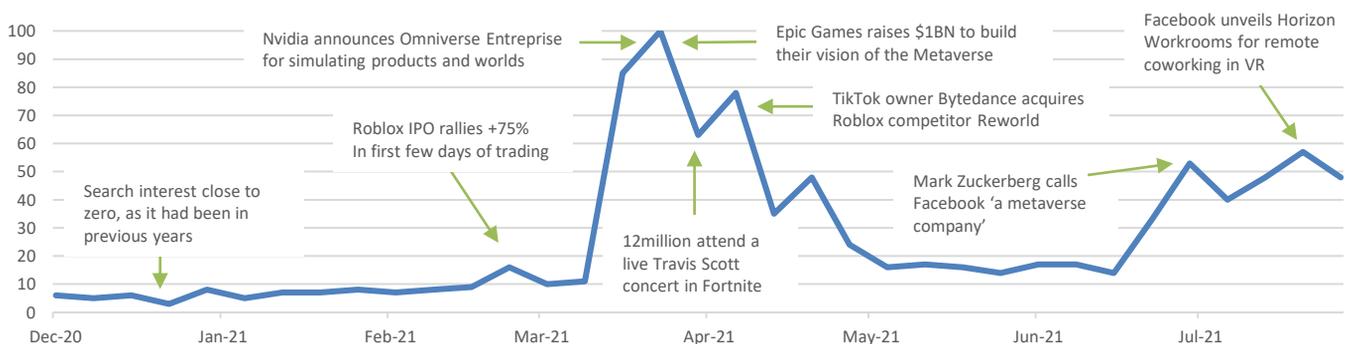# GREEN ASH
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On the Horizon #2 – The Metaverse

The term 'Metaverse' was coined in Snow Crash, a 1992 science fiction novel written by Neal Stephenson. Published during the early years of the World Wide Web, the book imagined a future iteration of the internet where 'avatars' (also a term coined by the author) met in a shared, persistent, 3D world for recreational activities, to socialise and to engage in commercial transactions.

Snow Crash forms part of Silicon Valley's literary and ideological canon, which has been influential on the evolution of our digital infrastructure, whether it be recreational pursuits such as online videogames and social platforms, or shifting trillions of dollars of economic activity into the Cloud.

Until recently, the discussions about the Metaverse have been mostly confined to tech circles and video gamers. Like many trends in technology, the pandemic has been an accelerant for change, and has broadened the concept beyond recreation to include other domains such as entreprise, industry and infrastructure.

'Metaverse' web search interest over time (100 is maximum)

Source: Google Trends

The Evolution of the Internet

Experimentation with interconnected computer networks was underway as far back as the 1970s, however the internet as we know it was invented by Sir Tim Berners-Lee in the late 80s during his time as a software engineer at CERN, in an attempt to solve the problem of sharing information about the experiments undertaken between scientists scattered all over the world. In March 1989 he laid out his vision more formally, in a paper entitled 'Information Management: A Proposal' (his then boss wrote the words 'Vague but exciting…' on his hardcopy). He followed this up shortly afterwards with the first web server (CERN HTTPd) and the first web browser (WorldWideWeb).

The early internet was open-source, decentralised and basically free, with communications companies just charging for the use of their physical infrastructure. This allowed for explosive adoption and innovation in the 1990s, until a rather ignominious setback in the form of the dot-com bubble of 2000.

In January 1999, an information architecture consultant called Darcy DiNucci wrote a an article called 'Fragmented Future' in the Print magazine, where she referred to the internet of the 90s, with its "brochure-like displays of Times or Arial text", as Web 1.0. She went on to write, "The relationship of Web 1.0 to the Web of tomorrow is roughly the equivalence of Pong to the Matrix". The analogy to iterative software nomenclature was popular with the tech community and it stuck.

The Syntactic Web

Web 1.0 (1991-2004)

- Read only – passive consumption of content provided by a relatively small number of content providers
- Static pages, limited interactivity
- Company focus
- Banner advertising

The Social Web

Web 2.0 (2004-2020)

- Read-Write. Two-way relationship between content creators and users, site owners and customers
- Much richer, dynamic multimedia content
- Enables online gaming, podcasting, blogging/vlogging, curating, tagging, social media etc
- Community focus
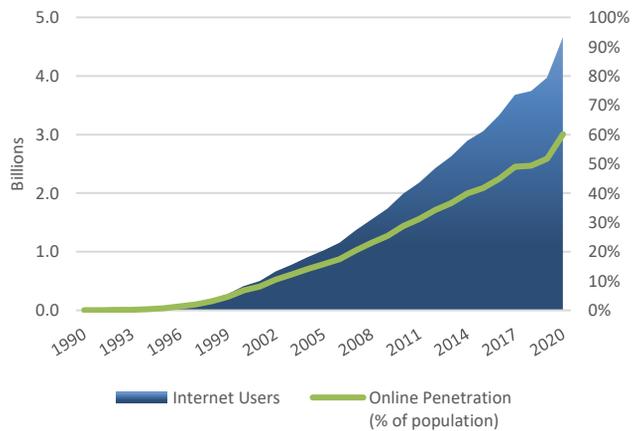- Interactive advertising

The Semantic Web

Web 3.0 (2020-)

- All information on the web organised into a semantic database which is decentralised and shared
- Artificial intelligence can understand interconnected data and metadata, and allow interaction through AI agents via natural language processing and computer vision
- Individual focus – portable, personal, permissionless
- Increasingly 3D - geospatial metadata + virtual, augmented, and mixed reality blur online and offline worlds
- Behavioural advertising
- Embedded payment rails

In practice the internet has evolved too gradually to easily delineate between iterations, but it is fair to say that it was Web 2.0 that made it an indispensable piece of societal infrastructure. When Amazon.com launched in 1995 there were just 45 million internet users worldwide, and 23,500 websites[1]. There are now just under 5 billion users worldwide and 200MM active websites[1] (100x user and 10,000x website growth in 25 years).

We are now entering the Semantic Web era with the arrival of foundation models such as BERT and GPT-3, which represent a leap forward in deep learning. These models have shown general purpose language capabilities across several domains (as well as better understanding language, GPT-3 can generate poetry, prose and computer code). Efforts are now being made to integrate natural language processing (NLP) with computer vision, to improve a model's ability to understand and contextualise multimedia datasets.

Total Internet Users and Internet Penetration Worldwide

Internet Users — Online Penetration (% of population)

Source: World Bank, Statista; Internet user numbers are based on global population estimates multiplied by internet penetration - 2020

[1] *Source: Internet Live Stats; there are over 1.8 billion websites if inactive ones are included*

GPT-3 creators OpenAI trained a 12 billion parameter version of their model that can convert text into images, which they called DALL-E - a portmanteau of Salvador Dali and Pixar's WALL-E. The results are impressive (less whimsical examples can be found HERE).

Text Prompt: an armchair in the shape of an avocado
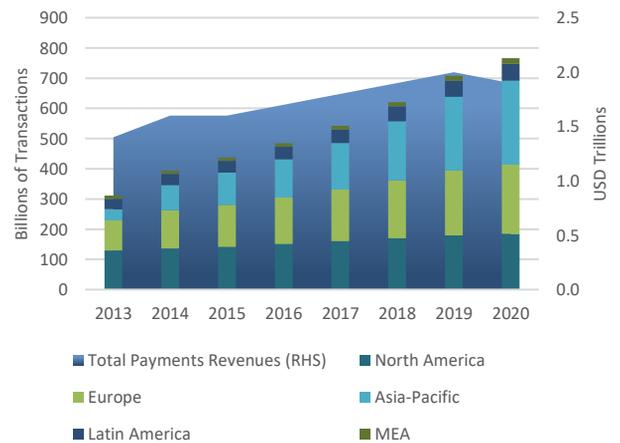**AI Generated Images:**

Source: https://openai.com/blog/dall-e/

Payment systems are also in scope for deeper integration in Web 3.0. Exactly how this is implemented has become something of an ideological battleground, as 'crypto-natives' try to leap on the opportunity to wrest the profitable electronic transfer business away from large payment networks. Digital wallets such as Paypal or Cash App lack interoperability with each other, and the 30% app store tithes exacted by Apple and Google paradoxically make frictional costs in the digital world an order of magnitude higher than old fashioned payment rails like the ACH network. It is easy to see why the decentralised P2P transfers enabled by blockchain are seductive, especially as they empower the individual, emancipating them from their dependence on rent-seeking centralised platforms.

The pace of innovation in the world of decentralised finance (DeFi) is dizzying, however as we have seen in the legacy banking system, there is a lot of inertia in the status quo, and there may not be sufficient appetite amongst the average consumer, who has already enjoyed significant improvements in convenience, efficiency, and access to financial services from centralised fintech disruptors, to abandon these platforms in favour of radical decentralised alternatives.

Part of this comes down to the user experience (UX). Currently those dipping a toe into the world of cryptocurrencies, non-fungible tokens (NFTs), and decentralised apps (Dapps) face a steep learning curve. Companies like Coinbase seek to abstract away some of the underlying complexities to give newcomers a more familiar UX, but there is still a lot of work to be done to match the smooth and comfortable user experience offered by 'Big Tech'.
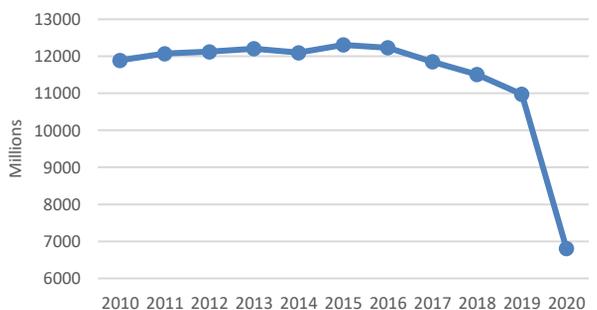
Also, while the decentralisation of the financial system is a grand vision and appeals ideologically to those who feel institutional gatekeepers perpetuate inequality in society, mass adoption would take considerable power away from governments and central banks, and could even pose a risk to the traditional role of a nation-state. Regulators have been slow to act, but are trying to catch up. Their task is made more difficult by the pace of adoption – in May 2021, cryptocurrency exchange Gemini estimated 14% of American adults own some

The global payments market is worth $2TN, and non-cash transactions have grown at a +14% CAGR between 2013-2020

Source: McKinsey; BIS; ECB; Capgemini – October 2020
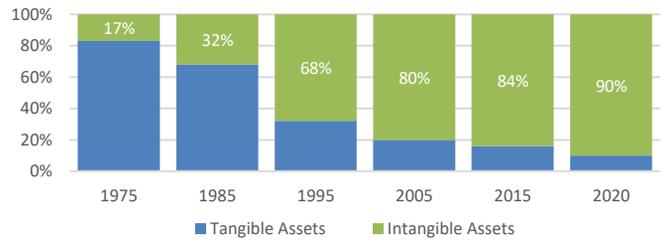
The pandemic accelerated the demise of cash

Source: ECB – July 2021

cryptocurrency (21 million people), and another 20% (>50 million) are likely to buy some in the next year.
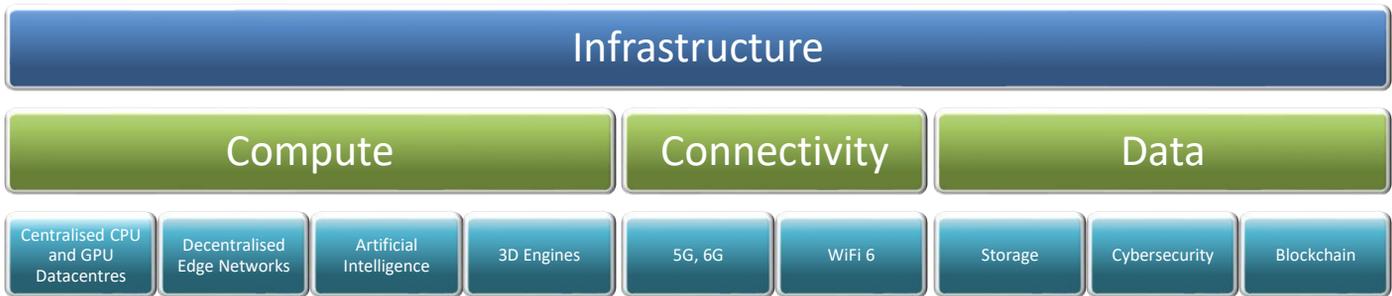
The idea that cryptocurrencies and non-fungible tokens could become the dominant medium of exchange in Web 3.0 may seem far-fetched, however it's worth noting that assets have been dematerialising for decades – intangible assets now comprise 90% of the value of the S&P 500, up from just 17% in 1975.

Intangible assets now comprise 90% of the value of the S&P 500

Source: Ocean Tomo study on Intangible Asset Market Value (market capitalisation minus tangible assets) – December 2020

Building a Metaverse

The basic hardware infrastructure required for the Metaverse exists already, however, richer content, mass adoption, and billions of additional connections to the physical world will require more. A lot more.
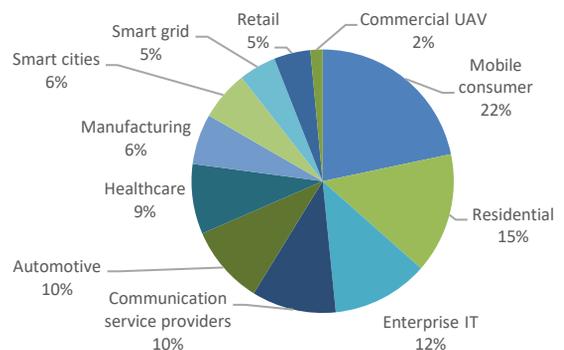
The videogaming industry spent much of the 90s developing increasingly sophisticated 3D engines, which evolved into one of the most computationally intensive workloads in the software industry. This necessitated ever more powerful GPUs on the hardware side, and these in turn were later found to have a valuable application in training neural networks and machine learning models on the vast oceans of data generated by humanity as we digitalise our world. Consequently, in AI, GPUs found a large new secular growth market.

In the Metaverse they will find another - augmented/virtual reality overlaid on the physical world, with real time 3D rendering and accurate simulation of physics, billions of IoT and human interface points, and embedded artificial intelligence everywhere will be the most demanding use case for computation yet attempted. It is estimated that the market for GPUs – about $20BN in 2019 – will grow to over $200BN by 2027 (+34% CAGR)[1]. Decentralised edge networks – placing data processing resources closer to the point of consumption - will play an increasing role in making this computing power, and therefore the Metaverse, more universally available.

[1] *Source: Allied Market Research – June 2020*

Nvidia's datacentre revenues have grown at an +80% CAGR since 2014, driven by a new market for GPUs: AI

Estimated share of edge computing infrastructure in 2028, by segment

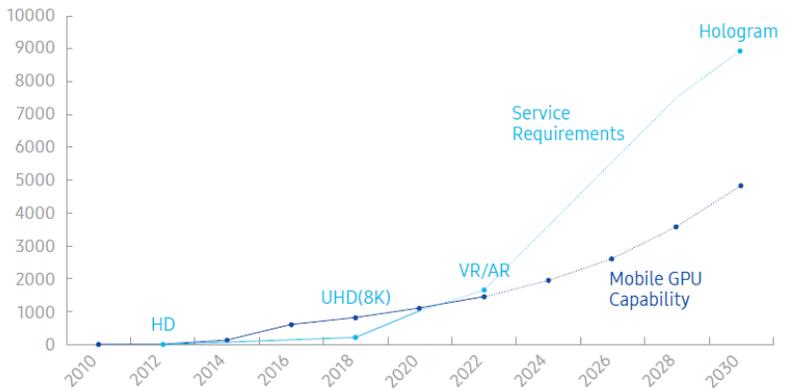*Sources: Bloomberg – October 2021, State of the Edge – March 2021*

Connectivity is another important prerequisite for the Metaverse, which will place higher demands on bandwidth, but crucially will require low latency. While our smartphones would be considered supercomputers by 1990s standards, they will not be able to handle the computing demands of the Metaverse on their own, instead connecting to more powerful edge computing systems, or the Cloud. Nvidia's most powerful graphics cards are nearly a foot long and draw similar amounts of power to an e-bike propelling you along at 40km/h, so are not well suited to our portable or wearable electronic devices.

Latency will be the key bottleneck as network delays would ruin immersive 3D rendering experiences, or worse, pose critical safety risks to autonomous vehicles or remote surgeries. The accelerating roll out of 5G networks will help with this, potentially bringing latencies down from the 30-100ms of 4G into the single digits. The development of 6G has already begun, and will be rolled out towards the end of this decade. This could take latency down to just 1ms, increase speeds by another 10x, and importantly also increase connection density by the same factor. Cisco estimates there will be 500 billion devices connected to the internet worldwide 2030 – 58 devices per person![1]

The roadmap for 5G and 6G addresses the latency issue for wireless connectivity, pushing the limiting factor to other parts of global telecom infrastructure such as subsea cables – there are 1.3 million kilometres of them[2] encircling the planet, routing 99% of global internet traffic. Typically every 1000km of cable introduces 10ms of latency. Landing stations and other routing points introduce further latency to the system. AI will have a role to play in driving network efficiency, as legacy fibre backhaul, wireless base stations, satellites, and connected devices are meshed together.

[1] Cisco – Internet of Things; UN global population forecast of 8.5 billion for 2030 [2] TeleGeography data

Computing power requirements for immersive mixed reality and digital twins will outpace mobile GPU improvements

Mobile GPU Capability (gigaflops/sec); Source: Samsung 6G Vision – July 2020. In 1995 the fastest supercomputer in the world could achieve just 170 gigaflops.
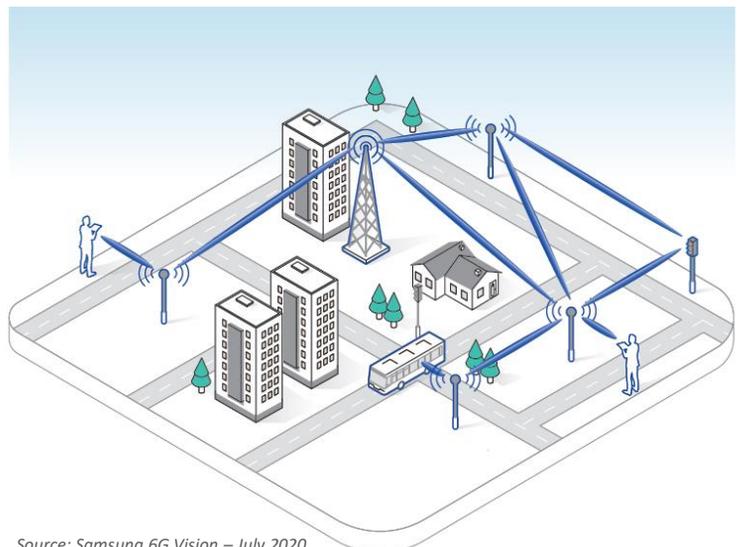
Each generation of wireless technology supports 10x the connection density. Manhattan has a population density of 27,000 people/km²

Source: Statista; ITU; Samsung – July 2020   100,000 devices/km²

We will start to move towards mesh network topology for even network densification and more efficient two-way connections
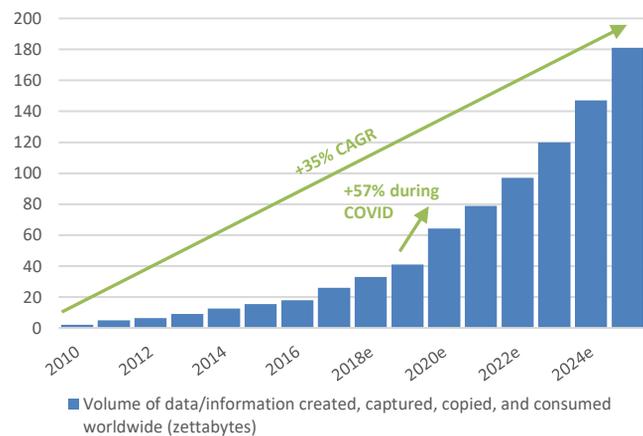

Source: Samsung 6G Vision – July 2020

One of the most exponential products of the digital age is data. The creation of data started to take off as the internet evolved from text and images to video, and as entreprises digitalised and moved to the Cloud. This trend will be accelerated further by the Metaverse and its adjacent technology trends.

The portability of data is an important feature of the Metaverse, as digital assets are currently highly fragmented and often trapped in a certain ecosystem. This goes far beyond our collections of photos, Spotify playlists, or social graphs. The rise of digital wallets, digital currencies and new kinds of digital assets will make interoperability a prerequisite foundation for the Metaverse to work. Video gamers have been grappling with this problem for years – why shouldn't someone be able to transfer a Fortnite skin that cost $20 over to Call of Duty? Outside of gaming, there are annoying siloes in other areas, such as loyalty points or airmiles – these digital assets have a dollar value, and yet they can become stranded in their own walled gardens.

In blockchain, we have a technology that can provide a decentralised ledger of digital asset ownership, and allow this ownership to be transferred easily, cheaply, and even fractionally. This can extend beyond purely digital assets to financial assets, and intangible assets such as intellectual property. Smart contracts eliminate the need for intermediate institutions to confer trust on transactions between parties that don't know each other. They also enable novel microtransactions – for example, what if you could 'rent' the compute cycles of your idle smartphone or laptop to the edge network, or sacrifice some battery from your parked EV in return for a payment in digital currency. Blockchains and non-fungible tokens can revolutionise the way we identify ourselves online, doing away with hundreds of passwords scattered across the internet. We could use out digital wallets to hold our identification credentials, our health information, and our CVs, as well as our digital assets, current accounts, financial products and other contractual obligations.
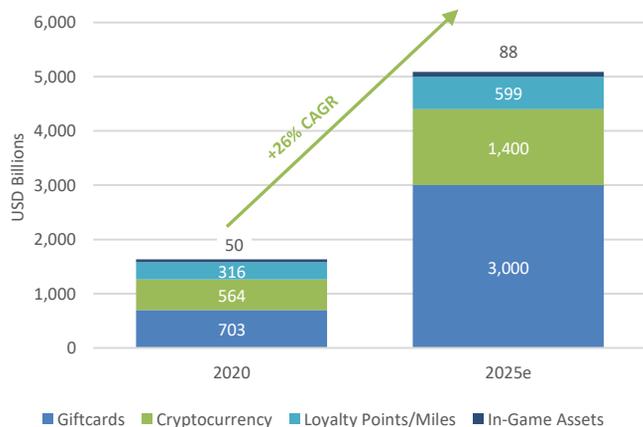
Of course the many conveniences and efficiencies that this could confer are only desirable if they are secure. Decentralisation presents an entirely new landscape of attack surfaces for hackers, and there have been many successful 'heists' of crypto exchanges, some running to the hundreds of millions of dollars.

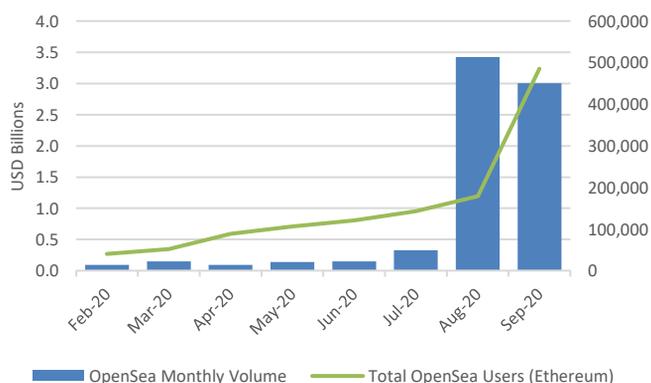### IDC estimate only 2% of data created are stored; a zettabyte is a trillion gigabytes

Legend: Volume of data/information created, captured, copied, and consumed worldwide (zettabytes)

Chart annotations: +35% CAGR; +57% during COVID

Source: IDC; Seagate; Statista estimates – June 2021

This nine month old estimate for digital assets reaching $5.1TN by 2025 already looks stale - the crypto market alone exceeded a $2TN this year

Chart annotation: +26% CAGR

2020: Giftcards 703, Cryptocurrency 564, Loyalty Points/Miles 316, In-Game Assets 50

2025e: Giftcards 3,000, Cryptocurrency 1,400, Loyalty Points/Miles 599, In-Game Assets 88

Legend: Giftcards; Cryptocurrency; Loyalty Points/Miles; In-Game Assets

Source: Bakkt Investor Materials (Giftcards: Allied market Research; Cryptocurrency: CoinMarketCap 14/12/20, Ark Investment Management estimates; Loyalty Points/Miles: Management estimates based on Infiniti Research; In-game Assets: Management estimates, industry data) – January 2021
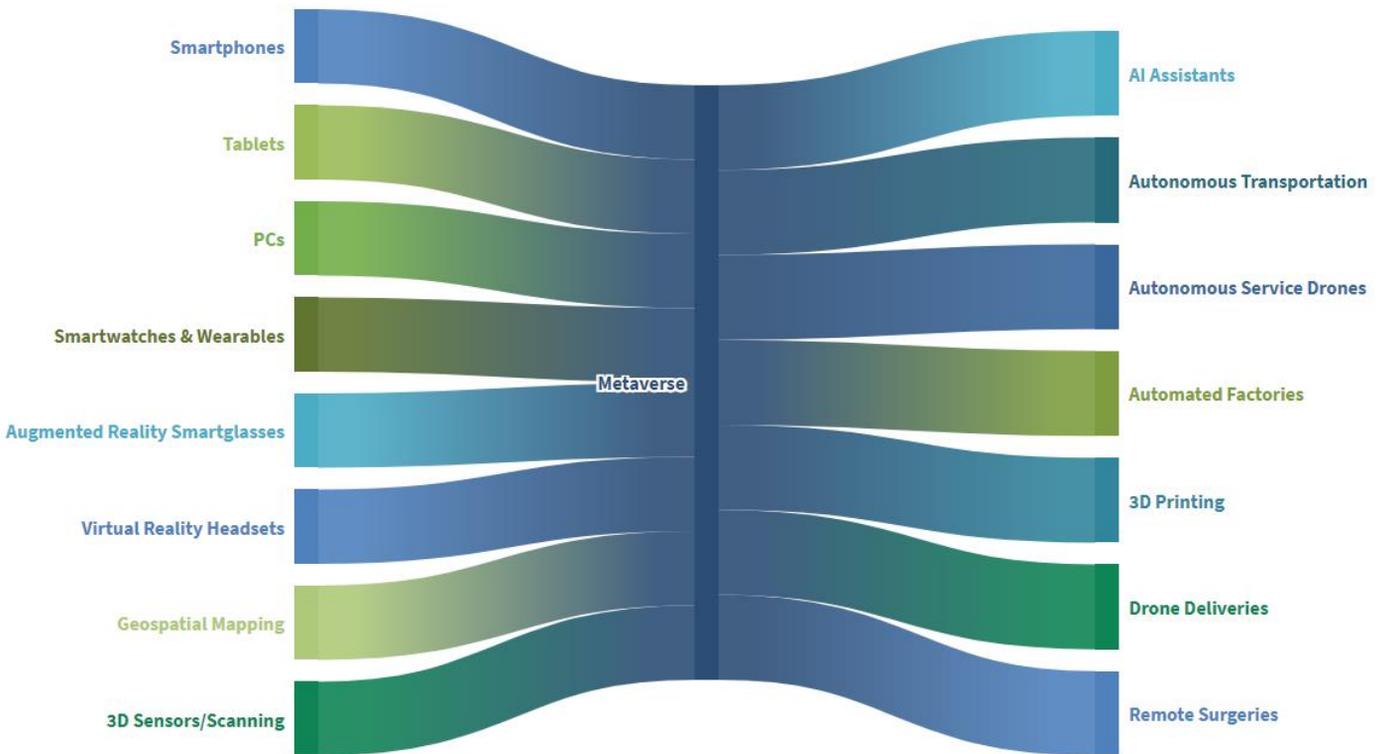
Non-fungible tokens (NFTs) have become a hot topic, engendering a new burst of innovation

Legend: OpenSea Monthly Volume; Total OpenSea Users (Ethereum)

Source: Dune Analytics – October 2021

Metaverse Interfaces (Input/Output)

Smartphones have been one of the most successful products ever created, and will probably remain our most ubiquitous access point to the online world for years to come. Their increasingly potent computing, storage and bandwidth capabilities, as well as their suite of motion sensors, cameras, microphones, and GPS also make them a powerful hub for smartwatches, smartglasses, health monitors, and the numerous connected devices scattered around a modern home.

This diverse network of connected devices offers plenty of ways to interact with the Metaverse. These range from passive monitoring at the most basic end of the spectrum (perhaps for healthcare or fitness), moving through voice and gesture control, to richer content such as video. Augmented reality and mixed reality will further enrich our interactions with the Metaverse, as digital information increasingly overlays the physical world. Finally, immersive virtual reality will be the most complete interface, conferring a sense of presence and enveloping an ever greater portion of the human sensorium.

Virtual reality headsets have existed as far back as the 90s, and have so far been rather a poor imitation of the real thing. That said, progress in this area is accelerating rapidly, and is coinciding with 'digital native' Gen X - a generation that has grown up with the idea of working, socialising and playing online.

Global smartphone sales for the first four years of the last decade, versus VR/AR/XR market forecasts for the first four years of this decade

Source: Statista, Counterpoint Research, Boston Consulting Group, Mordor Intelligence – May 2020, February 2021

As we will build ourselves better interfaces to interact with the digital world, we will also be building interfaces for the digital world to interact with the physical. AI assistants can already control the heating, lighting, and appliances in many households, but their authority will continue to expand into agriculture, offices, factories, transportation & logistics networks, supply chains, and even hospitals.
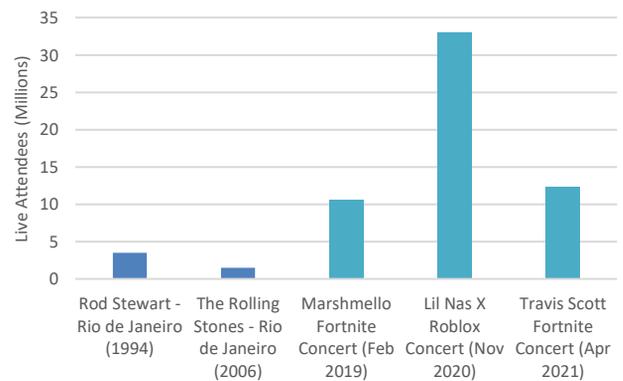
The Metaverse

Consumers			Creators			Social		
Shopping	Games/ eSports	Immersive Experiences	Content	Microservices	Hybrid Work	Persistent Virtual Environments	Live Events	Content Curation/ Product Ratings

In July 2021, the Chicago Bulls launched 'The Bulls Legacy Collection' in the form of non-fungible tokens (NFTs), and sold through Shopify's eCommerce platform. Collectibles are an early example of products going digital. We are in the first stages of an evolution in eCommerce where the line between online and offline shopping will be blurred by augmented and virtual reality. Behavioural habits and interests that inform targeted advertising while we are online could start to feature in a more personalised perception of the offline world.

Clothing retailers may replicate their fashion lines digitally, allowing shoppers' avatars to trial outfits while they walk around physical stores. Eventually we may see 'Metaverse Malls', taking the whole shopping experience fully online. PWC estimate 30-40% of clothes purchased online end up being returned, the majority of which are due to fit. Digitalisation of the $1.5 trillion global clothing market streamlines the customer experience, thereby bolstering a brand's image, while also helping to improve supply chains, expand margins, and cut waste. There will be opportunities like this across all areas of commerce, driven by connectivity, AI, and new ways of marketing products to consumers.

Digital counterparts of recreational activities that traditionally only took place in the physical world are starting to emerge online, and at scale. The nature of digital distribution empowers creators of all kinds to reach their audiences all over the world. Taking live concerts as an example, a metaverse performance has none of the logistical or venue costs incurred on an international tour. Forbes estimate Travis Scott's 2019 Astroworld Tour *grossed* $54 million over 57 shows in 2019, with total attendees numbering in the hundreds of thousands. By contrast, a single eight minute performance on Fortnite reportedly *netted* him $20 million, with 12.3 million attendees.

'Metaverse' concert live attendees versus two of the the largest live concerts of all time

Source: Statista, Epic Games, Roblox - 2021

Travis Scott reportedly earned $20 million for his 8 minute live concert on Fortnite

Source: YouTube screenshot

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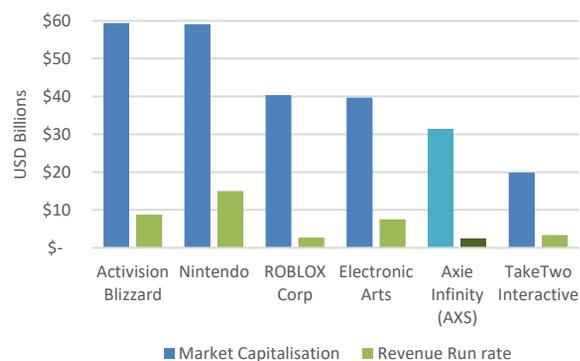
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New economies are starting to emerge, based on 'tokenomics' - just two years since launch, Axie Infinity has risen to prominence as the first NFT-based videogame to reach a market cap comparable to a major videogame studio. Built on the Ethereum blockchain, Axie has over 2 million users who currently generate a revenue run-rate of over $1.5BN. The game is one of the first examples of a large play-to earn ecosystem – 40% of the player base resides in the Philippines, where it is reportedly possible to earn several times the average monthly salary of around $885 by playing Axie full time.

The concept of NFTs is an interesting one, and presents opportunities for companies with strong brands and intellectual property. Disney is a great example, with their broad library of much loved content and characters. These could be minted into NFTs and traded throughout the digital economy, with Disney receiving their cut of every transaction (Star Wars, Marvel and even Nike have already featured in Fortnite). Dolce and Gabbana recently unveiled Collezione Genesis - a nine-piece NFT collection that are unique, tradable, and can be used to clothe avatars in the Metaverse. NFTs are in their earliest days, and tokenomics presents fertile ground for innovation as we find new ways to exchange value and reach audiences in the digital world.

The Metaverse also has applications for the more prosaic world of office work, now the pandemic has made hybrid working a permanent feature for many employees. 2020 saw us go from zero-to-many hours on Zoom/Microsoft Teams/Google Meet per week, and developers are adding spatial audio and other features to try to make remote meetings more engaging. In time, board meetings might feature half of the board attending as holograms, with the others kitted out in AR glasses. Facebook is trying to go fully virtual with their Horizons Workroom app on the Oculus Rift 2. Without wanting to prejudge, this seems a little cartoonish for mass adoption in a typical professional environment – it will be interesting to see how it develops.

'Gamification' and augmented/virtual reality has the potential to revolutionise learning. EdTech was amongst the fastest growing categories of VC funding last year, riding on the success of TikTok's 'micro-learning' initiative (there are now millions of videos with a #learnontiktok hashtag, garnering billions of views). This goes beyond the classroom, offering opportunities to upskill professionally or take up new hobbies. Two-thirds of EdTech investment went to China last year, however recent actions by the government have effectively nationalised the sector. This will shift the balance of innovation back to the West.

Axie Infinity's $30BN market cap and $1.5BN in annual revenues rivals some of the largest video game studios

Source: Bloomberg, Token Terminal. Axie Infinity revenues based on weekly run rate, company revenues based on street estimates for FY21e. As of 11/10/21

Facebook's first attempt at VR meetings may be a little cartoonish for mass adoption

Source: Facebook

AR can help us upskill professionally, take up new hobbies or…perform DIY engine repairs

Source: BEterna

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The Omniverse

Enterprise	Industry 4.0	Civil Infrastructure

Intelligent Cloud	Commerce/ Advertising	Design/ Worldbuilding	Digital Twins	Automation	Smart Cities	Smart Grids	Autonomous Public Transport

Nvidia's Omniverse platform broadens the scope of the Metaverse to nearly every corner of the physical world, with digital twins offering opportunities to modernise infrastructure and construction, which have lagged other sectors in technology-enabled productivity gains.

Industry 4.0 is already incorporating digital twins into the engineering and design process. This will also improve manufacturing efficiency as factories and plants automate. Automakers are embracing this technology in nearly every aspect of their business, from design and testing, to supply chains, manufacturing, and plant maintenance. Even after the car has left the production line, 3D visualisations help sell the car to customers, its digital identity streamlines aftermarket maintenance and allows for targeted recalls if and when necessary. Porsche are now rolling out augmented reality glasses to dealerships to help them diagnose complex technical issues, giving local mechanics access to remote experts. This approach has applications across many industries, and is another trend that has been accelerated by the pandemic.

Digital twins will also enable personalised medicine, as our digital selves provide doctors with specific information on our genome, transcriptome, proteome and microbiome – a complex bioinformatic library that can be analysed and indexed by AI and assessed by doctors with the relevant specialty. They can be located anywhere in the world, and eventually may even perform surgeries remotely through robot proxies.

Digital twins will eventually span whole cities – Las Vegas is currently embarking on this project, building a digital model of the city's buildings, transportation systems and infrastructure, with real time data transmitted by sensors over a 5G network. The goal is to provide planners, building owners, and system operators with better visibility into their assets' operations to improve mobility, air quality, noise pollution, water management and emissions.

Digital twins and augmented reality have boundless applications across industries

Source: MagicLeap

In Summary

The conversation about the Metaverse tends to focus on the ways it could change how we socialise, shop, learn and play. It is a democratising technology, that puts power back in the hands of consumers and creators at the expense of centralised platforms. Interoperability and portability of our digital assets between platforms, and frictionless ways of transacting are key pillars that will be required for the Metaverse to work.

Innovation in the areas of Web 3.0 and fintech is moving at breakneck speed, and the giants of Web 2.0 will need to adapt to avoid obsolescence. The parallel developments in the industries of the 'old economy' are also profound, though the exponentiality of change may take a little longer to be apparent.

Much like attempting to predict the nature of today's internet back in the 90s, it is impossible to know how the Metaverse might evolve. One constant we can depend on is that it will drive sustained demand for the underlying infrastructure, as the digital world continues to expand our requirements for computation, data storage, and connectivity.

The Companies of the Metaverse

Source: Building the Metaverse by Jon Radoff, CEO Beamable. Oct 2021

Further Reading

Mathew Ball – VC investor and writer
Not Boring by Packy McCormick
Jon Radoff on Medium – CEO, Beamable
The $1 Trillion NFT Market – Doug Clinton, Uncomfortable Profit
Samsung 6G White Paper - The Next Hyper-Connected Experience for All

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