6G: Building Metaverse-ready Mobile Networks

An analysis on network requirements and technology trends to support immersive living

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Introduction

- The next generation of mobile networks (Next G) seem likely to be driven by a set of expectations in visions of the immersive living, cyber-physical convergence, Internet of Senses and in summary, The Metaverse.

- We expect more devices, much more data, richer experiences and in particular immersive multi-sensory experiences, digital twins, greater use of cryptocurrencies and de-centralisation.

- More people will spend even more of their lives immersed in virtual worlds that will become in many respects indistinguishable to the physical world.

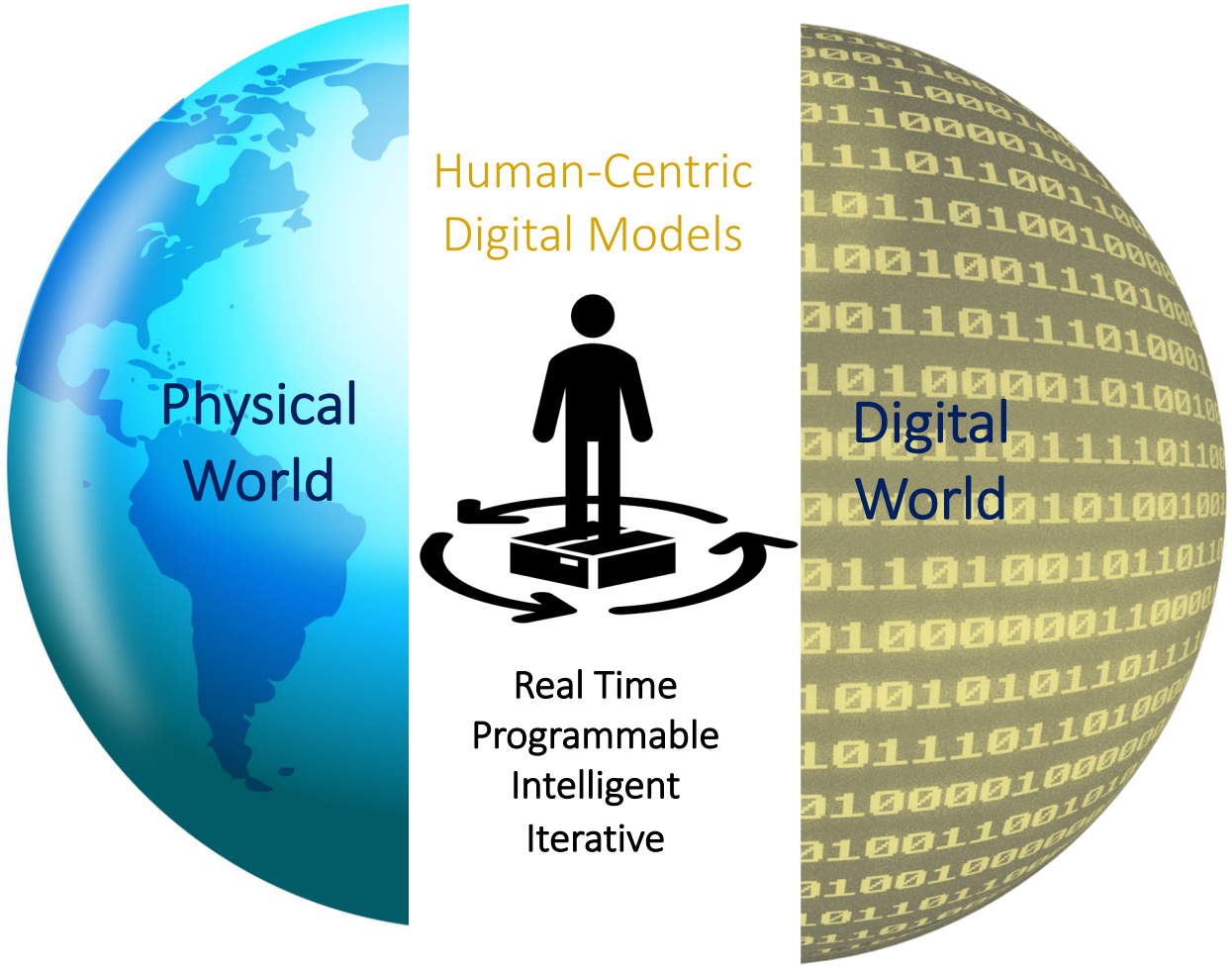
- The metaverse will create an environment where different intelligent autonomous machines will interact with the physical world to improve the quality of life and to support the UN SDGs

- The Metaverse will allow geographically distant participants to enjoy realistic, spatially-aware experiences that seamlessly blend virtual content in a user's physical world and empowers billions of users to feel more connected with each other.

- But what are the implications of the metaverse with regards to the underlying connectivity infrastructure and services; technology for user devices; innovative content creation and distribution; and how this new conceptualisation of a hyperconnected world.

Metaverse: Cyber-Physical Convergence

The physical world of digital connectivity, sensing, data, compute and real world experiences



Digital representation of physical world scenarios

Context

- The metaverse will not be an application that runs on top of existing infrastructure. It’s the next iteration of the network infrastructure that supports real-time experiences

- Delivering the metaverse experience will require step-change innovations in network architectures and underlying technologies

Multiple use-cases

- Industry 5.0
- *n*D (*n*-dimensional), multisensory XR experiences
- Media, Gaming , Collaborative creative arts
- Tactile, interactive and real time education and training
- The future of health
- Connected robotics and autonomous systems including transport
- Tourism
- The future of work
- Commerce in the virtual world – NFT/Blockchain

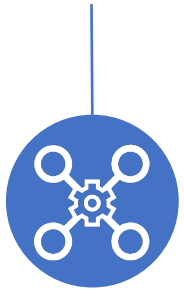
Network Requirements

- Reducing latency by two orders of magnitude faster - to low of ms and towards 10's μs
- Deterministic latency
- Symmetric high capacity bandwidth over long distances - Overall speed of networks more than 1 Tbps peak data rate
- Network coverage-connecting the unconnected
- Openness and interoperability
- Autonomy-Self composition and self-optimisation
- Networked Sensing
- Security assurances
- Ultra resilience (dependability, availability, reliability)
- Privacy and trust
- Security and resilience
- Human-centricity
- Consistent quality of experience
- Energy consumption & Wider UN Sustainability Goals
- Zero carbon footprint

Key Technologies

New Hardware

Generic HW acceleration, RIS and Meta surfaces, New high throughput fibre and associated amplifiers (e.g., Hollow Core) Cell-free massive MIMO, Holographic radio, Ultrafast switches, Cost efficient and simple transceivers, heavily integrated components and subsystems

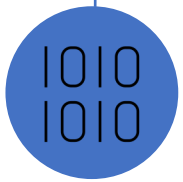


Open hardware/interfaces

Higher reliance on open hardware platforms, open-source and open interfaces

Quantum

network, computing, sensing

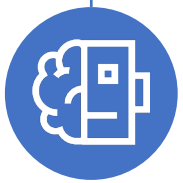


Native Security

Cyber and physical layer

Integrated AI

Widespread use of AI in cognitive and data-driven networks, Intelligent spectrum management



Spectrum

THz, sub-THz and optical (infrared and visible light)

Cloud & Edgification

Continued cloudification for cost/efficiency and horizontal scaling, Federated and Split Edge computing

Continuous evolution

Fast evolution of network SW and app development, blockchain and distributed ledger technologies, Digital Twins

Infrastructure evolution

Convergence (wireless, optical, satellite, computing, sensing, control), Distributed, resilient, self-composable

Desired Outcomes

- Convergence architectures for sensing, computing, control and communications to fully support immersive experiences
- Cyber security threat landscape for the metaverse – with insights on how this conceptualization changes depending on the architectures and technologies involved
- Dynamic digital twins with synchronous real-time updates
- Co-design, co-creation methodologies
- Improved cooperation and interaction
- Same experience independent of location around the globe
- New business opportunities and models in the Metaverse
- Policy, regulation, standards
- Reduced carbon emissions through improved cyber work and leisure environments

Research Base

Contributions based on world-leading research carried out in a number of academic centres in the UK:

- University of Bristol, Smart Internet Lab: www.bristol.ac.uk/smart
- University of Strathclyde, LiFi Centre: https://www.lifi-centre.com
- Queen's University Belfast, Centre for Wireless Innovation: https://www.qub.ac.uk/ecit/CWI/
- University of Leeds, Institute of Communication and Power Networks: https://eps.leeds.ac.uk/electronic-engineering-communication-power-networks
- University of Southampton, Next Generation Wireless: https://www.wireless.ecs.soton.ac.uk & Optoelectronics Research Centre: https://www.orc.soton.ac.uk
- University of Glasgow, Communications Sensing and Imaging: https://www.gla.ac.uk/research/az/csi/
- Compound Semiconductors, Wales: http://www.compoundsemiconductorcentre.comhttps://www.cardiff.ac.uk/institute-compound-semiconductors; https://www.swansea.ac.uk/campus-development/developing-bay/key-projects-bay/cism/
- University of Sussex, 6G Lab: https://6g-lab.org
- University of Sheffield, Communications Research Group: https://www.sheffield.ac.uk/eee/research/groups/communications
- University of Lancaster, Sub-Terahertz Engineering Centre: http://wp.lancs.ac.uk/sub-thz-electronics/
- Darham University, Centre for Communications Systems: https://www.durham.ac.uk/research/institutes-and-centres/communications-systems/
- Bangor University, DSP Centre of Excellence: https://dsp-centre.bangor.ac.uk
- King's College London, Centre for Telecommunications Research: https://www.kcl.ac.uk/research/ctr
- 6G Futures: https://www.6gfutures.uk