

Digitalization 5.0: Metaverse Trends, Challenges, Roadmaps, and Standardization

Yu Yuan, PhD

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Chair, IEEE VR/AR Advisory Board

Founding Chair, IEEE Metaverse Standards Committee (CTS/MSC)

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Co-founder, VerseMaker

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November 18, 2022

Before we share our opinions...

DISCLAIMER:

The opinions expressed herein are the opinions of me and not necessarily the opinions of IEEE or IEEE SA.

IN MEMORY OF



PROF. YUZHUO ZHONG

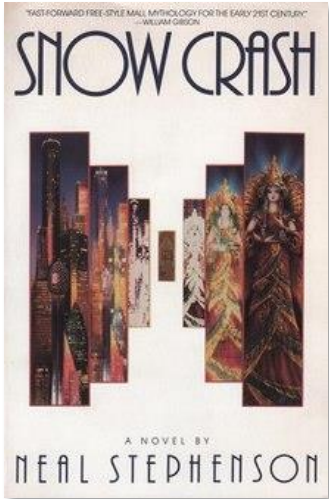
Founder of Multimedia Discipline in China

1938 - 2022

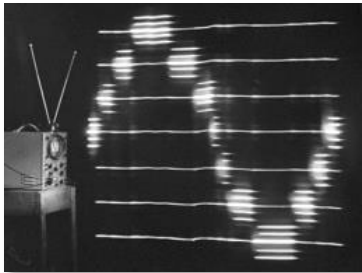
Metaverse is the ultimate form of multimedia.

What is the Metaverse?

A brief history



Author: **Neal Stephenson**
Publication: **June 1992**



Metavision

Inventor: **Steve Mann**

In **June 1974**, Steve Mann invented and coined the term "metavision" as extended reality using wearable computing.



Designer: **Philip Rosedale**
Initial release: **June 2003**



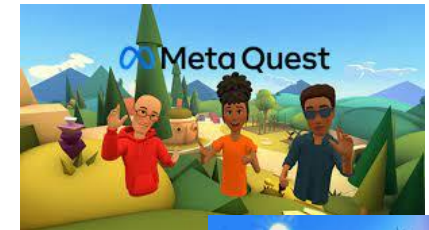
Initial release: **June 2005**
IPO: **March 2021**

Roblox's Prospectus (February 2021)

- **Identity.** All users have unique identities in the form of avatars that allow them to express themselves as whoever or whatever they want to be. These avatars are portable across experiences.
- **Friends.** Users interact with friends, some of whom they know in the real world and others who they meet on Roblox.
- **Immersive.** The experiences on Roblox are 3D and immersive. As we continue to improve the Roblox Platform, these experiences will become increasingly engaging and indistinguishable from the real world.
- **Anywhere.** Users, developers and creators on Roblox are from all over the world. Further, the Roblox Client operates on iOS, Android, PC, Mac, and Xbox, and supports VR experiences on PC using Oculus Rift, HTC Vive and Valve Index headsets.
- **Low Friction.** It is simple to set up an account on Roblox, and free for users to enjoy experiences on the platform. Users can quickly traverse between and within experiences either on their own or with their friends. It is also easy for developers to build experiences and then publish them to the Roblox Cloud so that they are then accessible to users on the Roblox Client across all platforms.
- **Variety of Content.** Roblox is a vast and expanding universe of developer and creator-built content. As of December 31, 2020, there were over 20 million experiences on Roblox, and in 2020, over 13 million of these were experienced by our community. There are also millions of creator-built virtual items with which users can personalize their avatars.
- **Economy.** Roblox has a vibrant economy built on a currency called Robux. Users who choose to purchase Robux can spend the currency on experiences and on items for their avatar. Developers and creators earn Robux by building engaging experiences and compelling items that users want to purchase. Roblox enables developers and creators to convert Robux back into real-world currency.
- **Safety.** Multiple systems are integrated into the Roblox Platform to promote civility and ensure the safety of our users. These systems are designed to enforce real-world laws, and are designed to extend beyond minimum regulatory requirements.



Founded: **January 2004**
IPO: **January 2012**
Name change: **October 2021**



Neal Stephenson's Original Definition of Metaverse



Neal Stephenson

@nealstephenson

The assumption that the Metaverse is primarily an AR/VR thing isn't crazy. In my book it's all VR. And I worked for an AR company--one of several that are putting billions of dollars into building headsets. But...

11:02 · 08 Jun 22 · [Twitter Web App](#)

Dr. Yu Yuan's Definition of Metaverse

Metaverse refers to a kind of experience in which the outside world is perceived by the users (human or non-human) as being a universe that is built upon digital technologies as a different universe ("Virtual Reality"), a digital extension of our current universe ("Augmented Reality"), or a digital counterpart of our current universe ("Digital Twin").

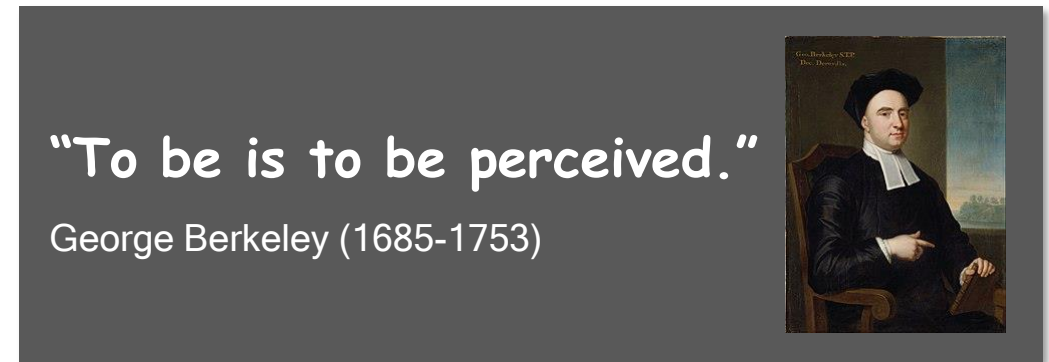
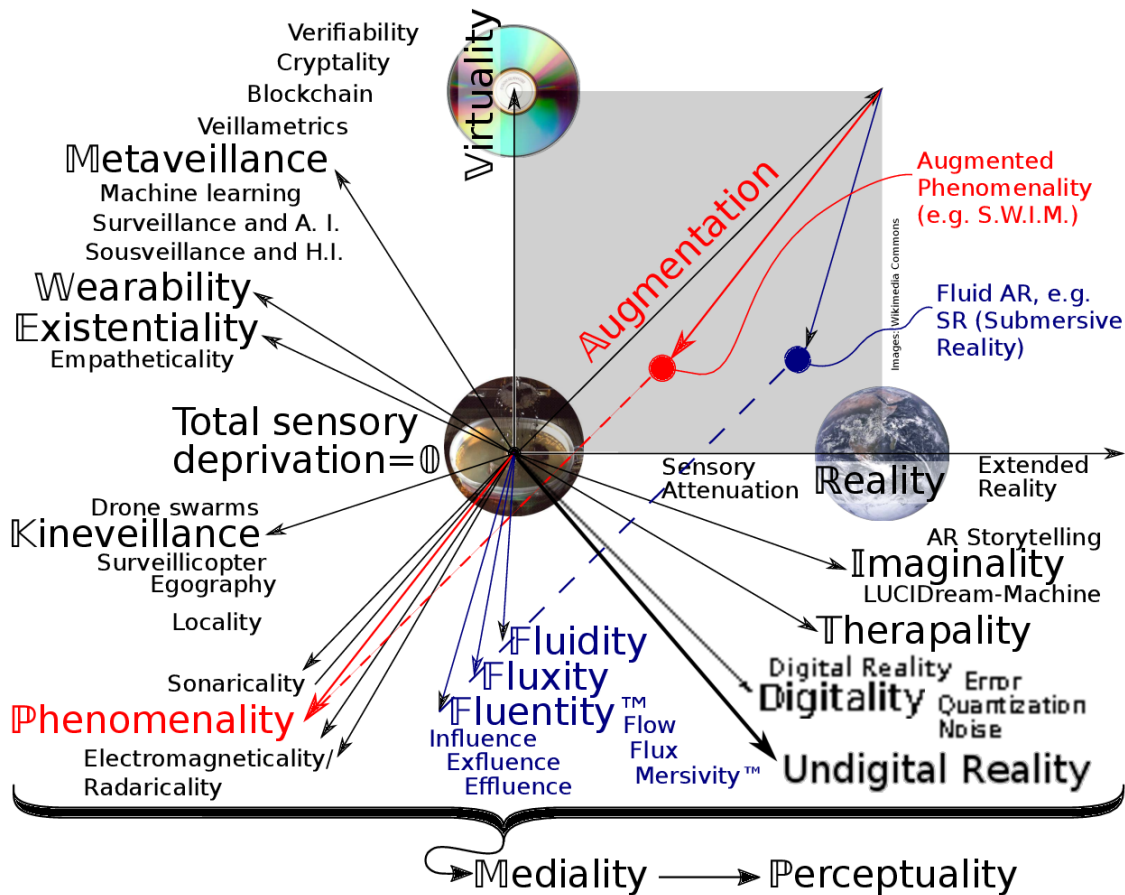
Named after the universe, a metaverse shall be **persistent** and should be **massive, comprehensive, immersive, and self-consistent**. Described as "meta", a metaverse should be **ultra-realistic, accessible, pervasive**, and may be **decentralized**. In a narrow sense, metaverse may be simply defined as **Persistent Virtual Reality (PVR)**. In a broad sense, metaverse is the advanced stage and long-term vision of **Digital Transformation**.

元宇宙是关于外界被用户（人类或非人类）感知为一个建立在数字技术之上的宇宙的一种体验，这个宇宙或者是与我们当下的宇宙不同的宇宙（“虚拟现实”），或者是我们当下的宇宙的一种数字扩展（“增强现实”），或者是我们当下的宇宙的数字对应物（“数字孪生”）。

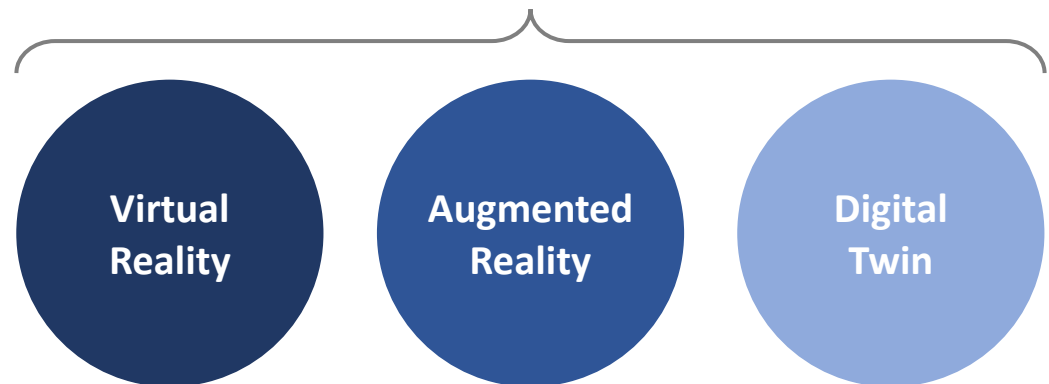
元宇宙既然以宇宙命名，就必须是**持久的**，而且应该是**巨大的、全面的、沉浸的、自治的**。元宇宙既然用“meta”来形容，就应该是**逼真的、易用的、泛在的**，并且可以是**去中心化的**。狭义上，元宇宙可以简单地定义为**持久存在的虚拟现实**。广义上，元宇宙是**数字化转型**的高级阶段和长期愿景。

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Three types of metaverses



Source: Steve Mann, Tom Furness, Yu Yuan, et al., "All Reality: Virtual, Augmented, Mixed (X), Mediated (X,Y), and Multimeditated Reality", arXiv:1804.08386, 20 Apr 2018

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Shall be:

Persistent

Should be:

Massive

Comprehensive

Immersive

Self-consistent

Ultra-realistic

May be:

Decentralized

INTERNAL ("Universe of Bits")

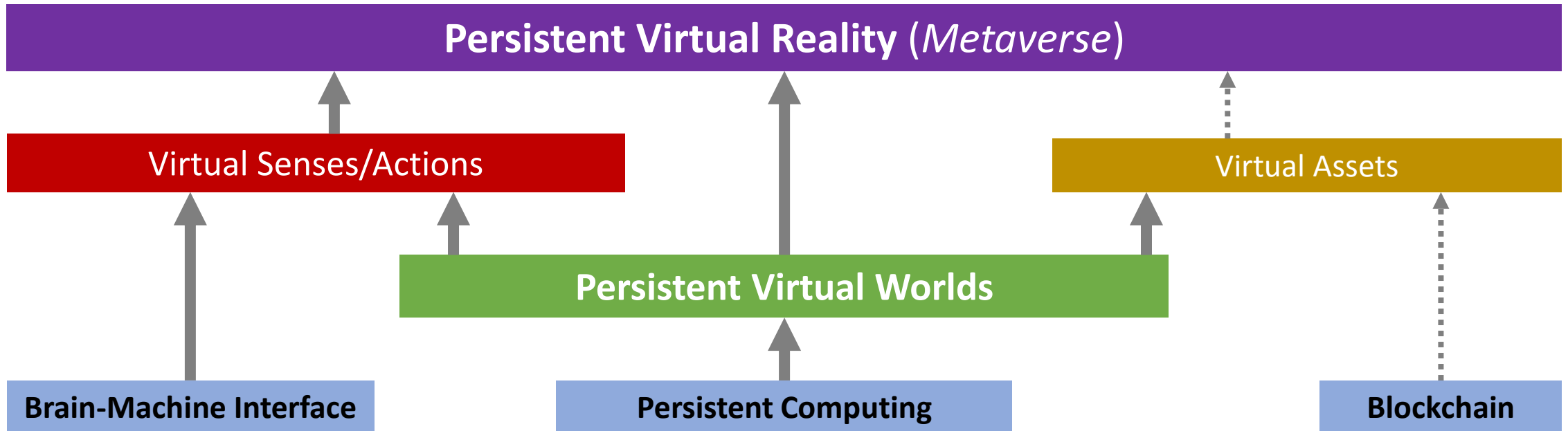
EXTERNAL ("Universe of Atoms")

Accessible

Pervasive

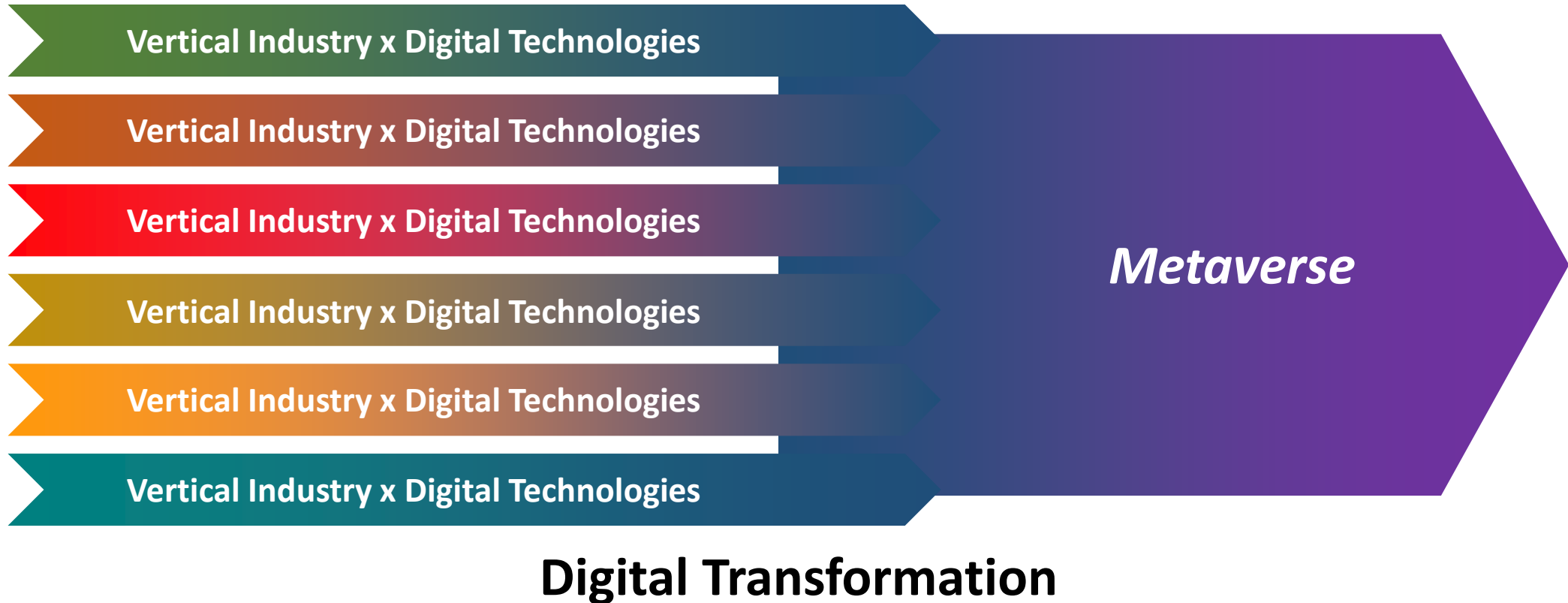
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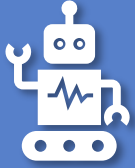


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Dr. Yu Yuan's Chronicle of Digital Transformation



Digitalization 1.0:
Automation

数字化1.0:
自动化



Digitalization 2.0:
Interconnection

数字化2.0:
互联化



Digitalization 3.0:
Personalization

*Web 2.0 =
Massive UGC +
Personalized Recommendations*

数字化3.0:
个性化



Digitalization 4.0:
Intelligentization

数字化4.0:
智能化



Digitalization 5.0:
Realitization
(Metaverse)

数字化5.0:
现实化
(元宇宙)

Digital Reality

Digitalization 1.0 – 5.0

Dr. Yu Yuan's recommended practice for usage of the word "metaverse" in English

In terms of how to use the following variants:

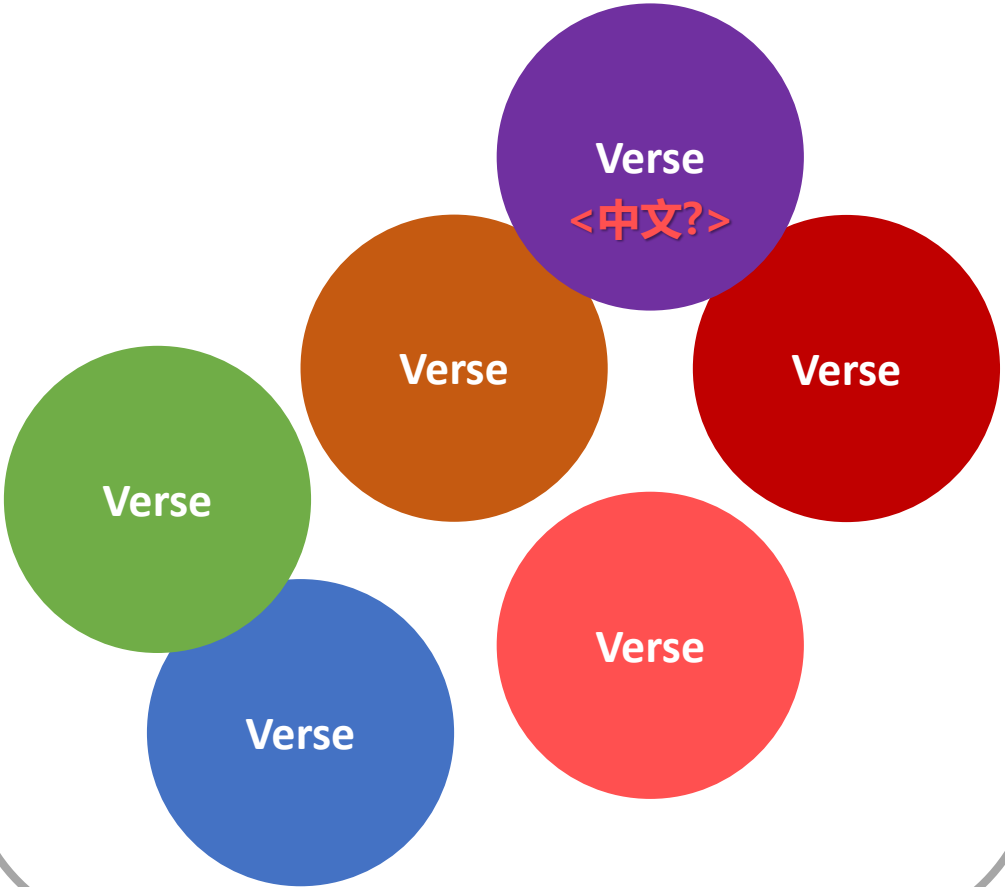
1. **metaverse**
2. **a metaverse**
3. **metaverses**
4. **the metaverse**
5. **the Metaverse**
6. **Metaverse**

My preference is:

- 1 should be used in most cases like when we are using other technical terms (virtual reality, cloud, blockchain, etc.) while not having to capitalize them.
 - Example: "... projects relevant to **metaverse** interoperability ..."
- 2/3/4 should be used to refer to specific implementations (or embodiments) of metaverse.
 - Example: "... **the metaverse** created by her company is **a decentralized metaverse**."
- 5 should be used to refer to the entire metaverse industry or the sum of all metaverses, similar to "the Internet".
 - Example: "... we believe that **the Metaverse** will have a profound impact on everything."
- 6 should be used in proper nouns, such as "**Metaverse** Standards Forum".

The Metaverse vs. The Internet of Metaverses

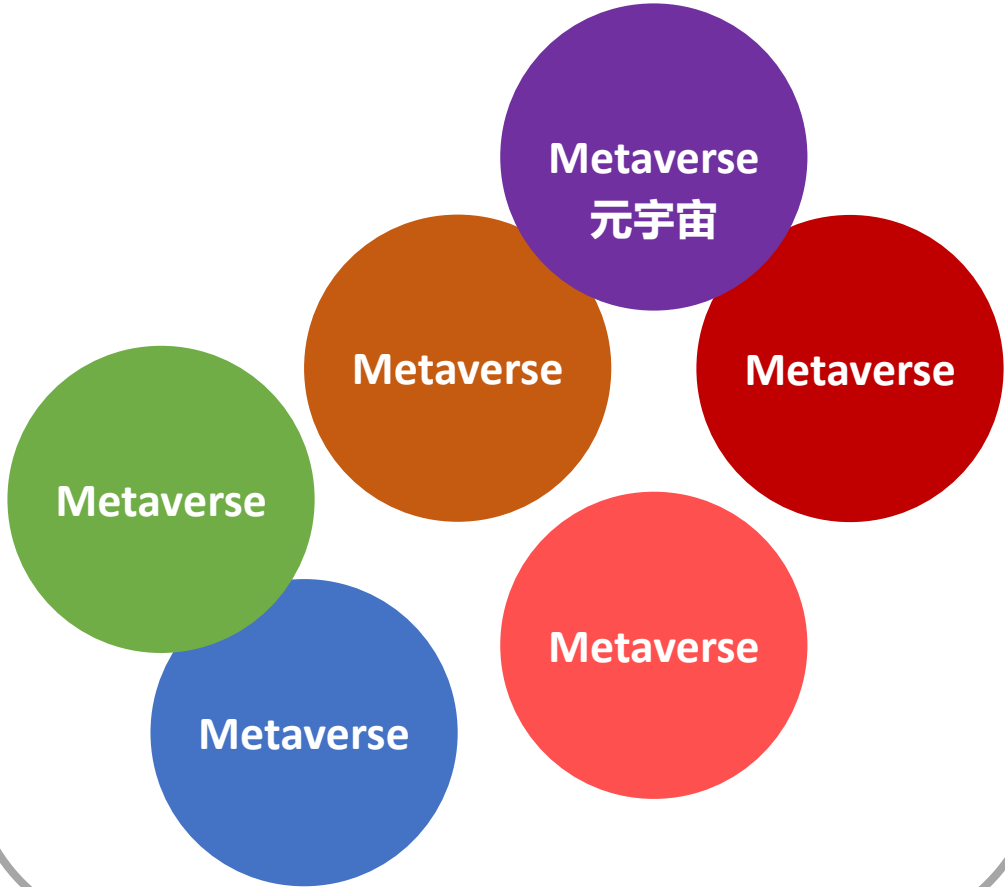
The Metaverse 元宇宙



VS.

The Internet of Metaverses 互联网

《尸子》曰：「上下四方曰宇，往古來今日宙。」



What is NOT the Metaverse

The concepts that are currently labeled as the Metaverse but are not actually the Metaverse

NFT is not the Metaverse

- Today, most NFTs have no use value but only the so-called collection value or investment value.
- Collecting and investing are only a small part of our real life today and will be the same in the Metaverse in the future.
- **The mainstream demand of mankind for the Metaverse will never be collection and investment.**

NFT is not a necessary element of the Metaverse

- **Play for Fun vs. Play to Earn**
 - These are two very different groups of users
- **Transferring assets from one virtual world to another is NOT a rigid demand, but can be harmful**
 - Why should you be allowed to bring a weapon from *Call of Duty* to *PUBG*?! Have you heard of the term “**game balance**”?
- **Virtual economy does not have to be built on NFT**
 - Examples: *Second Life*, *Roblox*
- **Metaverses can be NFT-free**
 - Industrial metaverses (Digital Twin / Augmented Reality / Virtual Reality for enterprise)
 - Consumer metaverses purely for fun
 - Consumer metaverses for different lives (“**Life is elsewhere**”)

What is NOT the Metaverse

The concepts that are currently labeled as the Metaverse but are not actually the Metaverse

NFT application scenarios in the Metaverse may be very limited



Source: Call of Duty Mobile

Source: PUBG Mobile

What is NOT the Metaverse

The concepts that are currently labeled as the Metaverse but are not actually the Metaverse

Web3 is neither the Metaverse nor a necessary element of the Metaverse

- A metaverse may be decentralized in terms of infrastructure or application scenarios, but it does not have to be.
- Centralized metaverses can do better than decentralized metaverses in many aspects.
- Web3 advocates like to talk about ownership, but **what really matters to users is use and service, not ownership.**
- Why should everyone own a portion of the Metaverse while being advised that they do not need to own their own house or car in the era of sharing economy?!

Ownership does not matter. You can save money and enjoy services.



Ownership does matter. You should pay for that by purchasing tokens.

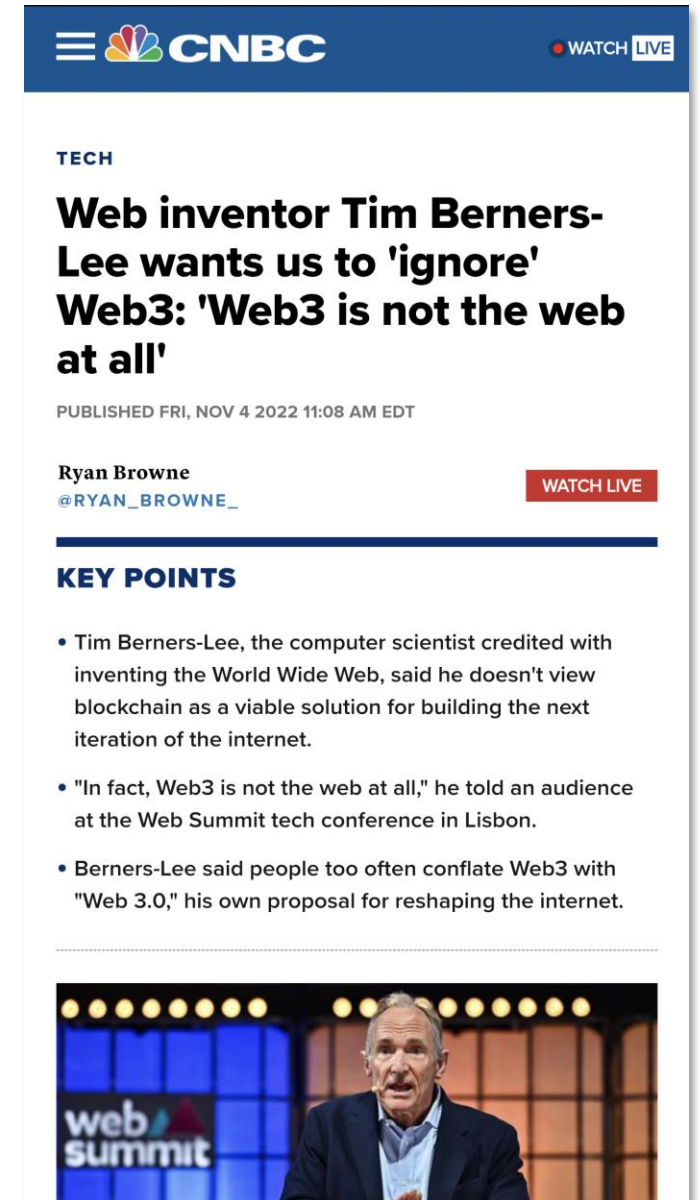
Web3

What is NOT the Metaverse

The concepts that are currently labeled as the Metaverse but are not actually the Metaverse

Web3 may not have a bright future at all

- **Web3 != Web 3.0**
 - The term "Web3" was coined by Ethereum co-founder Gavin Wood in 2014, referring to a "decentralized online ecosystem based on blockchain".
- **Web != Internet**
 - Every CS or EE student knows this
 - If you are talking about the next generation of the Internet, you should say "InternetX" or "Internet X.0"
- **"Web1: read-only -> Web2: read/write -> Web3: read/write/own" is a fake history** invented by Web3 advocates. Don't get too excited about it.
 - **The Internet was never read-only.** Have you heard of BBS or MUD?
- Web is no longer the mainstream way to access the Internet
 - Web -> Apps -> then what?
- "Web5", "Web6", and "Web7" have been coined. What's next?
- **Can we find a better term to replace "Web3"?**
 - Candidate terms: [Decentralized Ownership & Governance \(DOG\)](#), [Internet of Rights \(IOR\)](#)



The image is a screenshot of a CNBC news article. At the top, the CNBC logo and 'WATCH LIVE' button are visible. The article is categorized under 'TECH'. The main headline reads: 'Web inventor Tim Berners-Lee wants us to 'ignore' Web3: 'Web3 is not the web at all''. Below the headline, it says 'PUBLISHED FRI, NOV 4 2022 11:08 AM EDT'. The author is identified as Ryan Browne (@RYAN_BROWNE_) with a 'WATCH LIVE' button next to his name. A 'KEY POINTS' section follows, containing three bullet points: 1. Tim Berners-Lee, the computer scientist credited with inventing the World Wide Web, said he doesn't view blockchain as a viable solution for building the next iteration of the internet. 2. "In fact, Web3 is not the web at all," he told an audience at the Web Summit tech conference in Lisbon. 3. Berners-Lee said people too often conflate Web3 with "Web 3.0," his own proposal for reshaping the internet. At the bottom of the screenshot, there is a video player showing Tim Berners-Lee speaking at a 'web summit' event.

What is NOT the Metaverse

The concepts that are currently labeled as the Metaverse but are not actually the Metaverse

NFT is not the Metaverse, nor a core element or a necessary element of the Metaverse. It can serve some useful purposes in the Metaverse, such as incentivizing content creators, but exaggerating its role is harmful. In particular, we have seen lots of misleading and confusing propaganda that couldn't wait to add a metaverse label on NFTs that have no use value but only the so-called collection value or investment value. Collecting and investing are only a small part of our real life today and will be the same in the Metaverse in the future.

The mainstream demand of mankind for the Metaverse will never be collection and investment.

Web3 is not the Metaverse either. A metaverse may be decentralized in terms of infrastructure or application scenarios, but it does not have to be. From both the technical perspective and the business perspective, there can be centralized metaverses, which in many aspects can do better than decentralized metaverses. Web3 advocates like to talk about ownership, but **what really matters to users is use and service, not ownership.** Today, it is increasingly being advocated that even transportation should be a shared service that does not require everyone to own a private vehicle, so why should everyone own a portion of the Internet or the Metaverse? In particular, we need to be wary of rip-offs in the name of decentralization. What is concealed under the banner of decentralization could be the centralization of wealth to a small group of speculators.

Given that NFT and Web3 have become too dominant in the metaverse-related public opinion field, it is necessary to reiterate: **NFT and Web3 are neither the Metaverse nor necessary elements of the Metaverse. They are no more than optional elements that may be useful to the Metaverse in some cases.**

Dr. Yu Yuan's Metaverse Technology Landscape

CORE TECHNOLOGIES

Senses/Actions (Virtual & Real)

Human / Creature

NPC / AI

Machine

Brain Machine
Interface

Body Machine
Interface

Programming
Interface

Virtual
Sensors/Actuators

Real
Sensors/Actuators

Persistent Virtual Worlds ("Persistent Computing")

Virtual
Map

Virtual
Scenes

Virtual
Objects

Virtual
Characters

Modeling/Design/DCC:
PGC, UGC, AI+PGC, AI+UGC, AIGC, DTGC, ...

Engines:
Physics, Graphics, Sounds, ...

Digital Finance & Economy

Digital Assets:
Virtual Assets, ...

Decentralization

Blockchain

SUPPORTIVE TECHNOLOGIES

Computation

Storage

Communications

Data

Intelligence

The road to the Metaverse

Grand Challenges:

Virtual Senses/Actions



How to achieve comprehensive and ultra-realistic virtual senses and actions?

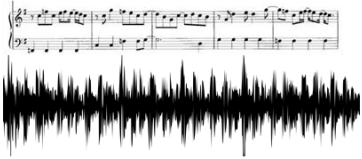
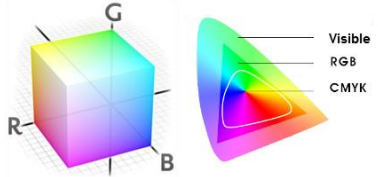
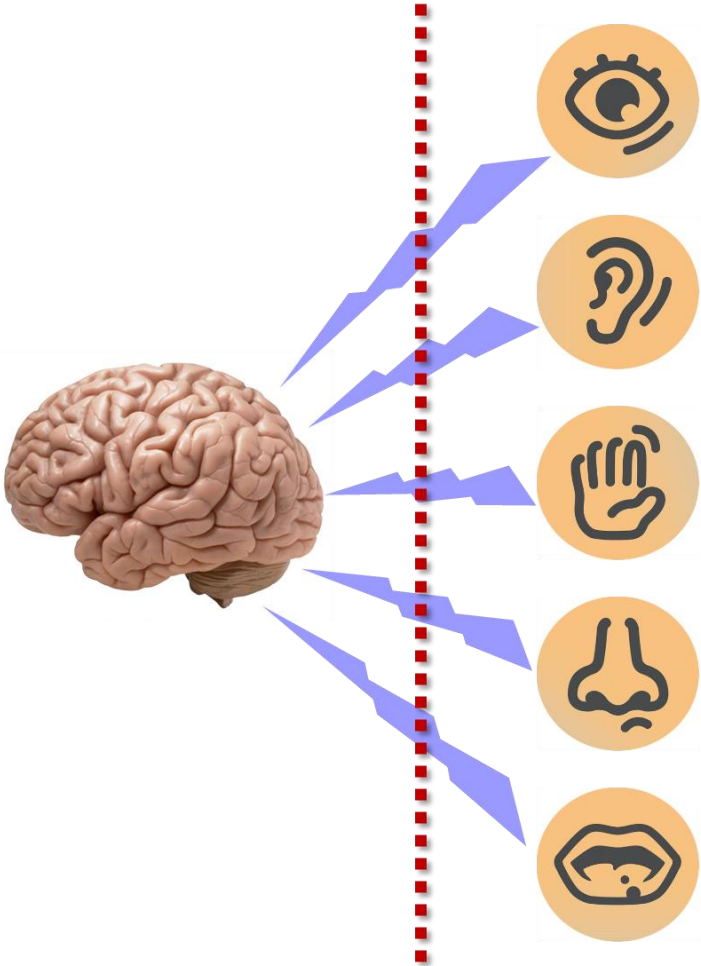
For example, when we can simulate not only the look, smell, and taste of beer, but also the dopamine and pleasure produced after drinking alcohol.



The road to the Metaverse

Grand Challenges:

Virtual Senses/Actions



The road to the Metaverse

Grand Challenges: Virtual Worlds



Steve Mann (“Father of Wearable Computing”) in Lake Ontario



Whalers Cove, Lake Washington

How to build a persistent, large-scale, fine-grained, and physically self-consistent virtual world?

For example, when a lake in a virtual world can not only glint like water, but also be so fine-grained that every virtual water molecule conforms to physical laws. Whether boating on the lake, jumping into it for swimming, or washing your face with a handful of water, the interaction between virtual water and other virtual objects can be completely in line with physical laws such as fluid mechanics, and even physicists can't find any flaws to tell that this is a virtual world.

The road to the Metaverse

Grand Challenges:

Virtual Worlds



Source: SecondLife.com



Source: Minecraft.net



Source: Improbable.io



The road to the Metaverse

Grand Challenges:

Integration between Virtual Objects and the Real World

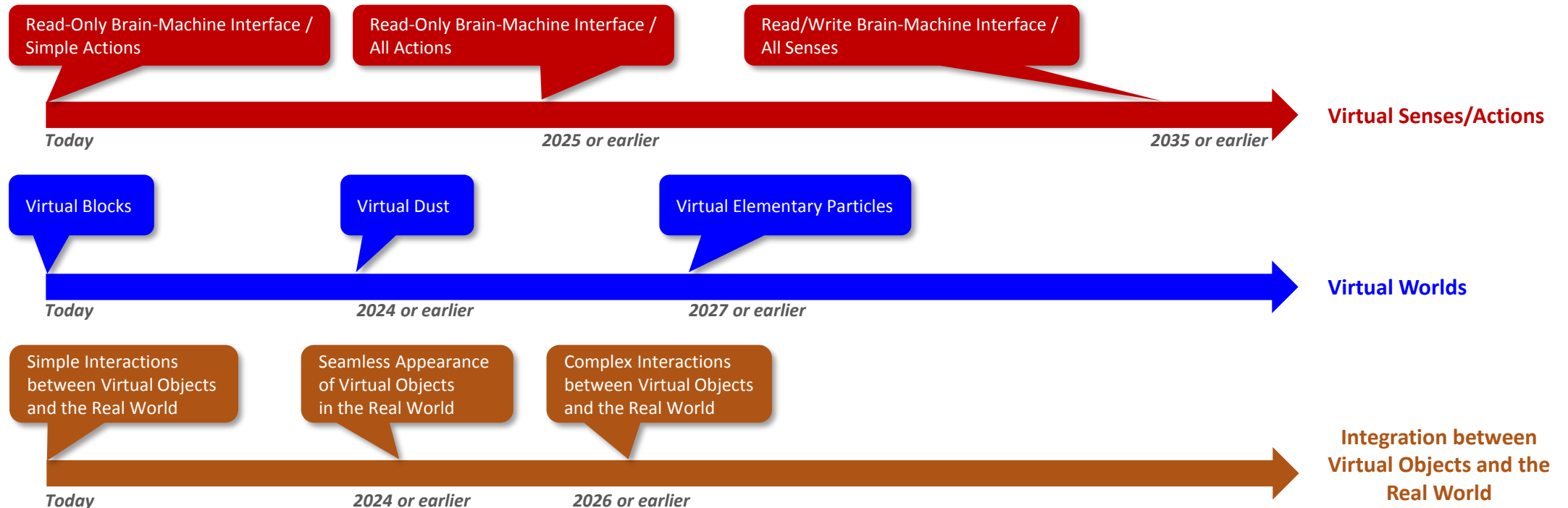


Source: "Blade Runner 2049" (2017)

The road to the Metaverse

Dr. Yu Yuan's Metaverse Technology Outlook

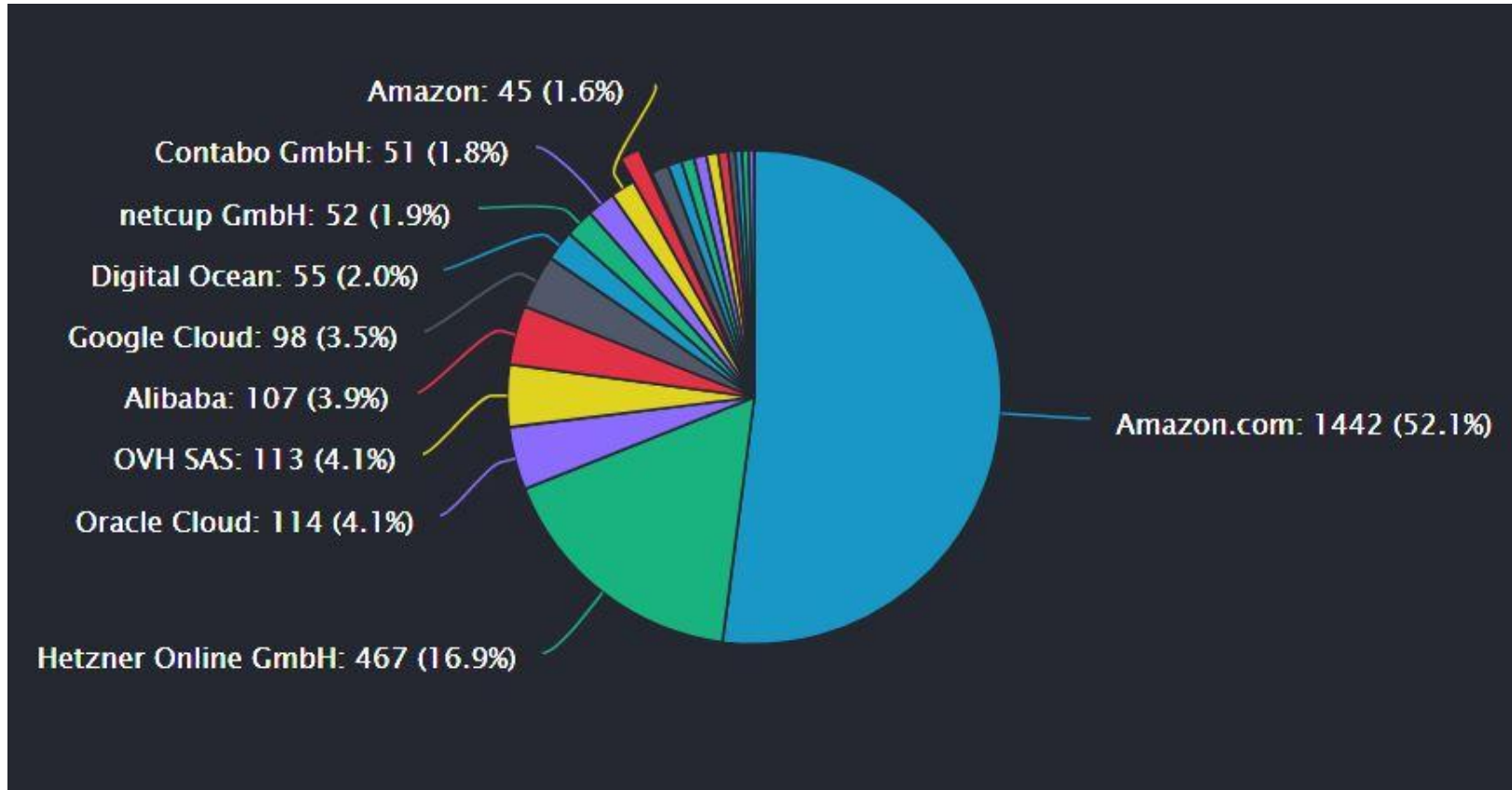
The best way to predict the future is to create it.



The road to the Metaverse

Grand Challenges:

Decentralization *(optional)*



Source: Cointelegraph

Ethereum nodes are being run through centralized web providers like Amazon Web Services, which could become a central point of failure.

The road to the Metaverse

Grand Challenges:

Decentralization *(optional)*

By contrast, as of 2013, BitTorrent had 15–27 million concurrent users at any time.

Bitcoin Centralized Mining Pools

REACHABLE BITCOIN NODES

Updated: Thu Sep 29 20:06:13 2022 EDT

14269 NODES

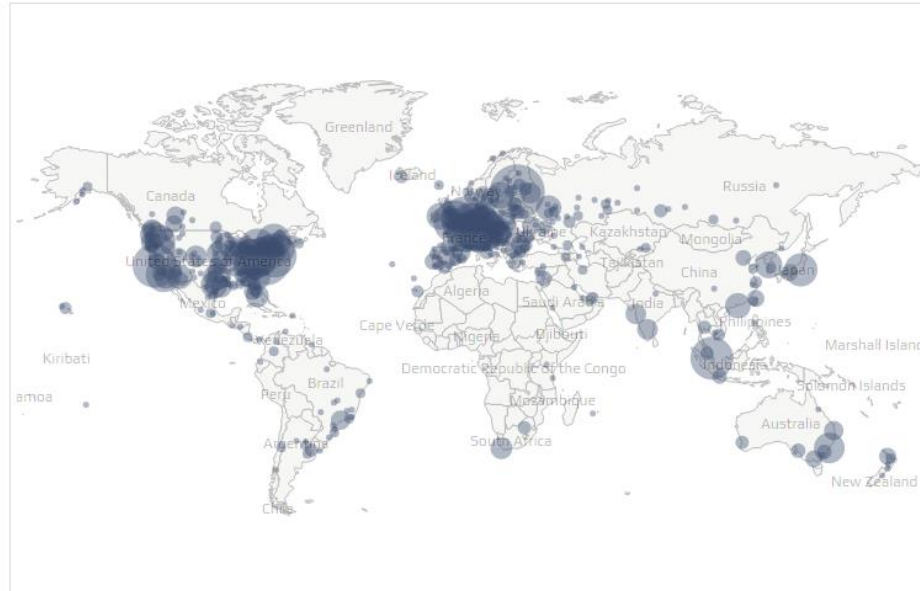
CHARTS

IPv4: -2.3% / IPv6: -1.1% / .onion: +1.8%

Top 10 countries with their respective number of reachable nodes are as follows.

RANK	COUNTRY	NODES
1	n/a	7337 (51.42%)
2	United States	1924 (13.48%)
3	Germany	1396 (9.78%)
4	France	440 (3.08%)
5	Netherlands	380 (2.66%)
6	Canada	310 (2.17%)
7	Finland	241 (1.69%)
8	United Kingdom	218 (1.53%)
9	Russian Federation	187 (1.31%)
10	Singapore	146 (1.02%)

All (98) »

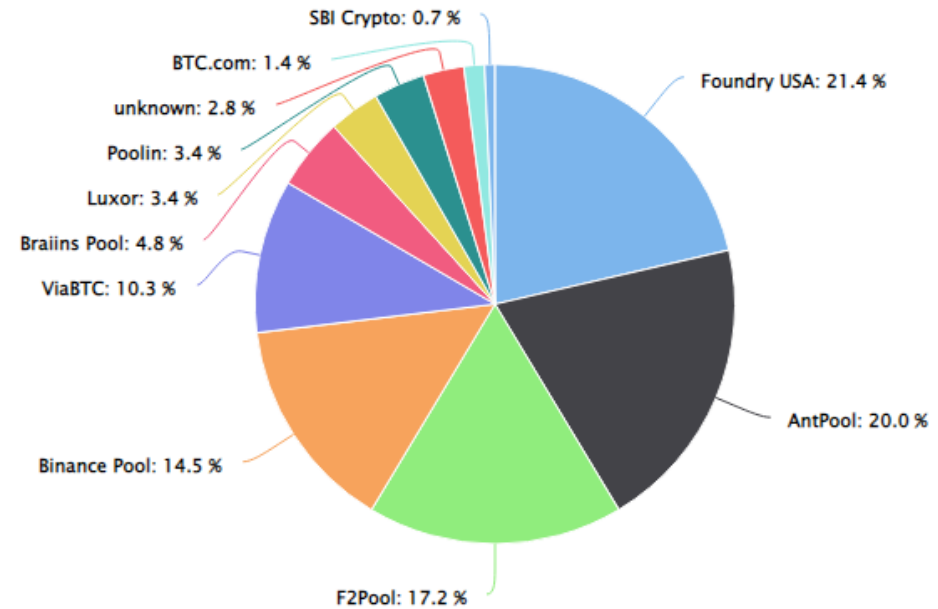


Map shows concentration of reachable Bitcoin nodes found in countries around the world.

LIVE MAP

Source: bitnodes.io

24 H



Source: <https://btc.com/stats/pool>

The road to the Metaverse

A Harvesting-While-Plowing Journey



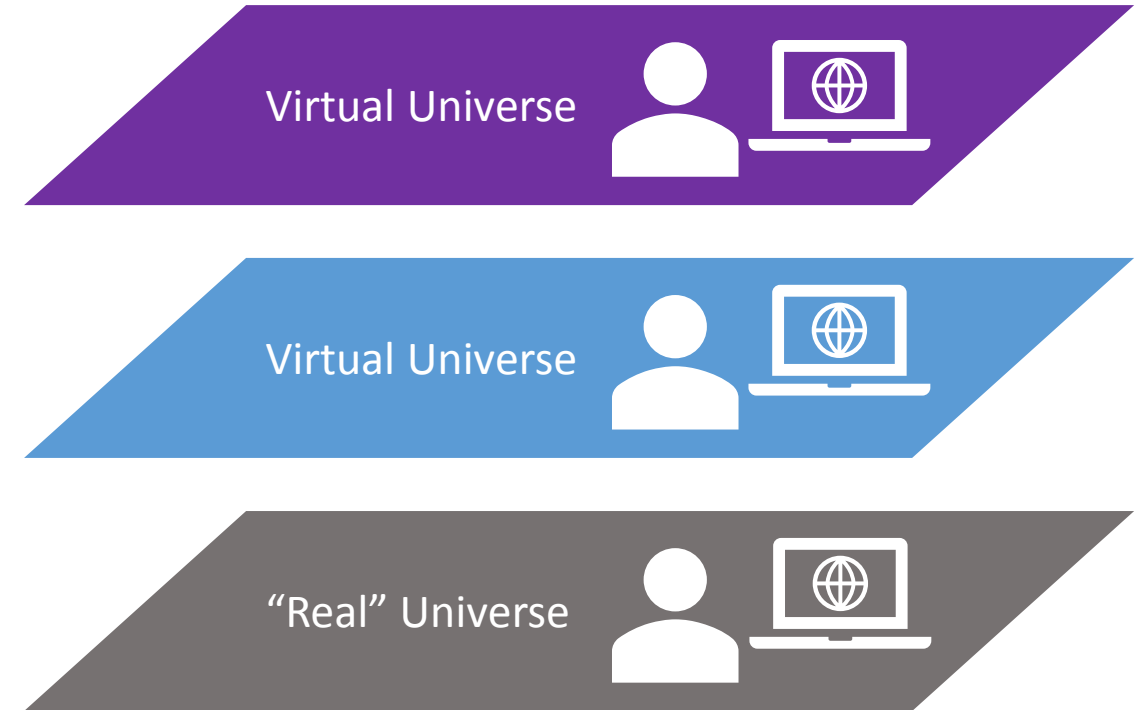
Not ideal, but usable & useful

The road to the Metaverse

What's Next

Are we living in a virtual universe?

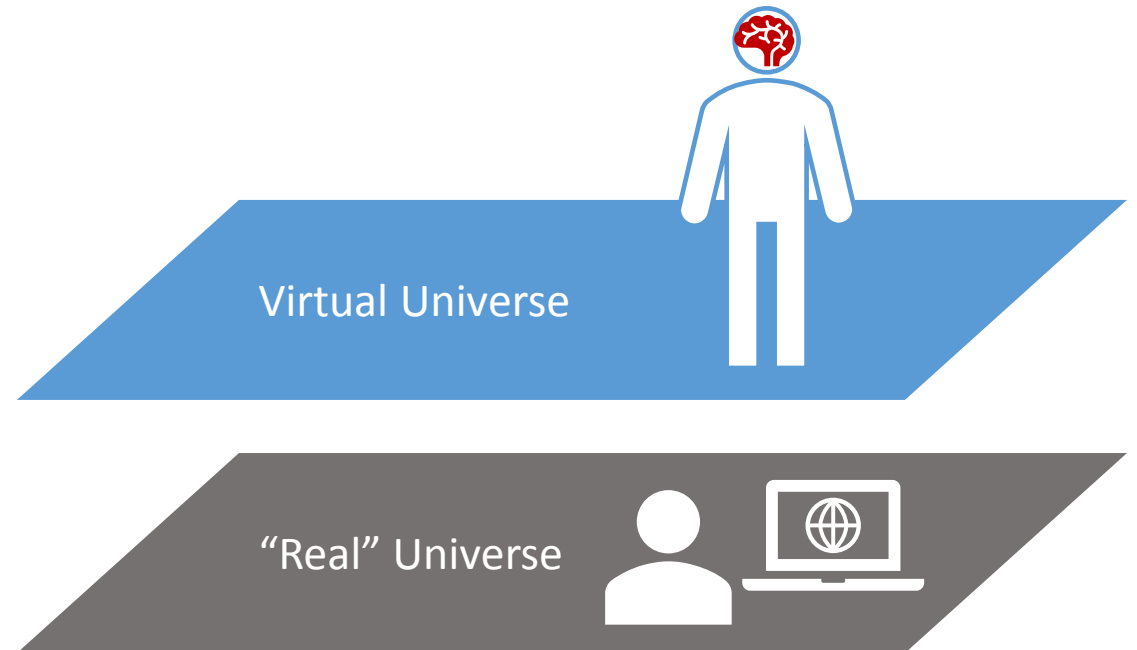
- ▶ Spatial challenges
 - **Indistinguishable Virtual Universe**
 - **Virtual Universe over Virtual Universe**
- ▶ Temporal challenges
 - **Oblivion**
 - **Overclocking**



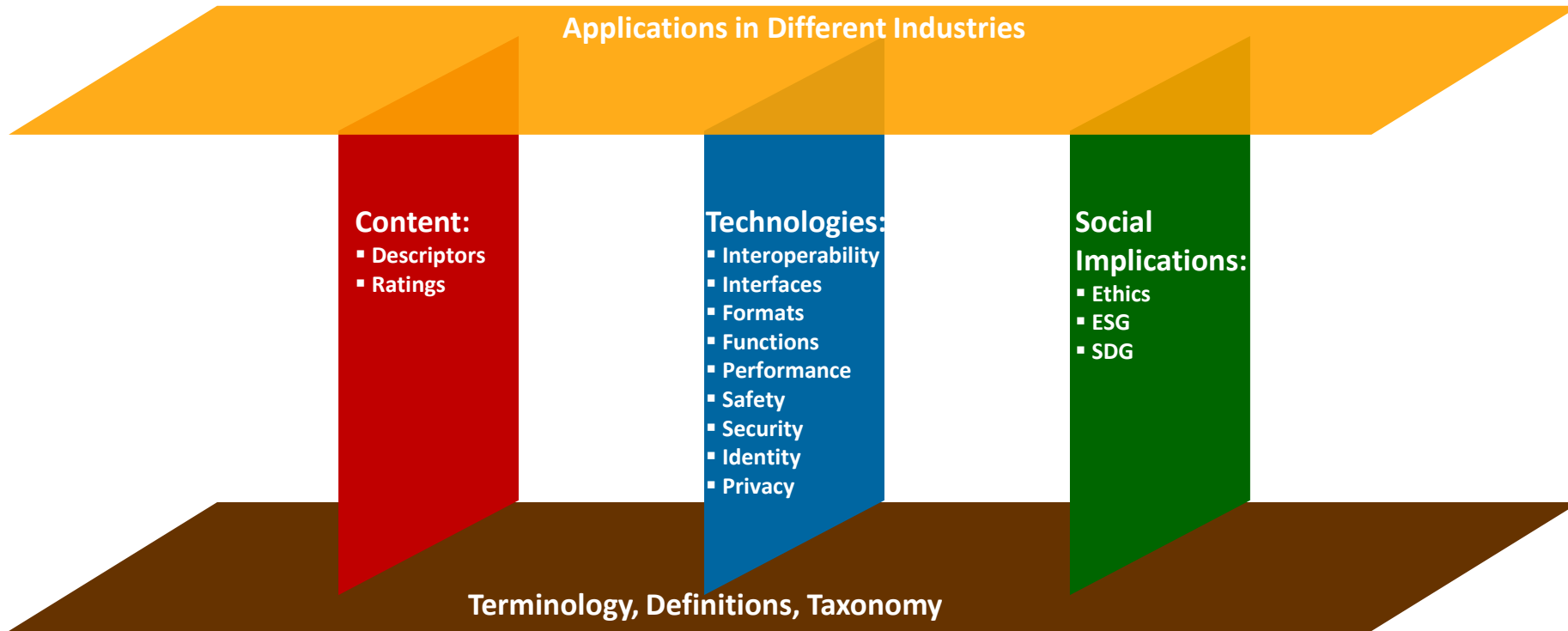
Special Food for Thought

Can we create consciousness by simulating human brain?

- ▶ If you are in a virtual universe, where is your consciousness?
 - In the brain of your avatar in this virtual universe?
 - In another universe that this virtual universe is built upon?
 - In another “soul-only” universe?



METaverse STANDARDIZATION NEEDS



IEEE METAVERSE CONGRESS

metaverse.ieee.org

A series of online or hybrid sessions

■ PILOT SESSION: **FORUM ABOUT THE METAVERSE**

■ 14 June 2022 | Hybrid (Toronto, Canada | Online)

■ SESSION 1: **DEMYSTIFYING AND DEFINING THE METAVERSE**

■ 6 July 2022 | Online

■ SESSION 2: **THE METAVERSE AND ITS RAPID GROWTH IN CHINA**

■ 9 July 2022 | Online

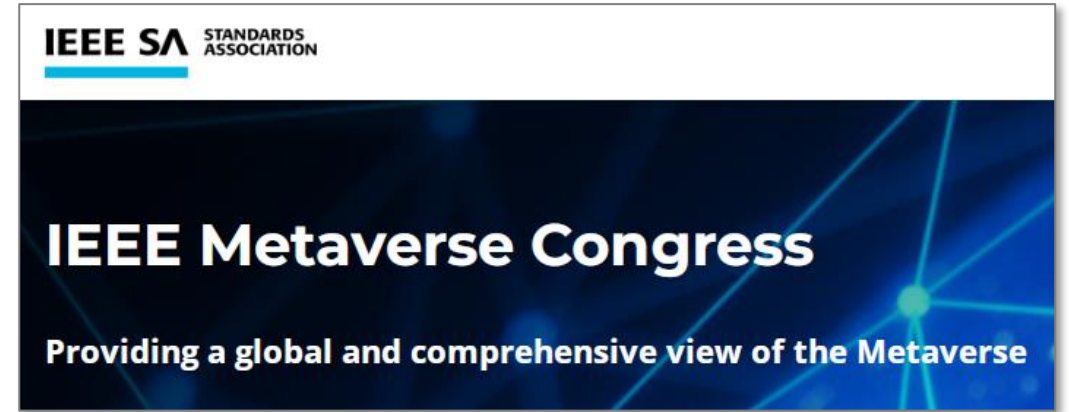
■ SESSION 3: **DEVELOPING AND DEPLOYING THE METAVERSE**

■ 27 September 2022 | Online

■ SESSION 4: **NEW OPPORTUNITIES FROM THE METAVERSE AND THE NEW WAVE OF DIGITAL ECONOMY**

■ 30 September 2022 | Hybrid (Shenzhen, China | Online)

■ More to come...



IEEE METAVERSE STANDARDS COMMITTEE (CTS/MSC)

The first standards committee on metaverse in major global/international SDOs

- Formerly **IEEE Virtual Reality and Augmented Reality Standards Committee (CTS/VRARSC)**

- Name change and scope change

 - Committee approval: 16 May 2022

 - IEEE SASB approval: 21 September 2022

- New scope:

 - The scope of the Standards Committee is to develop and maintain standards, recommended practices, and guides for **metaverse**, virtual reality and augmented reality, using an open and accredited process, and to advocate them on a global basis. Its technical scope is intended to be flexible and is ultimately determined by the sum of its approved PARs.

IEEE STANDARDS AND PROJECTS FOR METAVERSE

Many metaverse-related standards and projects are NOT listed here if their titles do not explicitly include “metaverse”

- **P2048 Standard for Metaverse: Terminology, Definitions, and Taxonomy**

- Status: Approved by IEEE SASB on 10 November 2022

- **P7016 Standard for Ethically Aligned Design and Life Cycle of Metaverse Systems**

- Status: Approved by IEEE SASB on 10 November 2022

- **IC22-012 Persistent Computing for Metaverse Initiative**

- Status: Approved by IEEE SA CAG on 12 October 2022

- **IC22-015 Decentralized Metaverse Initiative**

- Status: Approved by IEEE SA CAG on 12 October 2022

THANK YOU

Dr. Yu Yuan

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Dr. Yu Yuan's List of Recommended Movies and TV Shows about XR/Metaverse



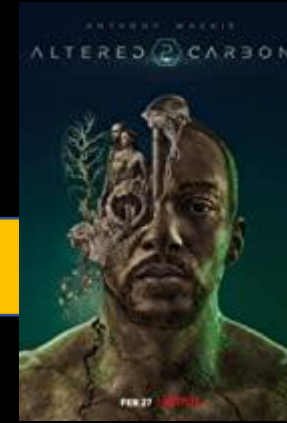
Ghost in the Shell
(2017)



Blade Runner 2049
(2017)



OtherLife
(2017)



Altered Carbon
(2018–2020)
S2, Ep1: Phantom Lady (2020)
S1, Ep1: Out of the Past (2018)



Free Guy
(2021)



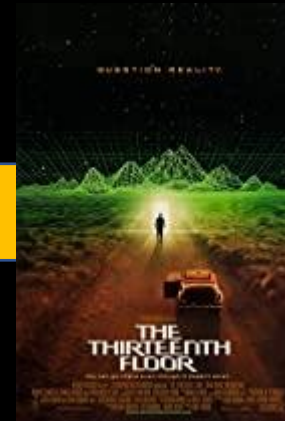
Westworld
(2016–)
S3, Ep6: Decoherence (2020)
S3, Ep2: The Winter Line (2020)



Black Mirror
(2011–2019)
S3, Ep2: Playtest (2016)
S2, Ep4: White Christmas (2014)



Avatar
(2009)



The Thirteenth Floor
(1999)



The Matrix
(1999)



Dark City
(1998)