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Article

Making the metaverse real

Digital Business

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Zalan, Tatiana; Barbesino, Paolo (2023) : Making the metaverse real, Digital Business, ISSN 2666-9544, Elsevier, Amsterdam, Vol. 3, Iss. 2, pp. 1-7, <https://doi.org/10.1016/j.digbus.2023.100059>

This Version is available at:

<https://hdl.handle.net/10419/337935>

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Research Note

Making the metaverse real

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ARTICLE INFO

Keywords:

Augmented reality
Digital ID
Internet
IT infrastructure
Metaverse
Virtual reality
Virtual worlds
web3

ABSTRACT

Key stakeholders across different industries with competing visions, motivations and technology bets are investing significant financial resources in developing the building blocks of the metaverse. The purpose of this opinion piece aimed primarily at practitioners is to explore the key question: *What is needed to make the metaverse real? What are the key uncertainties that must be resolved?* We are motivated by shedding light on whether the metaverse is just a new marketing buzzword or a new transformative trend. We have identified six areas with key uncertainties, which require agreement and solutions from industry players – the space, the interface, the IT infrastructure, the monetary infrastructure, the digital ID and the energy. These uncertainties will be resolved in a series of cooperative and competitive games among the key stakeholders who will need to work on being aligned on a set of standards. The practical implication is that the metaverse cannot be ignored, but there are non-trivial challenges that need to be resolved first. Our paper provides a framework for practitioners to think through these issues in a more systematic fashion.

1. Introduction

The metaverse market potential is enormous – by 2031 the metaverse's contribution to the global GDP is expected to be over 3 trillion dollars (Christensen & Robinson, 2022). It is no wonder that technology giants, including Meta, Epic Games, Microsoft and Baidu, who are investing billions of dollars, have ambitious plans to materialize the metaverse, and are engaging in what can only be described as a race to build their own versions.

This surge of interest in the world of practice has been mirrored in the academe. A bibliometric review of the metaverse in the field of business and management (Schmitt, 2022) reveals a sharp increase in interest in the topic during 2021–2022. One of the most comprehensive surveys of the metaverse to date (Lee et al., 2021) reviewed the state-of-the-art technologies as enablers of the metaverse and proposed a technological framework, paving a way to realize the metaverse. Nevertheless, the metaverse remains “vaguely defined, but seemingly imminent” (Ball, 2022, p. 19).

The purpose of this short communication - aimed primarily at executives, boards of directors and policy-makers - is to explore the key questions: *What is needed to make the metaverse real? What are the key uncertainties that must be resolved?* The article is informed by academic and practitioner literature and written by pracademics with nearly sixty

years of collective experience in academic and technology research and the web2 and web3 spaces. We are motivated by shedding light on whether the metaverse is just a new marketing buzzword, a hype (Dwivedi et al., 2022) or, conversely, we may be at an early stage of a trend which will be genuinely transformative. In any case, the metaverse cannot be ignored.

Contrary to wide-held beliefs that the metaverse is a reality (e.g., McKinsey and Company, 2022), we find that it has still a long way to go, and collective effort is needed to make it eventuate. Drawing on Citi (2022) framework of the metaverse ecosystem, we identify six areas with key uncertainties and risks, which require agreement and solutions from industry players and increasingly regulators around the globe – the space, the interface, the IT infrastructure, the monetary infrastructure, the digital ID and the energy.

The remainder of the article is structured as follows. In Section 2 we point out that there is no collective grand vision of the metaverse and identify three key groups of private stakeholders that will likely shape the direction of the metaverse. The six domains of agreement and key uncertainties are discussed in Section 3. Concluding remarks are in Section 4.

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2. The grand vision and competing visions of key players

Many individuals and companies have tried to create a metaverse, a term coined by Neil Stephenson in his sci-fi novel *Snow Crash* (1992). Arguably, “virtual reality” (VR), a related concept, was first mentioned in French dramatist Antonin Artaud’s essay in 1938, while the first genuine prototype of the metaverse was developed in 1968 by the computer scientist Ivan Sutherland, who combined computer simulation with stereoscopic vision technology (Chalmers, 2021).

Clearly, the metaverse is not a new idea. But what do we mean by “metaverse”? In the technical literature, conceptions of the metaverse range from “an immersive environment using a universal and shared digital media network that removes the barriers of time and space by deceiving users’ visual senses” to an “increasingly intelligent world where AGIs are integrated into interactive human social networks” (Park & Kim, 2022). The grand visions are equally divergent. Pew Research (2022) reports that 54% of experts say that they expect by 2040 the metaverse to be a truly fully immersive, well-functioning aspect of daily life for a half billion or more people globally, with 46% arguing the opposite. We, too, have consulted visions coming from a range of ecosystem stakeholders - academics, consultants, investors, entrepreneurs and executives of major corporations. Some of the visions are developed by web3 native stakeholders, others by web2 companies with the expectation of the corporate metaverse. We agree with Ball (2022, p. 18) that most industry leaders define it “in the manner that fits their own worldview and/or the capabilities of their companies”. It is obvious that there is no one single vision of the metaverse – the paint is still wet. Beyond a general consensus on the metaverse being “one conceptual next iteration of the internet supporting a collection of real-time applications and experiences across devices” (Citi, 2022, p. 21, also Meige, Abascal, Eagar, & Papadopoulos, 2022), the semantic ambiguity of its current definitions is a testament to how the metaverse agendas of different players is conflicting on key issues. More generally, such definitional vagueness is usually a sign of any new technology in the making.

For the purposes of this opinion piece, we adopt a working definition of the metaverse as an immersive shared virtual space where various activities (e.g., creating, learning, playing, shopping, socializing, and working) can be carried out with the help of augmented reality (AR) and virtual reality (VR) services (see Damar, 2021). Combined with generative artificial intelligence (AI), the metaverse will enable a new kind of agency, not only human-to-human (or avatar-to-avatar), but also human-to-a fully AI-powered persona, and a seamless transition between the physical and the digital worlds (see Park & Kim, 2022). For organizations, as pointed out by Dwivedi et al. (2022, p. 3), significant potential exists to adapt their business models, “with transformational impacts on marketing, tourism, leisure and hospitality, citizen-government interaction, health, education and social networks”. Some researchers (e.g., Lee et al., 2021, p. 43) go as far as to suggest that “a complete set of economic and social systems will be formed in the metacyberspace, resulting in new currency markets, capital markets, commodity markets, cultures, norms, regulations, and other societal factors”. Practitioners and academics agree that materializing the metaverse is not without it challenges – both technical (e.g., interoperability, super-realism and zero-latency at scale) (Lee et al., 2021) and social (e.g., ethics, data security, privacy, regulation, safety and governance issues) (Dwivedi et al., 2022).

Unlike the internet that evolved as a top-down government initiative first built for military purposes and then embraced and developed by universities and research institutions to become the engine of economic growth and job creation, the metaverse is natively emerging bottom up as the result of market forces (Evans, Frith, & Saker, 2022). With boundaries among adjacent markets being redefined and investments estimated above \$120B in 2022 alone (McKinsey and Company, 2022), rivalry between organizations is set to significantly reshape the internet value chain. We expect established players to see their competitive

positions change and new ones to emerge in a broader metaverse landscape currently dominated by three categories of players: Big Tech (e.g., Meta, Microsoft, Nvidia, Sony and Apple), venture capital (e.g., SoftBank, a16Z, Outlier Ventures), and non-tech corporations and brands (e.g., Nike, Gap, Disney, Dolce & Gabbana, and Gucci). Their motivations and strategic bets are highly divergent, defying categorization. For example, the current explosion in gaming (3 billion gamers globally) drove Meta and Microsoft to make over fifteen combined acquisitions in gaming (CBInsights, 2022) Venture capital bet on open metaverse in 2021, and on support services (e.g., digital architects, AI developers, content creators) in 2022 (NASDAQ, 2022). Non-tech corporations and brands are looking for an alternative to the declining returns that online advertising, digital marketing and social media show in terms of their ability to generate competitive advantage. They are increasingly interested in social commerce and direct engagement with customers on the platforms (e.g., Epic Games and Roblox) where they may spend more of their time in future.

With more than 2500 companies being part of an emerging metaverse value chain (McKinsey and Company, 2022), it is not surprising that alternative competing visions are shaping the direction and configuration of the metaverse. At one extreme, one sees a handful of closed platforms and Big Tech companies acting as gatekeepers and achieving a significant level of syndicated centralization with the aim of creating shareholder value predominantly through user data monetization and advertising in line with the current web2 business model. An alternative vision is championed by a more diverse mix of both established and new players leveraging open protocols and blockchain to enable participation in a completely decentralized governance based on consensus building among users. In this community-governed and, over time, freely interoperable Open Metaverse, content creators own their original creations and monetize them as tokens or NFTs. Related to the open-closed tensions are the questions of whether there will be ONE metaverse or a collection of siloed virtual worlds with little to no interoperability (see Hackl, Lueth, & Di Bartolo, 2022; Meige et al., 2022). We argue that even in its rather broad definition as “the next iteration of the internet”, the likelihood of the metaverse to become both a viable platform for human interaction and a sizeable market depends on whether and how a viable agreement is reached on key uncertainties.

3. Six zones of agreement

We organize our subsequent discussion of these key uncertainties around the ecosystem framework in Citi (2022, p. 21) which delineates four components, two above the customer interaction line directly impacting user experience (‘the space’ and ‘the interface’) and two below that line (the ‘IT infrastructure’ and the ‘monetary infrastructure’). To these we add two more domains – the digital ID and the energy, as we strongly believe that both will make or break the metaverse. The digital ID remains the unresolved socio-technical challenge since the inception of the internet and is deemed critical to the interoperability of the metaverse, while the unsustainable environmental impact of the metaverse can only be addressed with radical innovations on the energy production and consumption side.

3.1. The space

When it comes to ‘the space’, that is, a shared virtual world environment which people can access via a telecommunication technology, the key question is how cross-environment interoperability will be achieved in order to allow users to retain and enjoy the plurality of their roles in different environments across different experiential domains. This problem of fragmented networks and disconnected protocol suites characterized the history of commercial Internet at its inception too (Ball, 2022), and a similar mid-1990s scenario is emerging again today. One way to achieve the continuity of user’s digital experience is leveraging engines originally developed for the gaming industry by Epic

Games or Unity Technologies that bundle technologies and frameworks to build such experience and make it available to anyone developing a virtual world beyond game-making through licensing agreements. On the other hand, Integrated Virtual World Platforms such as Roblox, Minecraft and Fortnite Creative can allow “a growing middle ground of persistent, open, accessible and expressive environments that are much more about social and identity than games per se, and that can become platforms and ecosystems for developers” (Evans et al., 2022) thanks to their “no-code” approach and a thriving marketplace economy allowing developers to upload and trade anything they custom made for their virtual world (Ball, 2022, pp. 105–113). Nvidia's Integrated Virtual World Platform, specifically designed for creating and running VR and AR applications, adds to Omniverse, a more general-purpose platform that allows users to create and collaborate on 3D content and simulations.

Similar to how the singular internet rests on a set of layered standards which allow heterogeneous networks to communicate with each other transparently, a singular metaverse will only emerge if corresponding standards allow disparate virtual worlds to seamlessly exchange or transport objects, behaviors, and avatars (Dionisio, Burns III, & Gilbert, 2013). We believe that there can be no metaverse without interoperability, and yet today's metaverse is a collection of “proto-metaverses” – walled gardens, where major industry players (e.g., Epic Games, Nvidia, Microsoft, Meta) are developing proprietary platforms with no interoperability. Various metaverse consortia are being formed, including among influential web2 players, but they do not seem to collaborate with each other on developing a set of technology standards. In addition, there is a tension between users and brands (who maximize value by having an interoperable metaverse) and vendors (who invest massively and want a return on their investment, hence will benefit from a lack of interoperability and push for a proprietary solution (Dionisio et al., 2013; Meige et al., 2022)). This lack of interoperability is a key uncertainty that needs to be resolved. Indeed, “it is interoperability that puts the capital M in the Metaverse” (Dionisio et al., 2013, p. 3021).

3.2. The interface

‘The interface’ is hardware to access virtual worlds. Even though the quality of social immersion enabled by different types of activities is a pre-requisite for the metaverse to exist, OEMs generally take a technologically deterministic stance and claim that the hardware computing interface is one of its most essential ingredients. Competing visions are putting more emphasis respectively on VR (i.e., virtual reality that generates an immersive experience using visual, audio, and touch-based devices); AR (i.e., augmented reality, in which what we see in the real world is “augmented” with information fed through the device); and MR (i.e., mixed reality, a user environment in which physical reality and digital content are combined in a way that enables interaction with and among real-world and virtual objects).

Considering the significant investment that VR requires, it is no surprise that some of the leading Big Tech companies are deeply exploring a technology with a lot of potential but not yet globally ready for the mass market. Through a bundle of software and hardware that includes the Oculus headset line-up, Meta is championing the VR-based approach to the Metaverse, in the belief that better displays and sensors, more engineering and significant investments will take the market to an inflection point in five to ten years (Evans et al., 2022).

By contrast, Apple Inc. is betting on MR, combining hardware, software, and dedicated services. Apple MR headset is expected to run on a M2 Apple silicon, mount more than 10 cameras and the highest-resolution displays ever featured in a mass-market headset. The device will run a new OS, which will include MR versions of core Apple apps. Apple is working to build a video service for the headset featuring 3D content that can be played in VR, following the company's 2020's acquisition of NextVR which partnered with artists and professional sports leagues to transmit VR content to headsets (Gurman, 2022). This

will facilitate the incremental switch of screen time from iPhones to Apple headsets for apps and general use, from transactional payment capabilities (including cryptocurrencies and NFTs), augmented shopping, mapping, to representation of products allowing for better rendering of items in mixed reality spacing.

Microsoft with HoloLens and Alphabet Inc. with Glass are also commercializing hardware that overlays digital content atop users' real-world surroundings for consumer, enterprise and industrial applications. Alphabet Inc. plans to integrate AR and AI into Google's internet-based navigation, online collaboration, and video content services in what it defines as “ambient computing.”

Companies like Neuralink and Snap are investing in more advanced cognitive user interfaces such as BCI (Brain-Computer Interface) technology that leverages ML and AI algorithms to convert electrophysiological input from the user (through implantable or non-invasive sensors) into commands that control devices. BCI aims to replace traditional screens and input devices on computers and mobile devices with direct connections to the user's brain. These companies are focusing their Metaverse effort predominantly on AR devices, such as camera apps and smart glasses.

What will be the devices that users embrace at a significant global scale? Given direct access to billions of customers and huge financial resources, Big Tech companies are in a strong position to play a gate-keeping role and shape the interaction framework of the metaverse, leveraging hardware as a lock-in factor.

3.3. The infrastructure

A genuine metaverse is not about VR headsets, avatars, virtual conferences, meetings and concerts. The metaverse is a conception and design of a totally new world, a new reality, a fusion of biological, physical and digital worlds, so that one experiences the metaverse in a way that is no different from reality, with all five human senses involved. In this metaverse, people will be able to travel without leaving their homes, fly, go back in time into the reconstructed VR of the past or visit other planets. Consider, for example, the following rich experiences described in Bhat and Alqahtani (2021):

We would soon witness 3D games or multi-dimensional video that interacts with all the five sense organs of the body to create an illusion of real-world by combining VR and AR to render a true virtual gaming experience

...haptic ways of communication will enable them [users] to express the information by the sense of touch.

As a future trend, each mobile phone will be equipped with more than five ultra-high-definition cameras to capture an event and render multiple dimensional videos that give an immersive experience of the event being captured to all the human senses. In other words, a video may be a multi-dimensional real-time projection with the audio-visual effect of the person or object being telecasted in a virtual meeting...

Are there any obstacles to realizing such immersive experience enabled by the cyber-bio-physical technological triad? Yes, because our existing infrastructure capabilities are not suited for this rich environment.

Let's start with the volume of data and the “persistence” characteristic of the metaverse (Ball, 2022). A virtual environment generates an immense number of high-definition 3D objects, as well as their positions, motions, sounds, surroundings, and simulated interactions and, correspondingly, a large amount of data which could increase rapidly during real-time events involving a large number of geographically dispersed participants. Further, achieving persistence would require computing and data architectures capable of hosting always-on, interconnected virtual spaces as well as high-bandwidth, low-latency, high availability wireless networks to support user devices and provide real-time access.

Traditional Internet's low-bandwidth “buffering” prevents data from being transferred quickly enough, while high-latency “lagging” creates a

sensation of video and/or audio being slow when using applications that require a high rate of frames-per-second (e.g., gaming or socializing). Latency is a primary problem in securing a seamless user experience, calling for different network infrastructure scenarios in terms of computing distribution across device, edge, and cloud. In addition, computer vision, graphics, and physics simulation will need to converge in a coherent architecture. Cloud data centers are at the core of this architecture that will leverage edge computing to allow ultra-low latency for virtual-world applications through smaller computational facilities closer to the “edge of a network”, which may solve the problems of limited bandwidth and latency, a critical requirement for an immersive experience.

Further, real-time and ubiquitous access to the virtual world also requires mobile communications technologies more advanced than 4G that does not support the bandwidth, latency, and reliability required by the Metaverse. On 5G networks, VR headsets or AI-powered bots will disclose experiences such as haptics, and AR that lets visitors have in-depth, sensorially rich conversations with AI hosts. Nevertheless, even low latency, low jitter, and high bandwidth 5G networks are better suited for machine-to-machine communication, rather than large-scale user interactivity. While the new generation 6G may be the natural candidate to power the data-intensive applications of the metaverse, and work is under way across the world, judging by past trends, it will be ready for customer use no earlier than 2030 (Lee et al., 2021).

In summary, user expectations of immersive multimedia, personalized holograms, multi-sense haptic services and so on are not supported by the current networks (Strinati et al., 2019), while hardware, software, cloud services, devices and data management algorithms will need a serious upgrade (Yifei, Yajun, Baiqing, & Sergio, 2020). To realize the metaverse grand vision, we need a new infrastructure, with radically new capabilities and a 1000× computational upgrade (Citi, 2022), to store and transmit data at incredibly high speed.

3.4. The monetary infrastructure

One of the key questions is how the metaverse will be monetized assuming that small-value transactions and micropayments will be the norm to remunerate creators, builders and users. Today, most metaverse-like platforms (e.g., Roblox) rely on a centralized in-world game monetary system with withdrawal limits, marketplace fees and rents. Some of these web2 virtual worlds (e.g., Decentraland and The Sandbox) integrate with crypto payments and NFT/digital assets marketplace commerce, but standards are still missing to make digital assets (wearables, objects, brands and virtual currencies) transferable across different virtual worlds (JP Morgan, 2022). These standards should enable digital assets take a potentially specific manifestation in each world: the same NFT may appear as a special edition t-shirt in a virtual world, but is a uniquely designed vehicle in a race car video game. Similarly, cross-border and cross-platform foreign exchange and liquidity solutions are yet to appear (JP Morgan, 2022).

In an unlikely dystopic scenario, a handful of corporations will exert ubiquitous surveillance underpinned by invasive biometric analytics and profiling, therefore reducing the opportunity for users to monetize their data. In a centralized set-up, where issuing digital ID verifiable credentials, KYC and AML compliance are performed by select organizations, existing currencies from the myriad fiat-based options available today, to cryptocurrencies, stablecoins, and central bank digital currencies (CBDCs) will be at the core of any monetization option. These currencies could be used to buy and sell virtual goods and services with different levels of pseudo-anonymity to preserve privacy and enable digital freedom not dissimilarly that in the offline world.

Payment service providers will emerge with new capabilities to enable seamless interfaces between the consumer and the platforms. Apple Pay and Google Pay will still act as gate keepers with a potentially leaner fee standard than the current 30% (Ball, 2022, pp.172–177) and most likely expand the range of supported payment types to fully

integrate cryptocurrencies and NFTs straight into their wallets. With over 3.5 M apps on Apple App Store, this represents a massive distribution opportunity reaching out to over 1 billion iPhone users globally compared to the just a little over a million monthly users of OpenSea, the leading NFT marketplace. In this predominantly centralized scenario, where gatekeepers may retain the hefty fee of existing app stores, the average consumer will not be confronted with the web3 complexities so that decentralized finance (DeFi) capabilities will operate on the background enabling cryptocurrency payment methods while centralized finance (CeFi) will provide a familiar interface to the user.

Another option is a new, virtual currency being created specifically for use in the metaverse, like the now abandoned centralized Libra/Diem project by Meta. Alternatively, in a truly open metaverse formats of money may emerge that are decentralized, trustless, and verifiable without centralized intermediaries as blockchain scaling solutions get more adoption, and more Layer One chains launch.

Ultimately, the configuration of a monetary infrastructure for the metaverse will likely depend on a variety of factors - the specific objectives of the different players involved in its development, the role of global regulators that are set to embrace a more proactive stance in the wake of a string of scandals such as the collapse of the FTX crypto exchange that undermined overall trust in crypto, and the level of user adoption.

3.5. The digital identity

“Digital identity will make or break the Metaverse” (Peake, 2022), which is why we put this issue at the centre of our framework. Digital ID is “a set of claims made by one digital subject (e.g., a user) about itself or about another digital subject.” (Cameron, 2005). Because the internet was built without a native user authentication layer, we are confronted with a multitude of challenges, such as ownership of personal data, digital ID's attributes and portability of these attributes and wallets containing various digital assets (e.g., NFTs, tokens, cryptocurrencies) across proprietary platforms, continuity of users' immersive experiences and tensions between transparency, privacy and personal safety. These are not just technological issues, but sociological and even political ones. The portability property of digital ID prescribes that information and services about identity must be transportable and must not be held by a singular third party, which implies a common data model for identity controlled by owners for secure identity transfer (Toth & Anderson-Priddy, 2019).

At the core of interoperability of IDs and digital assets is the sharing of data files across platforms. This means that current metaverse industry players will need “to consent to unprecedented (but secure and legal) data-sharing models that allow competitors to both ‘read’ and ‘write’ against their databases and even withdraw valuable items and virtual currency” (Ball, 2022, pp. 125–126). Further, most current models of ID management are provider-centric, whereby all ID data are maintained by the respective service providers who have the ultimate control over the ID data. Hence the key question (Cali, Dynge, Ferdous, & Halden, 2023) - who will be responsible for interoperability and setting unified standards for user credentials, private providers (corporate players as technology architects) or independent impartial entities (e.g., consortia, standards bodies, or public institutions)?

It is important to address this challenge, otherwise it can cause irreparable damage to individual and corporate brand image and reputations and open up endless opportunities for scams, fraud and cybercrime (Peake, 2022). Consider, for example, the extreme case of Nina Jane Patel, a beta tester for Horizon Worlds (Meta), who claimed that she was sexually assaulted by 3–4 male avatars with male voices (Patel, 2021). Avatars controlled by nefarious human users can easily engage in deceptive and unethical practices - impersonation, white lies, manipulation, social engineering and nudging (Falchuk, Loeb, & Neff, 2018). Moreover, if the metaverse eschews persistent identities, then we will see Sybil attacks, collusion and limited economic opportunities in

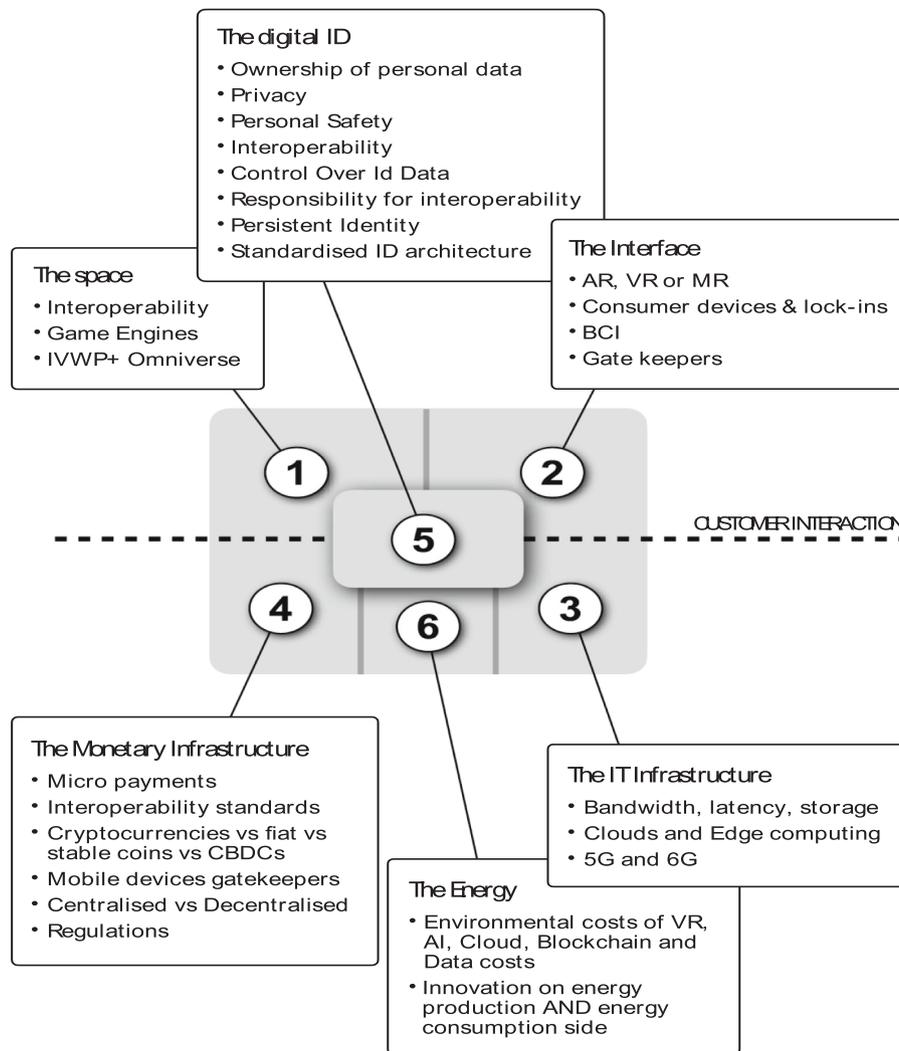


Fig. 1. Zones of agreement and key uncertainties.

the absence of wholly transferrable private property (Weyl, Ohlhaber, & Buterin, 2022).

How close are we to solving the ID problem? Efforts are underway to develop a standard ID architecture, and the EU is working on the EU digital identity wallet, with first large-scale pilots planned for 2023–2024. The architecture reference framework, however, is still debated - will it be a centralized, federated, hybrid or decentralized model?

3.6. The energy

Last but not least, a fully immersive metaverse will remain a fantasy unless the energy and carbon footprint issues are solved. Without dramatic increases in efficiency by 2030 the ICT industry could use 21% of all electricity in a likely scenario and 51% in the worst-case scenario, emitting up to 5.5% of the world's carbon emissions by 2025, more than any other country except the US, China and India (Andrae & Edler, 2015). This industry power demand is expected to increase from 2 to 300Twh of electricity a year now, to 1200 or even 3000Twh by 2025, with data centres alone producing as high as 1.9Gt (or 3.2% of the global total) carbon emissions (Andrae, 2017).

AI, VR, cloud and blockchain are commonly understood to be some of the key technologies enabling the metaverse, and each consumes large amounts of power. AI deep learning (DL) and neural networks models demand exceptionally large computational resources that

necessitate similarly substantial energy consumption, and have disastrous environmental footprint, with one AI language processing model's estimates of carbon footprint and electricity cost over 626,000 pounds of CO2 compared to, for example, an average car which consumes, including fuel, 126,000 pounds over its lifetime (Strubell, Ganesh, & McCallum, 2019). With video streaming and gaming projected to make up over 80% of consumer internet traffic in 2022, the metaverse could take up an even bigger proportion of future internet traffic. Heavy gamers consume 1100 kWh per year or more, well over the average electrical cost for other household appliances (cf. an energy-efficient washing machine which consumes 495 kWh per year) (Dellinger, 2020), pumping as much as 2000 pounds of CO2 emissions into the atmosphere each year. Cloud services are critical to VR and hence for the metaverse – if, say, 30% of gamers move to cloud gaming platforms by 2030, this will result in a 30% increase in carbon emissions (The Momentum, 2022). Our avatars, music, in-game assets, art, plots of land and luxury items are likely to be represented by NFTs, which are notoriously costly to mint – for example, an Ethereum PoS NFT transaction can consume 238 kWh of energy, which is more than how much it takes to make 100,000 visa transactions (149 kWh) (Kilgore, 2022).

Thanks to the new developments such as digital media streaming, mobile cloud, SaaS, IoT, data centres have become a critical component of the ICT infrastructure. Data centres almost always plug into the local electricity grid, which in most cases uses non-renewable energy (Andrews, 2021), and it is not surprising that many researchers and

analysts believe that the energy consumption from ICT is “unsustainable with present drivers” (Fagas, Gallagher, Luca, & Paul, 2017, p. 1).

The problem on the energy production side has never been more acute. Douglas Rushkoff, a futurist, predicts that “[t]he ability for a billion people to spend significant time in the metaverse by 2040 will depend on our ability to find new energy sources for the servers” (Pew Research, 2022). Generally, EROI (energy return on investment) has been declining; conventional energy sources (i.e., nuclear, hydro, coal, and natural gas) are one order of magnitude more effective than renewables such as solar and wind power (World Nuclear Association, 2021). Some experts claim that we are already heading toward energy catastrophe, which can only be exacerbated by the energy demands of the metaverse.

We concur with the view that “creating a metaverse at the expense of life on the planet is ridiculous and should only be pursued within the context of a radical transformation of our energy resources” (Pew Research, 2022, p. 179). Indeed, unless we resolve the energy and environmental issues *both* on the production and consumption sides through innovation, involving both private and public organizations, the metaverse will remain a dream.

We have summarized the key uncertainties that need to be addressed across the six domains needed to consolidate a stable configuration of the metaverse in Fig. 1 below. Two of them are above the customer interaction line, three below the line, and one – identity – is at the centre.

4. Concluding remarks

In this short communication we asked the question what is needed to make the metaverse real and the key uncertainties that must be addressed. The metaverse will happen, but not in the way many observers, analysts and executives predict, and certainly not any time soon.

A large number of stakeholders across different industries with competing visions, motivations and technology bets, including companies and private equity, are investing significant financial resources in developing the building blocks of the metaverse. As a result, a new iteration of the internet providing a data rich sensory experience is emerging without the top-down government blueprint that characterized the origins of the internet. Rather than through a big bang, the metaverse will shape up through distributed breakthroughs. We have identified six zones of agreement and pointed to key uncertainties – the space, the interface, the IT infrastructure, the monetary infrastructure, the digital ID and the energy – which are likely to be resolved in a series of cooperative and competitive games among the key stakeholders who will need to work on being aligned on a common set of standards. These de-facto standards will require multiple iterations to be established. Although we focused on industry and technology players, we see an important role for the public-private sector dialogue, especially in the areas of digital ID, privacy and data protection, ethics, security, monetary infrastructure and energy efficiency.

We have approached this discussion from a Western perspective, yet we are fully aware that geopolitics will shape the future direction of the metaverse. China is developing its own version of the metaverse with Chinese characteristics (without decentralization, cryptocurrency and a payment transaction layer), following the establishment of the metaverse industry group and a set of new regulations on cyber-sovereignty and data ownership. Just like the internet, the metaverse may end up splintered, with an open, interoperable, cross-border metaverse in the West and an isolated metaverse in China, with very little connection between the two. We expect that geopolitical concerns like the US-China decoupling and an emerging multipolar, more unstable world as well as regulatory pressure at regional and domestic level will push governments and regulators around the globe to play an increasingly proactive role (CRS, 2022).

The practical implication of our opinion piece for executives is that, at the very least, the metaverse cannot be dismissed, because there are indications that we are indeed at an early stage of a significant trend. On

the other hand, substantial investments in the above the customer interaction line could be premature for smaller firms with narrow capabilities, because there are non-trivial below-the-line challenges that need to be resolved first. Our paper provides a framework for executives and policy-makers to think through these issues in a more systematic fashion.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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