European Technology Platform Networld Europe

More than Gigabit Broadband & Metaverse on the move

POST-EVENT DETAILED REPORT

Jointly Organized by

NETWORLD EUROPE

CCSA

Event Overview

Objective

The event aimed to provide a deep understanding of the real requirements and Challenges that Metaverse may bring to mobile communications infrastructures, sharing the valuable experiences and practices of Europe and China.

- **Location:** Hybrid, Virtual and onsite Barcelona
- **Date:** 01/03/2023
- **Duration**: 3.30 hours
- **Number of registrations**184
- **Number of participants:** 106 (76 online+30 onsite)
- **Event Post-Report drafted by:**
  Fatma Marzouk, with contributions from Networld Europe and CCSA organization teams.

Agenda

Workshop	More than GigaBit Broadband & Metaverse on the move – NetworldEurope & CCSA	
Date	Mar. 1st CET 9:00 – 12:30, Beijing 16:00 – 19:30	
Agenda	Talk Title	Speakers
09:00-09:20	Opening Speech and Introduction	Rui L. Aguiar Networld Europe, Steering board chair Wen, Ku CCSA Board Chair
	Panel 1	
09:20-10:00	Explore the Broadband Technologies for the Metaverse 5G/6G, XR and the Metaverse – A Silicon Valley View An Outlook on Cellular Infrastructures for the Support of Metaverse Get in touch with the Metaverse	Wang, Zhiqin CAICT VP, Chairman of the Wireless Committee of CCSA, Chairman of IMT2030(6G) Promotion Group Mischa Dohler VP of Ericsson Emerging technologies Bi, Qi Chief Expert of China Telecom and CTO of China Telecom Research Institute Prof. Frank H. P. Fitzek Professor and head of the "Deutsche Telekom Chair of Communication Networks" at TU Dresden
10:00-10:40	**Experiences & Challenges Panel discussion** (Speakers + Lutz Schade Telecommunications Strategy Advisor, Wang, Xuemin VP of Huawei European Research Institute)	
10:40-11:00	Break	
	Panel 2	
11:00-11:40	Towards the Metaverse: Market Potential & Research Challenges Meet Bit Spectacles Path to Metaverse Ready Networks and 6G Network Innovations Empower Metaverse Era	Ioannis Arapakis Principal Research Scientist, Telefonica Research (Discovery) Wang, Shanshan Director of MIGU (CMCC) Metaverse Sports Center Volker Ziegler Senior Technology Advisor & Chief Architect, Nokia Strategy and Technology Wang, Xinhui VP & General Manager of Standards and Industrial Relations of ZTE
11:40-12:20	**Future Requirements & Innovation Panel discussion** (Speakers + Jyrki Huusko Vice Chair of the Steering Board of the Networld Europe, Amir Abdelazim Detecon Expert Partner)	
12:20-12:30	Closing Words	Wen, Ku CCSA Board Chair Rui L. Aguiar Networld Europe, Steering board chair

Program Summary

Opening Speech and introduction

Rui L. Aguiar (Networld Europe, Steering Board Chair/ University of Aveiro)

Prof. Aguiar welcomed the speakers and the audience, stated that the aim of the workshop is to provide an open information space to identify the requirements and challenges for mobile communications infrastructure in order to enable the metaverse, and explore how different stakeholders can work together to achieve goals. Prof. Aguiar concluded his opening speech by describing the workshop overall program and the interaction guidelines.

*Wen, Ku (*Board Chair, CCSA*)*

Mr. Wen, Ku welcomed the participants on behalf of CCSA and affirmed that the metaverse is a very hot topic, but the industry has no established clear definition. Then, Mr. Wen emphasized that "without the evolution and strong support of ICT technologies and infrastructure, the metaverse will only be a beautiful dream". Furthermore, as far as the depth and breadth of the metaverse are concerned, no industry giant can move forward in isolation and lead the way alone. Instead, it needs the cooperation of key global partners and open global cooperation. Mr. Wen further explained that, from the perspective of the terminal, the evolution of the metaverse will be roughly divided into three stages, namely, infancy based on existing devices, development relying on XR devices to provide sensory immersive experiences, and an ultimate stage, capitalizing on brain-computer interfaces to blur the boundaries between the virtual digital world and the real world. Mr. Wen further highlighted that, considering we are in the process of transitioning from the infancy to the development stage, from the perspective of wireless networks, MR/XR is the core of the current metaverse.

Mr. Wen also pointed out that 5G networks and their evolution need to support large bandwidths and strict latency for MR/XR services, detailing that in the next two to three years, the downlink bandwidth of a single user would reach 1 Gbit/s and the E2E latency would be 10 ms. Therefore, 5G wireless networks will require not only FDD and C-band spectrum but also new U6GHz and mmWave bands to enhance outdoor and indoor hotspot coverage and meet the basic requirements. In turn, the increasing number of multi-frequency and multi-layer wireless networks will bring huge workloads and costs in deployment and maintenance. As such, Mr. Wen raised the point that network implementation needs to be simplified as much as possible, maintenance automated to support MR, and XR services both indoors and outdoors seamlessly at affordable prices. After speaking about the computing and cloud architecture perspectives for the metaverse, Mr. Wen concluded that although the industry has not yet reached a consensus on the evolution roadmap for the metaverse, the requirements for technology and network evolution should be very clear.

Session 1 Discussion

Presenter: *Wang, Zhiqin (CAICT)*

Mrs. Wang, *Zhiqin* started her presentation with a brief description of the fixed and broadband situations in China. In this context, she mentioned that by the end of 2022, in China, the proportion of fiber optic users to fixed broadband users had risen to 94% and that 2.312 million 5G based stations had been built. In relation to the metaverse concept, Mrs. Wang affirmed that it is a continuation of the natural imagination of a virtual and real world that are becoming more and more integrated. Mrs. Wang's presentation also went through the two key scenarios of the metaverse, which are namely: (i) transforming the virtual into the real, leading to a "new" physical world that is foreseen to be: differentiated; combined with computations anchored to multiple

metaverse digital resources; open, allowing an interconnection between different metaverse apps; and strongly interactive. and (ii) Transforming the real into the virtual, which would bring about new demands on previous audio, video, and graphics rendering capabilities (specifically involving 360-degree 3D free view, 6 DoF spatial video, non-linear video, avatars, etc..). Furthermore, Mrs. Wang highlighted that metaverse enterprises should focus on the development opportunities of immersive business forms and the virtual economy, with an emphasis on key areas such as virtual-real business platforms, 3D immersive audio and video, XR intelligent terminals, avatars, supporting infrastructure, and new digital identities and digital assets. Mrs. Wang concluded her presentation by speaking about how 6G is expected to help realize the intelligent connection of the human, physical, and digital worlds, namely through the support of potential technologies and applications towards more immersiveness (Cloud XR, holographic communications, sensory interconnection), more intelligence (reliable AI intelligence accessible to every individual, digital twins, communication for sensing), and more ubiquitousness (global seamless coverage).

Presenter: *Misha Dohler (Ericsson Emerging Technologies)*

Prof. Dohler's presentation aimed to show how the three corners of the XR ecosystem, namely applications, devices, and networks, need to evolve with new capabilities to meet the requirements of XR (widely recognized as the main enabler for the metaverse). Prof. Dohler started his talk by presenting a brief analysis of the current and future trends in consumer media habits and demands, highlighting that the majority of top 5G applications are augmented by XR. Prof. Dohler followed up by sharing Ericsson's prediction for the XR timeline and device type. The prediction foresees, among others, a transition from VR to AR up to 2025, then AR taking the lead until 2027, with a global adoption of XR and a holographic society starting in 2027. On the edge compute side, Prof. Dohler said that as the rendering and resolution requirements become more demanding, mobile edge clouds will increasingly be required for offloading the processing. While this would lead to several gains (GPU, memory, and power), it would, on the other hand, put stringent latency and jitter requirements on the networks to support time-critical communications (10–40 ms latency & 3ms jitter required). Prof. Dohler concluded his presentation with some recommendations on the network side, which include allocating more spectrum for IMT via the ITU to avoid the future XR traffic crunch. The spectrum needed is namely in the centimetric range to support wide-area XR.

Presenter: *Bi, Qi (China Telecom Research Institute)*

Mr. Qi, Bi started his talk by stating that the evolution towards a multi-dimensional metaverse will be done in phases and that service providers' support for such a trend will therefore have to evolve accordingly. In his talk, the speaker distinguished four phases according to which the network requirement would be evolving toward a fully immersive experience, or metaverse. The phases start with an entry phase (20-50 Mbps bandwidth, 40 ms of delay), reaching a Full phase (2-5Bbps, with latency of 10ms), with 2 intermediate phases being partial (50-200 Mbps and 30ms) and deep (200Mbps-2Gbps, 20 ms). Mr. Bi also highlighted that metaverse needs stringent network and computing requirements and that network bandwidth is a clear critical component for the support of the metaverse. As for the key enabling technologies, the speaker explained that the support of the metaverse would involve the integration of many key technologies such as BlockChian, AI, Man-Machine Interface, Digital twin and Cloud Network Convergence. It will also require computation power > 1000 * current CPU capacity (therefore, the metaverse needs far more computing power than Moore's law). Through his presentation, Mr. Qi explained that, having a first-glance look at the evolution of the cellular data rates in terms of average data rate, 5G can be capable of supporting only the partial phase of the metaverse, with full phase support only provided by 6G. Nevertheless, analyzing the personal monthly data usage in China as per the latest China Telecom prediction, the data rate is expected to reach 70 Gbps in the middle of 5G (around 2025) and 425 Gbps in the early 6G level. Therefore, with both releases, it is possible to support the metaverse in the entry phase. Yet, the glitch is the business case for the aforementioned two technology phases. On the other hand, with 6G by 2040, it is possible to support the entry phase in mainstream settings but not the partial phase. Therefore,

the metaverse cannot be supported economically unless new approaches, technological breakthroughs, and revolutionary changes are put forward. Among the innovations, using smartphones as mobile relay nodes represents a CAPEX-light solution for increasing capacity and coverage, leveraging D2D- based P-RAN. In this context, the speaker followed up with an illustration of China-Telecom Proximity-RAN (P-RAN) commercial service branded "Emc e-Mutual Connect" which has been initially developed as a 5G indoor coverage solution but is envisioned to also evolve as a full P-RAN network in 6G. The speaker concluded his talk with a brief overview of China's telecom roadmap. The latter involves the preparation of infrastructure platforms and applications to fully support the metaverse.

Presenter: *Frank Fitzek (Deutsch Telecom Chair of Communication Networks, TU Dresden)*

Prof. Fitzek began his presentation by discussing the rationale behind the most recent initiatives to enhance communications networks and create the metaverse. The latter consists of the metaverse's ability to provide solutions to the various challenges that humanity has faced in recent years (pandemic, recessions, climate change, geopolitical problems, etc..). Then, Prof. Fitzek provided an overview of four topics or building blocks for the metaverse within 6G-Life, a research hub where TU Dresden and TU Munich have joined forces in order to optimize future 6G communications networks with a focus on human-machine collaboration. The 1st topic is Novel Architectures for Softwarized Networks. In this context, Prof. Frank emphasized that the key performance indicator that is vital for the metaverse immersive experience is latency, which cannot be supported by 5G release 15 as per the two video experiments showcased but is expected to be brought by upcoming evolved cellular communication systems. In this regard, Prof. Fitzek briefly spoke about plausible solutions systems, such as the non-public/campus solutions that are currently being showcased at TU Dresden, where a private 5G RAN and Core solution have been built, paving the way to more innovations thanks to the full system softwarization. Solutions that seem to also be promising include Open RAN, WiFi 7, and 5G R.18. Regarding the second building block, Human machine Co-Habitation, Prof. Fitzek highlighted the important use case of humans conveying skills to other humans and machines (example: teaching remotely a robot, relying on sensors that record the data associated with the human skills and AI to generate automatically the code to be running on the robot.). Prof. Frank followed up further by mentioning the use case of one of the startups that is building gloves for interacting with cyber-physical systems. The third building block raised by Prof. Fitzek is going beyond Shannon barriers in transmission capacity, which would help bring energy efficiency to the metaverse. Prof. Frank shed light on the fact that the latter building block is a promising research area on which he is currently focused, mentioning briefly one of his earliest research investigations in this direction. Prof. Fitzek concluded his presentation by speaking on the potential of the 4th building block, the quantum networks, to bring about further improvements in terms of security, network coding, compressed sensing, and the aforementioned post-Shannon theory, which is currently being established through a set of multi-testbeds developed for wireless local area networks within 6G-life.

Open Challenges from Panel Discussion 1

Speaker: Wang, Xuemin *(Huawei European Research Institute)*

Mr. Wang, Xuemin, commented that, two years ago, at the Visions for Future Communication Summit 2021, there was no metaverse concept, but it was mentioned that the upcoming 6G network needs more spectrum and more AI and computing technologies. He also said that today we have enough technology for connectivity but still lack it in terms of cloud computing technologies. Therefore, in the future, it will be important to work together on the definition of 6G. Mr. Wang's thoughts included also the fact that Metaverse can drive the 6G more quickly, emphasizing that work needs to be done on not only the cloud architecture and standards but also the application level.

Speaker: Lutz Schade *(Telecommunication advisor)*

Dr. Lutz asserted that all speakers touched on the point that the network needs to be prepared, but another important challenge is the business model (who does what, who builds the network, and who is financing that), stating that 5G is currently being financed by operators, but now the challenge is the return of investment (ROI). This question would be similarly relevant in the metaverse. Indeed, the current business model would not be able to build out a network that would meet the requirements of metaverse applications on a large scale.

Speaker: Frank Fitzek *(Deutsch Telecom Chair of Communication Networks, TU Dresden)*

Prof. Fitzek commented that we will have multiple metaverses and that the important question is where these metaverses will be hosted. Prof. Fitzek added that he believes that the metaverse needs to run inside the network (and not be hosted by OTT), given its stringent delay requirement. Regarding the way in which management and control of the metaverse would be handled, Prof. Fitzek asserted that the question was more, "Would the network operator be involved in the management or would the network operate without them?" Indeed, dedicated NPN solutions are coming fast as companies would prefer to have full access to create their own innovations, and maybe even their own dedicated metaverse for their employees.

Answering the question of what is missing for the metaverse, Prof. Fitzek confirmed that it is low latency, explaining that the existing solutions are more made for audio and video, but the metaverse is more about human senses, including touch and smell (ex: touching the texture of the meat when cooking, for instance). The types of sensors and actuators also need to be adapted for such use cases, and the telecommunication network has to separate these human senses, which calls for the investigation of advanced techniques to enable the multiplexing of these human senses through the same networks (network slicing, TSN, etc..).

Following a further comment related to the question of why now, Prof. Fitzek explained that it is driven by the human requirements that emerged in the last few years. In more details, the pandemic happened, and the interaction with video conferencing is not the same. In addition, with the aging of society, people want to interact with doctors remotely as if they were in the same room. All those opportunities and more good applications are possible with the metaverse. For instance, the metaverse can also help with the energy crisis and climate change.

Speaker: *Bi, Qi (China Telecom Research Institute)*

Mr. Bi, Qi argued also that, based on the applications in the future, multiple metaverses could exist. Nevertheless, service providers should prepare the network to support all the potential metaverses with respect to bandwidth and latency requirements by capitalizing on technological breakthroughs with a viable business case to have ROI.

Mr. Bi detailed further that currently service providers and network operators are hopeful that the metaverse can generate new revenues and opportunities for the industry, which is why they are all excited about it. However, it is predicted that the metaverse's requirements in terms of bandwidth and bitrates will go up exponentially. However, it assumes that the revenues for service providers could remain flat, but how can a flat revenue support an exponential increase in traffic demand. Mr. Bi underlined that the metaverse cannot be economically sustainable unless we have technological breakthroughs and a new business case.

When it comes to why metaverse is evoked now, Mr. *Bi* explained that there are two views. 1st one thinks that cellular industry as we see it now could be in saturation and a 2nd view believing that the cellular evolution need to continue for a good future. In line with the latter spirit, China Telecom sees the metaverse as a mean to a more efficient and harmonious world.

Speaker: *Wang, Zhiqin (CAICT)*

Mrs. Wang, Zhiqin said that there will be numerous metaverse systems in the first phase, but that there could be a unified one later on. Ms. Wang emphasized the need to ensure interoperability across systems and consistency of identities across systems in such a first phase. Mrs. Wang added that the unified metaverse system would require a single management system that oversees all of the resources and networks.

Session 2 Discussion

Presenter: *Ioannis Arapakis, Telefonica Research (Discovery)*

Dr. Arapakis said that Telefonica is a member of the Metaverse Standards Forum and is working hard to solve some of the most important technical problems that the metaverse brings up. This involves edge computing (how to process data more securely), low-latency technologies (stable connectivity, in a sustained manner), and Network as a Service (to provide to metaverse application developers APIs that dynamically change the configuration of the network based on the different needs of different use cases). According to the speaker, Telefonica perceives the metaverse as the next iteration of the internet that is spatialized, closer to how humans perceive and react naturally with the real world, while also being more integrated into the real world (e.g., using AR). After mentioning some use cases of the metaverse (such as the possibility of watching a football game from homes relying on VR technology and stereoscopic 360- video), the speaker emphasized that the metaverse needs to go beyond the technological challenges, and the industrial applications, and provide values to the users (such as the feeling of presence, the sense of community, etc..). Dr. Arapakis mentioned also a set of important ability barriers to adoption, together with some potential solutions. This includes, among others, making experiences more personalizable for users with different characteristics (for instance, easier using AI-supported content creation for senior adults), more realistic using wifi-based gesture recognition, and safer using protective "bubbles" for avatars to avoid undesirable interactions. Dr. Arapakis concluded his presentation with a set of important messages, including that there are challenges in performing usability evaluations on XR systems, considering that they cannot rely on design guidelines for traditional User Interfaces (UIs) like traditional Quality of Experience (QoE) assessments to consider things like the wellbeing of users and environmental presence.

Presenter: *Wang, ShanShan (MIGU Metaverse Sports Center)*

Ms. Wang, Shanshan started her talk by confirming that the Metaverse is coming and that China Mobile has been systematically building information infrastructure focusing on 5G, Computing force and capabilities center. According to Mrs. Wang these efforts has outlined a blueprint roadmap for the metaverse, relying on an outlook for infrastructure integrating four elements: Temporal spatial views, i.e physical digital space, Technology environment, Life View, and Values. In this context, Ms. Wang revealed that on November 2, 2021, CMCC released the MIGU route to Metaverse at the Global Partner Conference, leveraging on a set of key technology pillars: Ubiquitous Computing Power and capabilities, Gamified Interaction Engine, Immersive Social Connection and Mixed Reality. Then, Ms Wang spoked about two main scenario applications for the metaverse. The first one is of 5G- Ultra HD Technological evolution that provides improved immersive experience for the consumer(by supporting among others a wider color gamut, a color bit Depth, high dynamic rang). Ms. Wang illustrated this use case with some examples of metaverse broadcasting done by China mobile during the Winter Olympic 2021 and 5G+ Beijing Winter Olymics 2022, as well as during the first 5g World Cup Metaverse. The second metaverse use case application discussed by Ms. Wang is the Bit Spectacle, which has been used during the world cup in 2022 as well as in the context of a cooperation Initiative between China Mobile and Xiamen Municipal government, with the aim of supporting cultural, & tourism innovation. Ms. Wang concluded her

speech, by highlighting that China Telecom committed in the scope of the metaverse "to telling the Great Story, to deliver the Optimal Experience, and achieve the Information Civilization".

Presenter: *Volker Ziegler (Nokia)*

Dr. Ziegler's talk aimed to share Nokia's perspectives on the path to metaverse ready networks and 6G. Dr. Ziegler initiated his talk by speaking about the key trends shaping the world in 2030. The driving requirements for the ecosystem include: socio-economic & geopolitical requirements (Deglobalization risk, state-driven innovation, cybersecurity, and sustainability); technology convergence (Cloud, AI/ml, Web 3, Block CHAIN, 5g+, 6G and XR) and the emergence of evolved user needs with respect to industry-entreprise-consumer. Dr. Ziegler asserted that Nokia has a clear vision of the metaverse's opportunities. According to such a vision, metaverse opportunities are clustered into three types of metaverses: Consumer, Entreprise, and Industrial metaverse. In this context, Dr. Ziegler emphasized that the industrial metaverse is the most challenging for engineers (and where the market is likely to take off the fastest, translating it to a variety of use cases. In accordance with Nokia's visions, these opportunities rely on two pillars for the metaverse enablers, namely: human augmentation (already ongoing and example include the use of handhedls, tethered AR glasses, but more is to come such as connected bio- medicals implants), and digital-physical fusion(ongoing but in the future would evolve to include complex, enterprise-wide digital twins, Ecosystem interoperability, Interactive 3D digital twins, and 6G network sensing). After giving a brief overview of the main focus areas in 5G-advanced toward a boosted 5G experience (symmetric XR traffic, latency), boosted 5G operability aspects (including AI/ML enhancement and Radio Efficiency), and boosted 5G service usage (such as IoT optimized Reduced Capability support and Space-Air ground support), Dr. Ziegler summarized the main challenges to overcome to bring 6g to life. These include meeting not only the critical dimensions of technology performance indicators such as throughput, latency, scale, and flexibility but also creating values such as sustainability, digital inclusion, security and privacy. The talk highlighted also that network transformation requires new ways of building and integrating networks such as extreme performance specialized networks, Network of networks relying on a hierarchy of collaborative network layers including NTN, and Network-as-a-Service enrichment via consumable, intent-based networks as Code APIs and AI/ML based orchestrations. Dr. Ziegler concluded his talk with the important message that the network is key to realizing the opportunities of the metaverse, leveraging the capabilities of the network (not just capacity but also co-designed networks for both communication and sensing, as well as security & privacy and Trust), to meet the new service requirements (latency, throughput, and density).

Presenter: *Wang, Xinhui (ZTE Corporation)*

Mr. Wang, Xinhui started his presentation by affirming that there is no one definitive meaning of metaverse, yet some key features and typical use scenarios can be identified. In this context, in general, at ZTE, the metaverse is perceived as a virtual world in parallel to the real world with value added by digital technologies, and in particular, the integration of XR-related technologies with the Internet should be the focus. In line with such a perception, the metaverse is foreseen to have a clear set of characteristics with respect to the architecture, key features, and key objectives, where main architecture layers are infrastructure, human interface, spatial computing & decentralization, and application. Regarding the metaverse services, Mr. Wang mentioned the use case of traffic flow simulation and situational awareness, among many other metaverse services captured in 3GPP TR 22.856, highlighting how beneficial it would be to bring such a service to real life. Mr. Wang spoke also about the enabling technologies (wireless and network) and the huge capabilities needed for the metaverse, highlighting that the network is a key and that the challenge is to bring the metaverse to a wide commercial deployment phase. In order to address these challenges, Mr. Wang mentioned that some "brute force solutions" such as larger bandwidth & flexible spectrum usage, extremely large antenna array, and ultra dense & heterogeneous APs coupled with all the requirements for the handers (hardware and chipset capabilities) are also crucial to supporting the metaverse' needs. Furthermore, Mr. Wang concluded his talk by emphasizing that

a globally harmonized 6G standard, as well as a globally harmonized and sustainable supply chain and innovation chain, are really needed to make the metaverse happen.

Open Challenges from Panel Discussion 2

Speaker: *Amir Abdelazim (DETECON Expert partner)*

Mr. Abdelazim said that Metaverse would not peak until we have convenience issues solved from the user experience side. He also provided his view on network readiness, mentioning that most of the operators are on the right track, working on the network infrastructure to support different use cases, and maturity would only be reached within 5 to 6 years. Mr. Abdelazim also raised the point that the usability of the system is also important, not only the technical drivers and enablers, and that the focus should be on the immersive experience and the associated social responsibilities.

Following a further question on regulatory aspects and the ethical code of conduct for XR and VR, Mr. Abdelazim mentioned that Detecon is currently working in cooperation with the EU on ethical coding in a broader regulatory context than just the metaverse (for instance for defining the priority in case of accident for an AI driven car, or a glitch during a bio-medical XR experience).

Regarding how the metaverse can transform traditional telecom operators, the speaker noted that he foresees that the metaverse will also change the way network operation and management tasks are performed, enabling, for example, an immersive reality for network technicians on the network inventory system, which would impact the operation and business models of network operators.

Speaker: *Wang, ShanShan (MIGU Metaverse Sports Center)*

Ms. Wang, Shanshan commented that roadmaps are different between infrastructure and content providers, but there should be synergies among these roadmaps. Ms. Wang emphasized also that synergy needs to exist among the different coexistent metaverse services and technologies leveraging unified platforms. After highlighting the importance of usability, Ms. Wang presented a video showing the use case of XR for an immersive audio and video experience by China Mobile during the World Cup.

Speaker: *Ioannis Arapakis, Telefonica Research (Discovery)*

Through his intervention, Dr. Arapakis revealed that he personally thinks that one of the pivotal steps in realizing a metaverse is being able to onboard the human senses into the immersive digital experience. He also commented that he sees two parallel roadmaps, with the first one dealing with the infrastructure challenges from the point of view of network operators and the second one addressing the human-centric part of the experience.

Following a further discussion on the business model, Dr. Arapakis affirmed that the metaverse presents new opportunities. In this context, Dr. Arapakis spoke about the recently announced Telefonica Open Gateway, which is, an initiative joining the forces of many operators that would work toward standardizing APIs to access networks, seeking the acceleration of new services within, among others, the metaverse. As such, metaverse opportunities would go beyond the current pool of customers to expand to more B2C and B2B and open the door to metaverse developers' applications, which would definitely shape the business model in the future years.

Finally, yet importantly, Dr. Arapakis stated that he agrees that network readiness is one of the important technical challenges to be solved in the coming years, underscoring that we must also understand that the

metaverse will not replace our physical reality but rather allow us to perform things that would be impossible otherwise.

Speaker: *Volker Ziegler (Nokia)*

Dr. Ziegler commented that defining a roadmap begins with the inquiry of what are the most important and pertinent challenges we are attempting to tackle (for consumers, society, enterprise, and industry) as a starting point, then looking at which relevant technologies to push (6G sensing, AI native, etc.) while considering ecosystem readiness as well as the educational challenge. Dr. Ziegler stressed that we are in front of an opportunity that we need to grasp "by keeping up the research when it comes to 6g, keeping delivering the great innovation that is increasingly standardized, and making sure we are collaborating." Dr. Ziegler continued that MWC23 provided a lot of evidence that industry at large is merging into the opportunity of the metaverse because of its potential to bring productivity and efficiency gains, cost reduction, an improved consumer experience, as well as energy efficiency in conjunction with Tbps throughput and sub-millisecond latency.

Following a further discussion on the business model transformation, Dr. Ziegler affirmed that the two keys are namely the network-as-a service fundamental paradigm shift and making life easier for those who build the service (using the network as a code, new regimes of exposing capabilities), which ties into new ways of enabling the metaverse.

Presenter: *Wang, Xinhui (ZTE Corporation)*

Mr. Wang, Xinhui, commented that roadmaps need to be established not only in terms of time but also in terms of steps through which the different trends should go toward a successful and commercially sustainable metaverse. The main steps involve identification, research, standardization, and implementation. In addition, Mr. Wang raised that currently there are enough entertainment use cases, which is not the case for industry. This calls for exploring further how to make the metaverse quite beneficial and efficient for that sector.

Regarding addressing the regulatory issues in the metaverse, Mr. Wang asserted that this would be a huge task covering social, responsibilities, ethical, and legal aspects.

Closing Words

Mr. Wen, and Prof. Rui Aguiar concluded the seminar with some brief words on the lessons learned during the session, which summarized the identified specific challenges for the metaverse (spanning the network, the frequency bands, and the commercial business models), and with some comments on the necessity to repeat this type of information exchange in the future to push the whole industry straight forward to shaping the metaverse into reality.

Feedback after the session

Several formal and informal feedback was received after the session, from the participants globally. There was a large agreement on the feedback, with compliments on the quality of the workshop and its content.