Extended Reality in Industry4.0 (ERI)

Lecture 15: Metaverse

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Metaverse: Introduction

- **Metaverse** is literally a combination of the prefix "**meta**" (meaning transcendence) and the suffix "**verse**" (shorthand for universe), is a computer-generated world linked to the physical world.
- Metaverse, as an evolving paradigm of the next generation Internet, aims to build a fully immersive, hyper spatiotemporal, and self-sustaining virtual shared space for humans to play, work, and socialize.
- Driven by recent advances in emerging technologies such as extended reality, artificial intelligence, and blockchain, metaverse is stepping from science fiction to an upcoming reality.

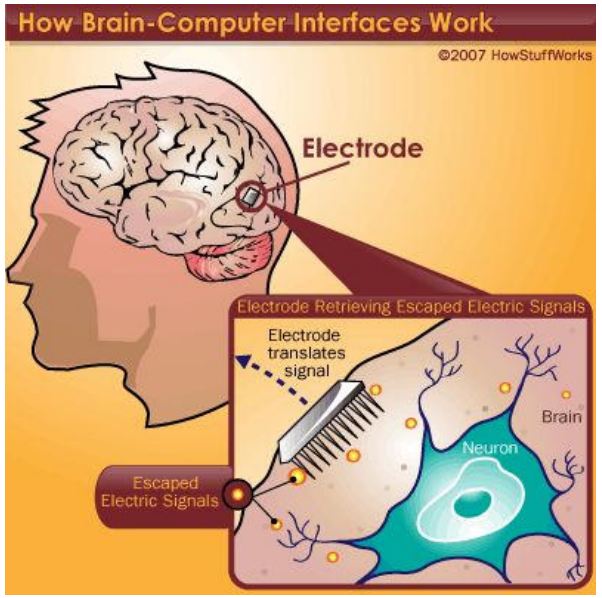
Metaverse: Introduction

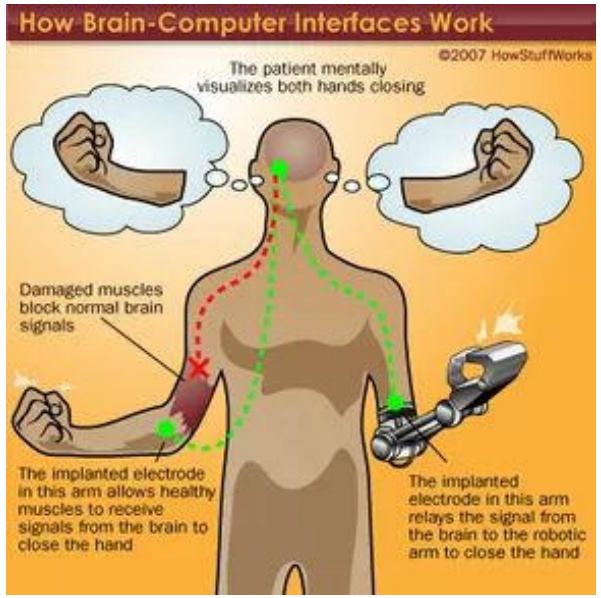
- The term metaverse was created by Neal Stephenson in his science fiction novel named *Snow Crash* in 1992.
- In this novel, humans in the physical world enter and live in the metaverse (a parallel virtual world) through digital avatars (in analogy to user's physical self) via virtual reality (VR) equipment.

Metaverse: Introduction

- The metaverse integrates a variety of **emerging technologies**.
- In particular, **digital twin** produces a mirror image of the real world.
- **VR** and **AR** provide immersive 3D experience.
- **5G** and beyond offer ultra-high reliable and ultra-low latency connections for massive metaverse devices, wearable sensors.
- **Artificial intelligence** (AI) enables the large-scale metaverse creation and rendering
- **Brain-computer interface** (BCI) enables user/avatar interaction in the metaverse.
  - *A **brain-computer interface** (BCI) is a system that enables a person to use their brain signals to control an external device. BCIs capture and analyze brain signals then translate them into usable commands for an external device to put into action in the metaverse.*

Metaverse: Introduction





- **Blockchain** play an important role in determining authentic rights for metaverse assets.
  - Blockchain is a shared immutable ledger that facilitates the process of **recording transactions** and **tracking assets** across a business network.
  - Blockchain stores information electronically in a digital format to make **transactions secure**.
  - It is also known as Distributed Ledger Technology (DLT). With the help of Blockchain technology, currency as well as anything can be converted into digital format and stored.
  - It is an exchange process, works on data blocks that are connected to one another. These blocks **cannot be hacked** and this technology aims to keep documents digitally secure. **It is ideal for applications like cryptocurrency**.

Metaverse: Introduction

- Driven by realistic demands and the prospect of feasibility of metaverse construction, metaverse recently has attracted increasing attention from around the world and many tech giants such as Facebook, Microsoft, Tencent, and NVIDIA have announced their ventures into Metaverse.

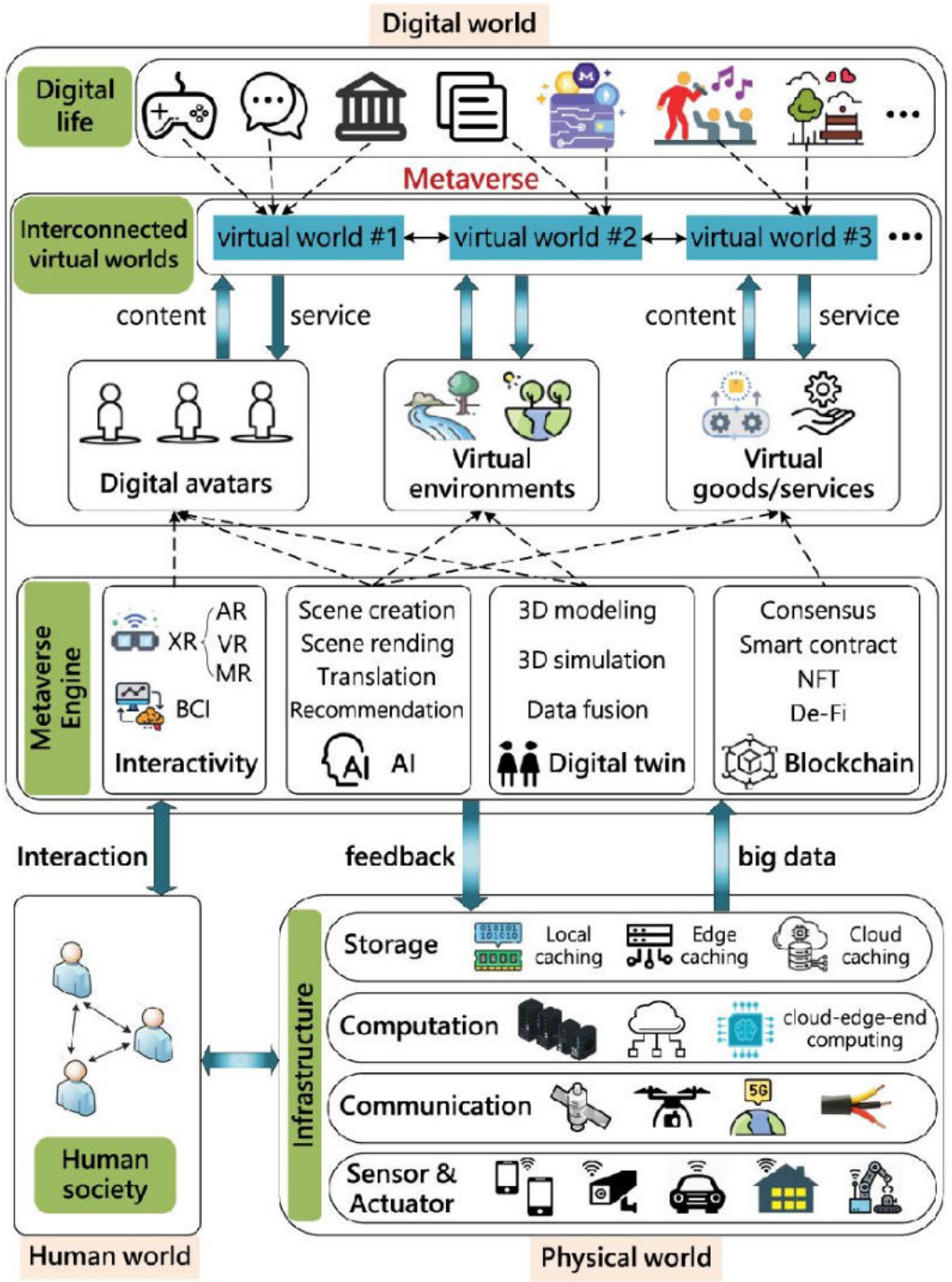
INTO THE METAVERSE

2023 Economic Outlook and Strategies for Growth

Challenges for securing Metaverse

- In spite of the promising sign of metaverse, **security** and **privacy issues** are the prime concerns that hinder its further development.
- A wide range of security breaches and privacy invasions may arise in the metaverse from the management of massive data streams, pervasive user profiling activities, unfair outcomes of AI algorithms, to the safety of physical infrastructures and human bodies.
- There have been incidents of emerging technologies, such as hijacking of wearable devices or cloud storage, theft of virtual currencies, and the misconduct of AI to produce fake news.

The architecture of metaverse in integration of the human, physical, and digital worlds.



Digital avatars

- Avatars refer to the digital representation of human users in the metaverse.
- A user can create various avatars in different metaverse applications, and the produced avatars can be like a human shape, animals, imaginary creatures, etc.

Virtual environment

- Virtual environments refer to the simulated real or imaginary environments (consisting of 3D digital things and their attributes) in the metaverse.
- Besides, the virtual environments in the metaverse can have distinct **spatiotemporal dimensions** (e.g., in ancient times or future worlds) for users to experience an alternate life.

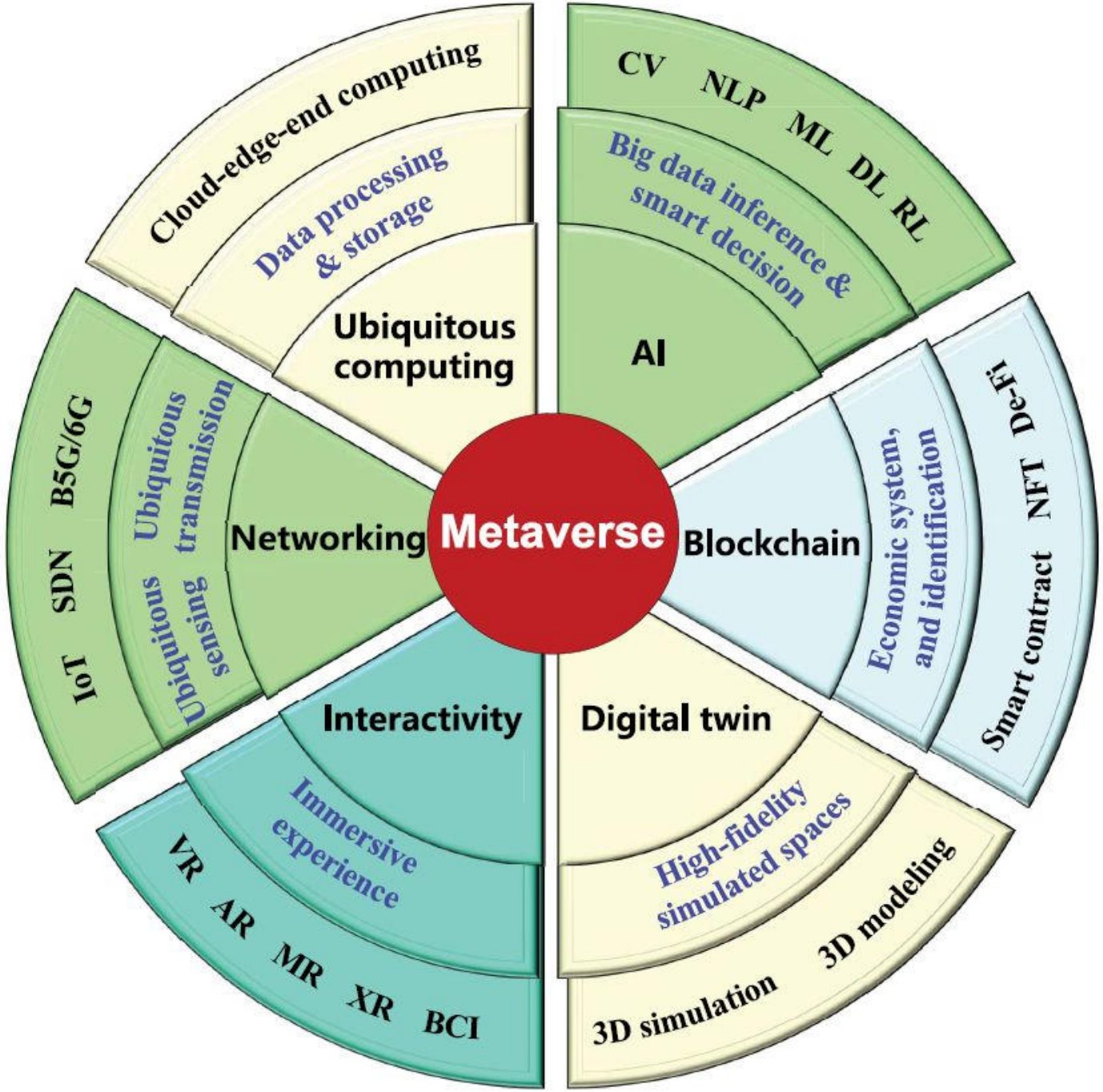
Virtual goods/services

- Virtual goods refer to the tradeable commodities (e.g., skins, digital arts, and land parcels) produced by virtual service providers (VSPs) or the users in the metaverse.
- Virtual services in the metaverse have a broad scope, including digital market, digital currency, digital regulation, social service, etc.

Metaverse Engine

- The metaverse engine uses the big data from the real world as inputs to generate, maintain, and update the virtual world via interactivity, AI, digital twin, and blockchain technologies.
- Particularly, with the assistance of XR and BCI techniques, users situated in physical environments are able to immersively control their digital avatars in the metaverse via their senses and bodies for diverse social activities such as car racing, dating, and virtual item trading.

The illustration of six underlying technologies including its roles and key components in the metaverse.



Existing modern prototypes of metaverse applications

- **Game**
- Considering the technological maturity and content adaptability, games are an excellent way to explore the metaverse.
- The sandbox game ***Second Life*****1** offers a modifiable 3D virtual world where players can join in as avatars and create their virtual architectures and sell them.
- ***Fortnite*****3** is a massive multi-player online (MMO) shooter game designed by Epic Games, where players can build buildings and bunkers as well as construct islands

Existing modern prototypes of metaverse applications

- **Game**

Second Life

Existing modern prototypes of metaverse applications

- **Game**

Fortnite

Existing modern prototypes of metaverse applications

- **Social experience**
- Metaverse can revolutionize our society and enable a series of immersive social applications such as virtual lives, virtual shopping, virtual dating, virtual chatting, global travel, and even space/time travel.
- For example, Lil Nas X held a virtual concert on Roblox in 2020, with over 30 million fans participating.

Existing modern prototypes of metaverse applications

Online Collaboration

- Metaverse also opens new possibilities for immersive virtual collaboration in terms of telecommuting in virtual workplaces, studying and learning in virtual classrooms, and panel discussion and meeting in virtual conference rooms.
- For example, *Horizon Workroom*5 is an office collaboration software (run in Oculus Quest 2 helmet) released by Meta (parent company of Facebook), which allows people in any physical location to work and meet together in the same virtual room.

Existing modern prototypes of metaverse applications

- **Online Collaboration**

Existing modern prototypes of metaverse applications

- **Simulation and design**
- Another promising application is 3D simulation, modeling, and architectural design on metaverse.
- For example, NVIDIA has built its open platform named *Omniverse*7 to support multi-user real-time 3D simulation and visualization of physical objects and attributes in a shared virtual space for industrial applications, e.g., automotive design


NVIDIA

Metahuman

- MetaHuman is a framework allows developers to create and animate high-fidelity digital human characters.
- Photorealistic digital humans can be created quickly and intuitively, which can be fully rigged and ready to use.
- With MetaHuman Animator, it is possible to reproduce facial performances as high-fidelity animation on any MetaHuman.

Metahuman

- MetaHuman presets are based on pre-existing scans of real people.
- With a huge range of facial features and skin complexions, plus many different choices for hair, eyes, clothes, and more, a variety of characters can be made.