where there is a lot of Metaverse activity too, such as Singapore and Dubai to name a few. Obviously in Europe and then in the U.S. So that's why the Stanford Human Perception Lab is part of the Global Esports Federation for us in order to solve some of the issues you have to have a collective and the first foreray into the Metaverse has been gaming so why not start there. That's the conclusion of my presentation. Thank you.

>> CHAIR: Thank you so much, Mr. Khaderi, for your presentation. I think the Human perception issue is very close to the digital human issue and contribute to the work of the digital human to the Metaverse.

Okay, so I think Dr. Khaderi can you share the presentation with the participants, I didn't see your presentation on the web pages, is your password to share the presentation. He nodded. Password is share the presentation.

>> KHIZER KHADERI: Yes. Yes. It is. I'm sorry. I was muted.

>> CHAIR: Presentation is also shared with the participants. Okay. Already time crunch. So I think we have two sessions for multimedia and Metaverse and convene SG 16 meeting. I think this is very useful and helpful for us to understand various technologies for Metaverse implementation in the future. I think the workshop will be referred to by relevant groups for future work, especially we'll use this for Study Group 16 in Study Group 16 and into activities. Okay, so I think Study Group Chair can make contributing remarks for the workshop.

>> NOAH LUO: Thank you, Dr. Kang and speakers in the second session. Despite quite late hours in some time zones, you are still working very hard and you still maintain very high quality of presentation. I don't think we really need something like concrete remarks. I, myself, also learned a lot and improved my understanding so I can manage the work in the general direction of

the Metaverse together with my vice-chairs and in particular with Dr. Kang and also Kepeng Li are also managing the correspondence group. I think in which direction we are proceeding is still up to our discussion and this correspondence group in a few days, and I really appreciate your participation, your interest in today's workshop, and hopefully you can still pay attention to our coming discussion in the correspondence group and in relevant questions that may still be quite interesting.

I spoke to some of our guests during the coffee break, and I think I tried to pass the understanding and impression to people that though Metaverse is something quite new and young -- I mean in this relevant work on underlying work if Study Group 16 can be for quite a long time, so at least more than a decade, so invisible underlying technologies are there to support today's effort.

Okay, so I stop here. Thank you, once again, for all of you for your time, for your interest, and for your -- I see remote?

Okay. I finish here and also give the floor to speaker from U.S. remote. Thank you.

>> UNITED STATES OF AMERICA: Thank you, Mr. Chairman. We can make remarks. We can make remarks to thank you to, thank you and your steering committee for this very excellent and comprehensive workshop. We learned a lot. The presentations were outstanding, and will definitely help us with our work in the ITU-T. Yes, we can make remarks by thanking you personally and your steering committee and Dr. Kang as well for the richness of the presentations that were made. Thank you very much.

>> CHAIR: Thank you very much. Yes. Thank you very much for your work and encouraged the work. Okay. So I think this is not only for myself and vice-chair for our steering group, and I think hopefully the recommendation are documented for all of us as a group. If there are no other reservation or comments, I just announce the termination of today's workshop. Okay. Thank you. The meeting -- oh, yeah. I also -- yes, reception I want to recapitulate the time and location of the reception and Huawei is quite happy to sponsor a reception and in the M building or cafeteria at 6:30 p.m. and I sincerely invite everyone who is available to join us. It's a very good gathering opportunity for socializing and also for the purpose of celebration of the physical start of this meeting for the last three years. You're all welcome, and also my thanks also go to all the ITU Staff, all the team, yeah, just to name a few, Semos and Eva and many others, Mark, who have been working very hard to make this workshop successful. I think I owe them my sincere appreciation. Okay. Meeting closed.

(session completed at 10:48 a.m. CST)

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