Sustainability as a Standardization Imperative for 6G

a Vision, Perspective and Roadmap…

N. KISHOR NARANG

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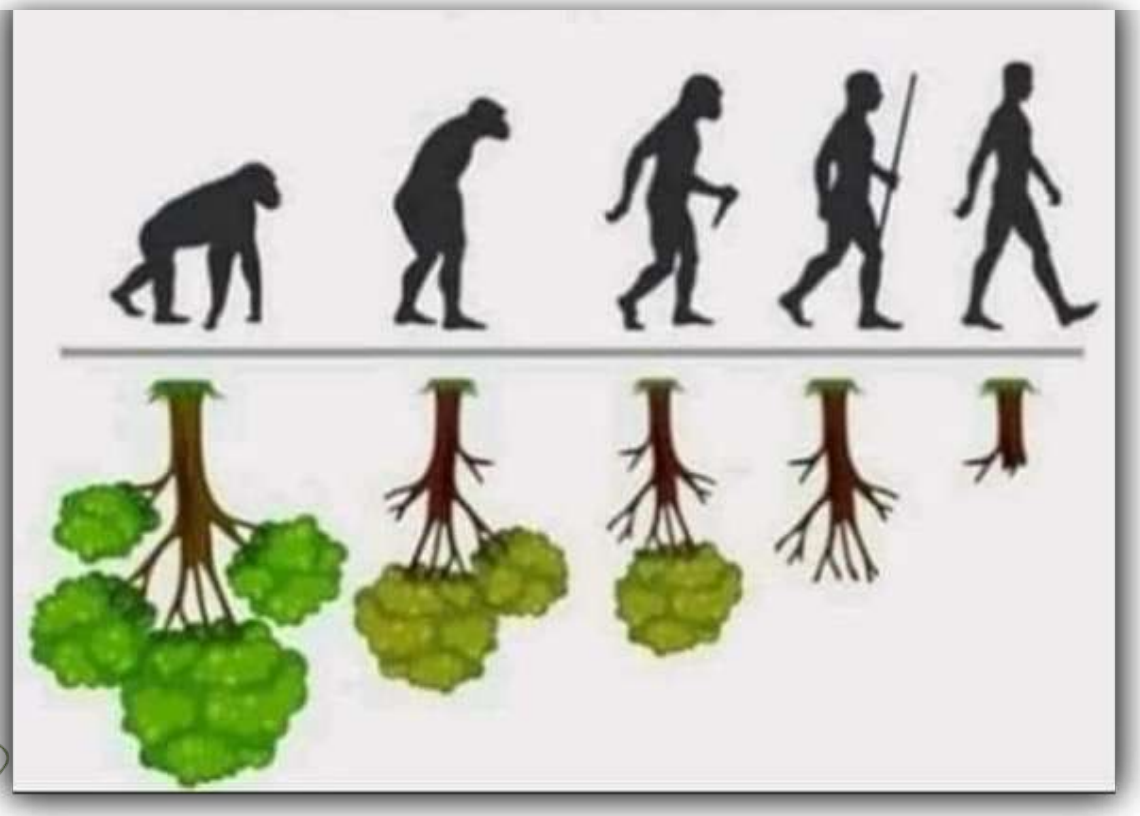
The Context…

The emergence of disruptive digital technologies has already begun profoundly reshaping our lives, our interactions, and our lived environments. As adoption of these technologies becomes widespread, they are likely to play a substantial independent role in society's energy consumption and environmental impact.

Following the deliberations in the COP26 & COP 27 climate conferences, private organizations and governments alike are stepping up their promises to combat climate change, bringing to bear a mix of public policy and innovative technologies to address one of our era's defining challenges.

The EVOLUTION we NEVER EXPECTED



It's a small world. It's also an increasingly hot, crowded, and contentious one.

The combined effect of climate change and society's impact on the earth is intensifying struggles over natural resources while also threatening our infrastructure, food systems and quality of life.

"Nature no longer runs the Earth, we do"

Climate is not politically strong enough to fight Carbon by themselves.

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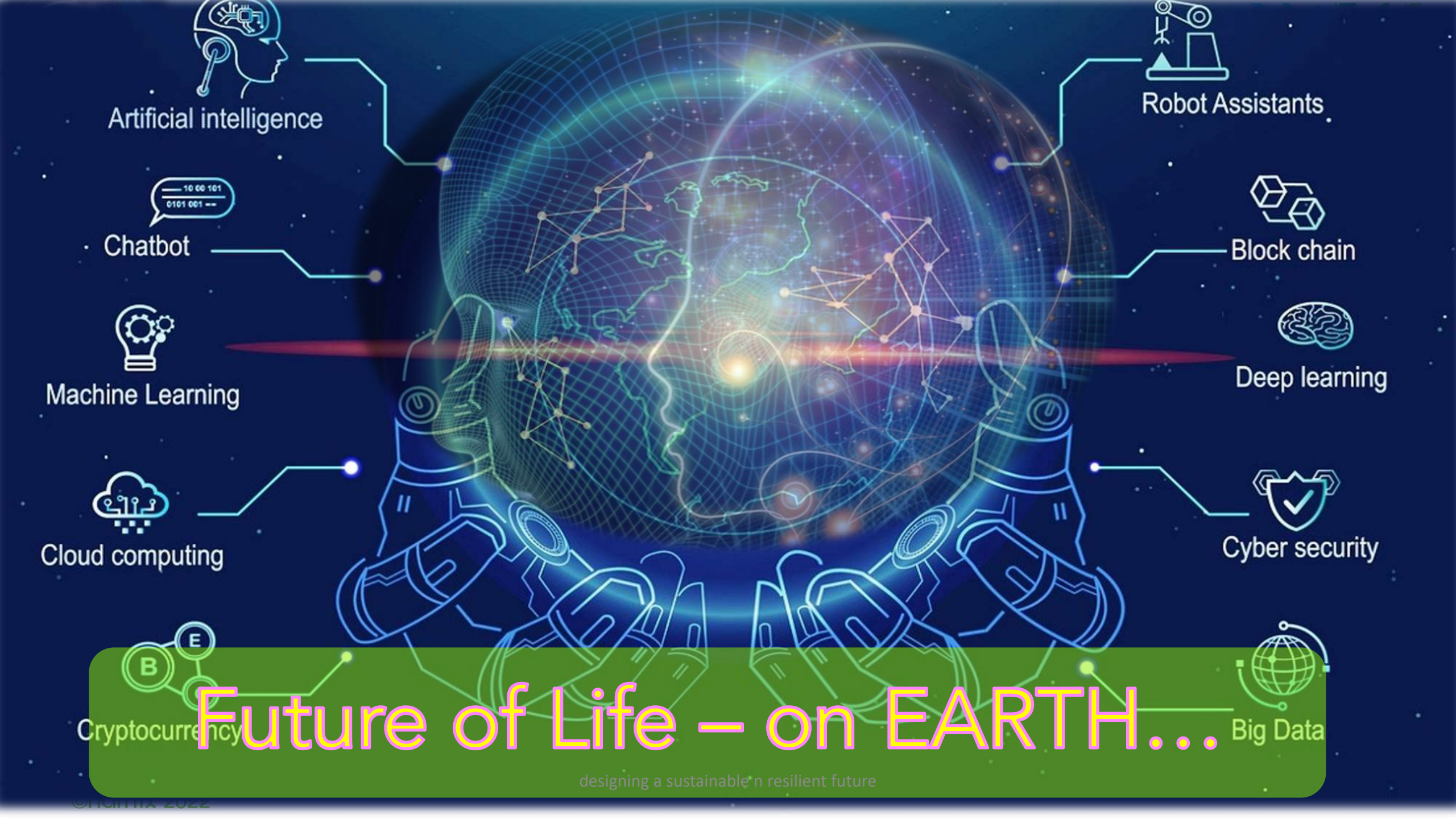

Future of Life – on EARTH…

designing a sustainable n resilient future

Future of Life… on EARTH…

It has been observed that the technologies developed by human beings in the last 2-3 centuries have had a major impact on the earth's climate and our nature's equilibrium

Some believe that we have reached a point of no return. This can have a huge impact on *life on earth*, especially on the *human species*.

However, while technology has been responsible for most of it, technology also seems to have a solution for it.

It's increasingly clear that today's environmental conditions are not sustainable. Over the past few decades, we have made huge progress fighting disease, poverty, and illiteracy.

Now we must apply that same ingenuity to the problem of global warming and other consequences of human activity.

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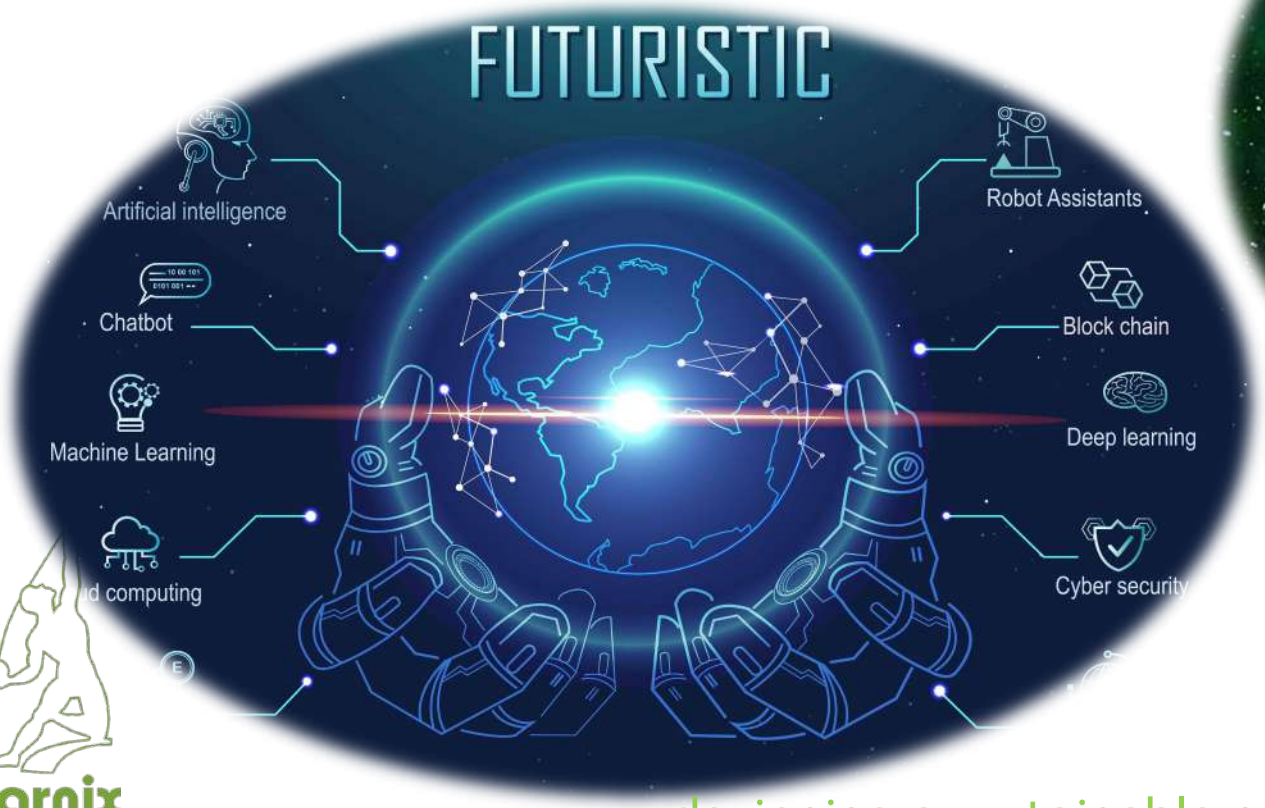
This pandemic has catapulted two diametrically opposite paradigms to the focus of the mankind

Digitalization



Sustainability

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designing a sustainable n resilient future

The current landscape & imperatives…

- Climate Change - Net Zero Goals and Going Carbon Neutral imperatives and initiatives
- Energy Security – Example - Current challenges that Europe is facing due to geo-political issues…
- Clean/Green Energy - Coal, gas and oil still meet three-quarters of global heat demand, making it heavily fossil-fuel dependent.
- Energy Efficiency - It is rightly considered as the 5th Fuel and a Source of Clean Energy rather than a strategy…
- Electricity Access - 90.5% in 2020. An estimated 660 million people would still lack access in 2030, most of them in Sub-Saharan Africa.
- Global Digital Population - Internet Users 5.0 Billion; Social Media Users 4.65 Billion
- Digital Transformation - Intertwining of IT, OT, NT, IoT & AI… DT is NOT about Technology, it is domain & context specific evolution leveraging Disruptive Technologies
- Growing Carbon Footprint of Digital Infrastructure – Impact of growing digitalization
- A meaningful Safe Digital Life - a fair, more livable digital future for our fast-evolving and technology-driven world
- Industry 4.0 to Industry 5.0 – Shifting perspectives: Man-Machine Collaboration & Sustainability on the forefront.
- Sustainability & Resilience – Whether Electrified and/or Connected , Society has to be Sustainable and Resilient to say the least…
- Green Washing - Need to control it comprehensively…

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Technology Trends…

Disruption is everywhere and the future is uncertain — no one knows what the world will look like even a decade from now. As we head into future, we are surrounded by disruptive innovation

As we look to the years & decades ahead, tech-disruption will be driven as much by the methods and systems as it is by the devices, we associate with tech disruption.

The pace of innovation is incredibly fast, with new things getting discovered daily. The future trends in technology are very diverse, very intertwined, and very promising…

There are several developments that have and will continue to shape business strategies. From **Automation** to **Sustainability**, organizations are adapting to a whole new wave of consumer preferences.

The Digital Transformation

The society, the business, the infrastructure, the services and all other aspects of the civilization on the planet Earth are going through a paradigm shift in the wake of technological advancements, especially in the field of ICT

All the ecosystems, be it Smart Cities, Smart Grid, Smart Buildings or Smart Factories now find themselves making three classes of transformations:

- Improvement of Infrastructure – to make it resilient & sustainable…
- Addition of the Digital Layer- which is the essence of the *smart paradigm*; and
- Business Process Transformation - necessary to capitalize on the investments in smart technology.

The genesis of Digital Transformation

In digital transformation in any paradigm, domain or ecosystem

- ‘Sustainability is the *True* Destination’
- ‘Resilience is the *Core* Characteristic’
- ‘Smart is *merely* the Accelerator’

Standards are the Chromosomes of Digital Infrastructure

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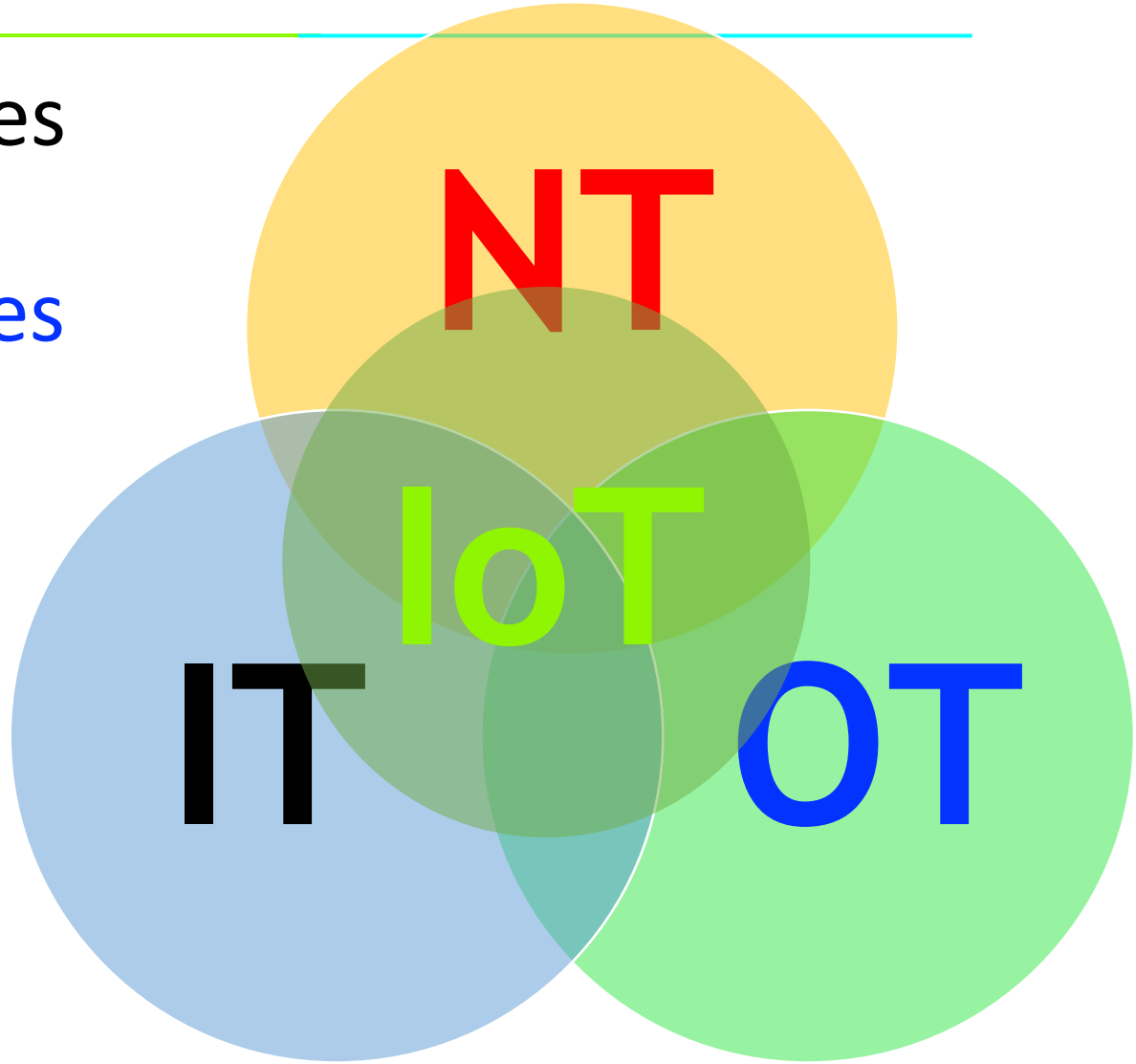
Digital Transformation Constituents

- Information Technologies
- Operational Technologies
- Network Technologies
- IoT Technologies



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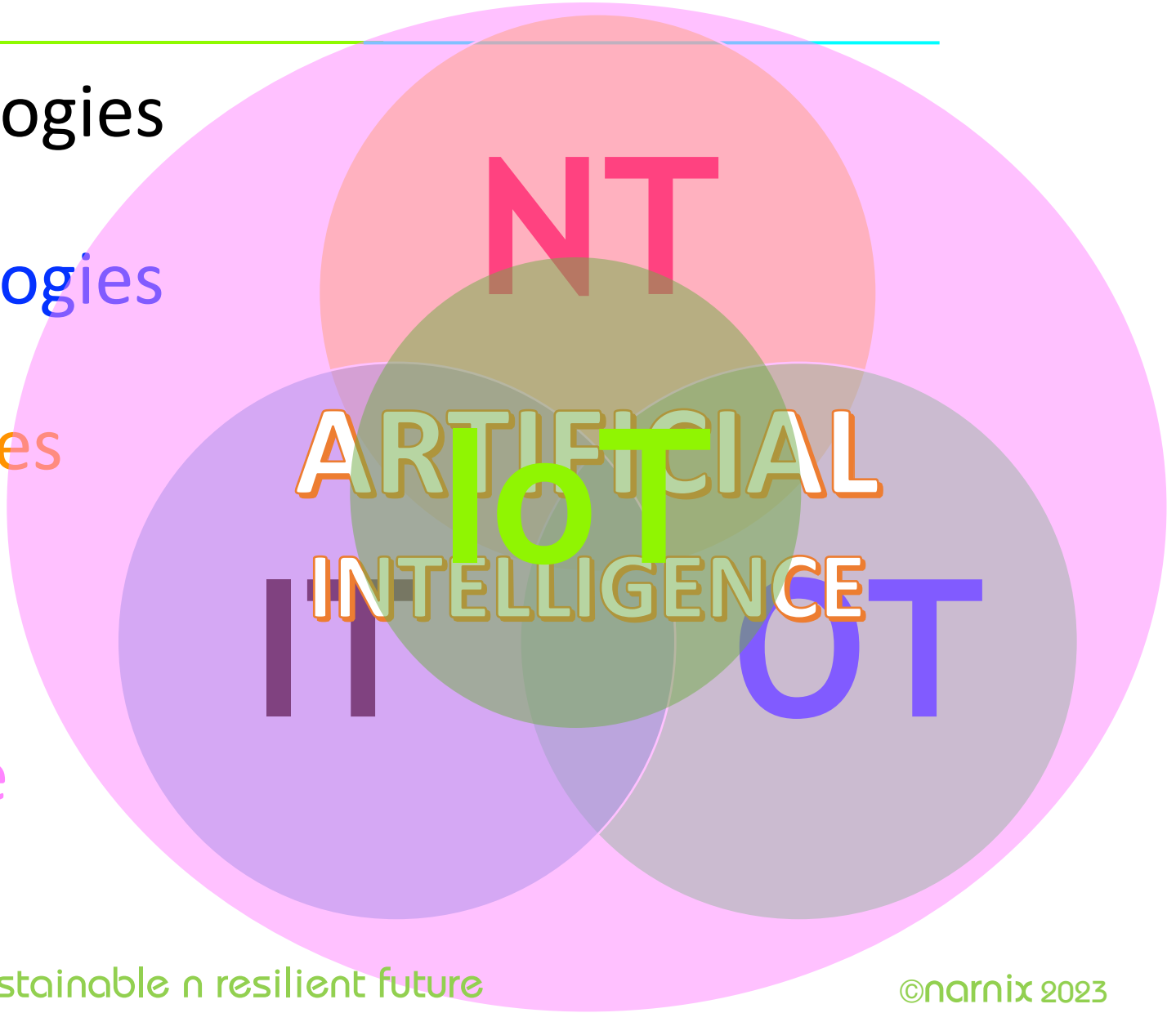
Digital Transformation Constituents

- Information Technologies
- Operational Technologies
- Network Technologies
- IoT Technologies
- Artificial Intelligence



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Digital Transformation

We are living in an ephemeral world

Disruptive Technologies on the Radar

- Artificial Intelligence/Machine Learning
- Blockchain
- Internet of Things/Everything
- Big Data
- 5G/6G
- AR/VR/XR
- Web 3.0
- Robotics & Drones
- Data Centers
- Digital Twin
- Metaverse….

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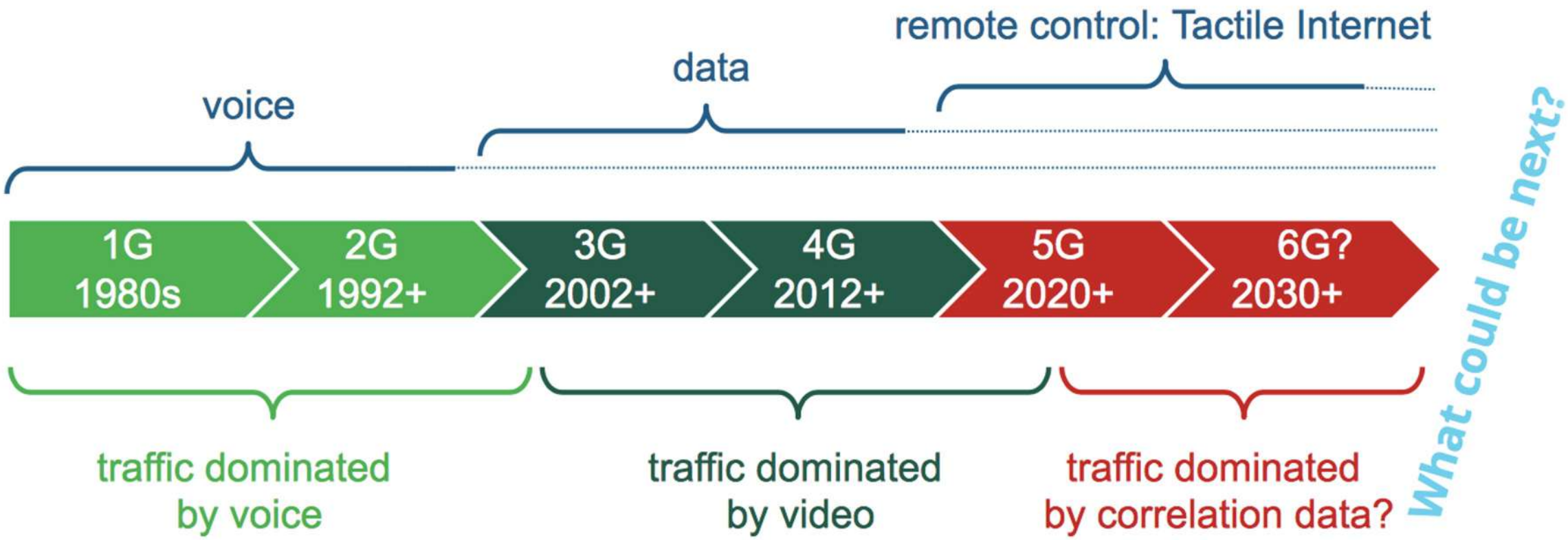
1G to 6G Cellular Networking



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5G – Only the Beginning…The Carl Benz Automobile for the Internet

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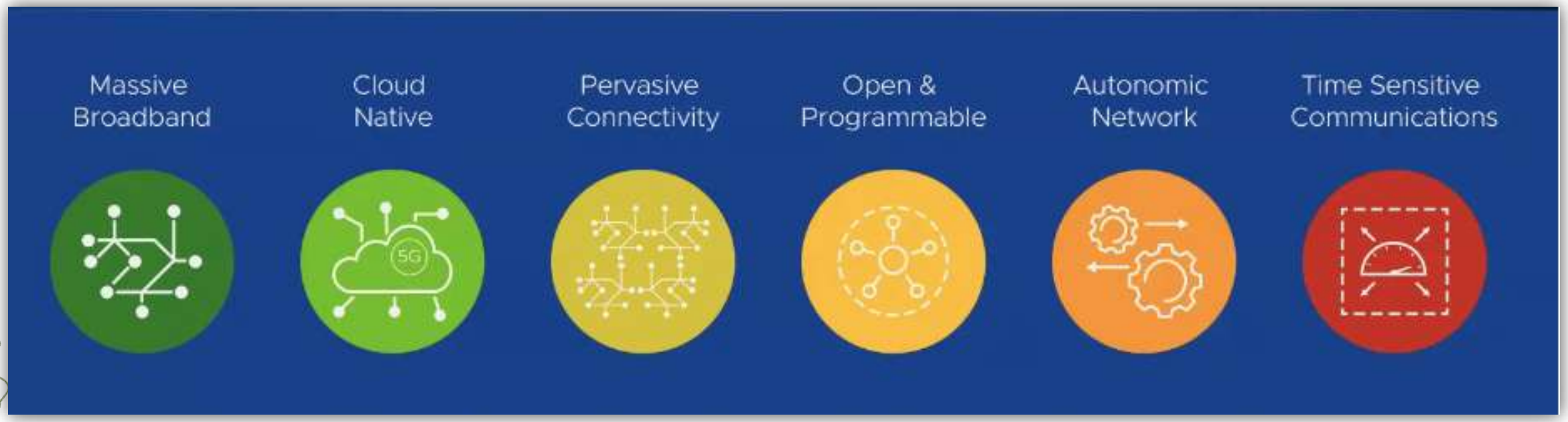
5G Foundation – A multi-industry scorecard…

A generations of many firsts, but much remains to be completed



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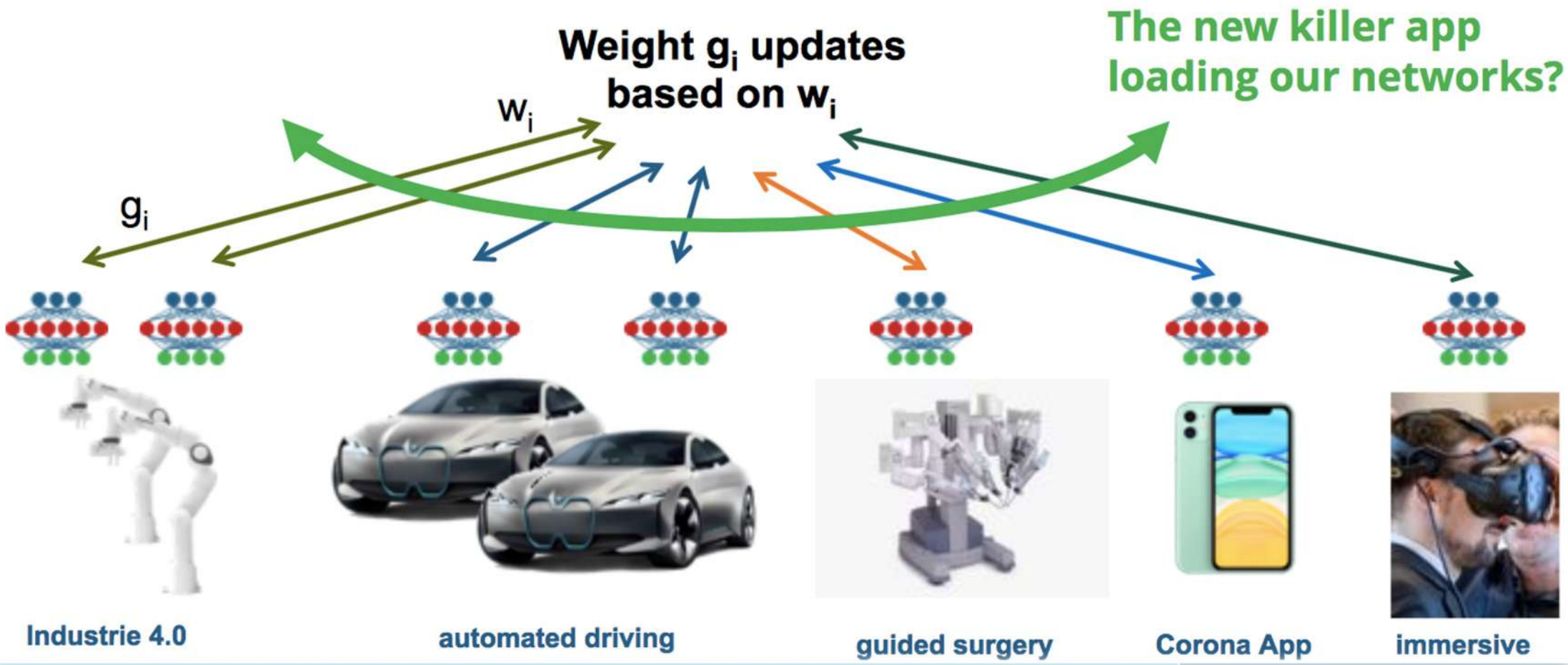
Tactile Internet – 6G & AI to Control Objects Remotely

Federated learning and more will lead to massive correlation data over wireless



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6G's Non- Evolutionary Tactile Internet Challenges

Energy Challenge

- Terminal data rate requires new PHY
- RAN and Edge Cloud requires new HW architecture – implementing softwarization?

Integrity Challenge

- Privacy (Core Network)
- Resilience (RAN)
- Trustwothyness ("trusted network with untrusted components")

Functionality JC&S: Joint Communications & Sensing

- Comms & Radar
- Spectroscopy
- Gesture
- "7 senses"

enabling the "Tactile Internet"
towards RF for "Ambient Cognition"

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Projecting a Path- towards Universal Autonomy

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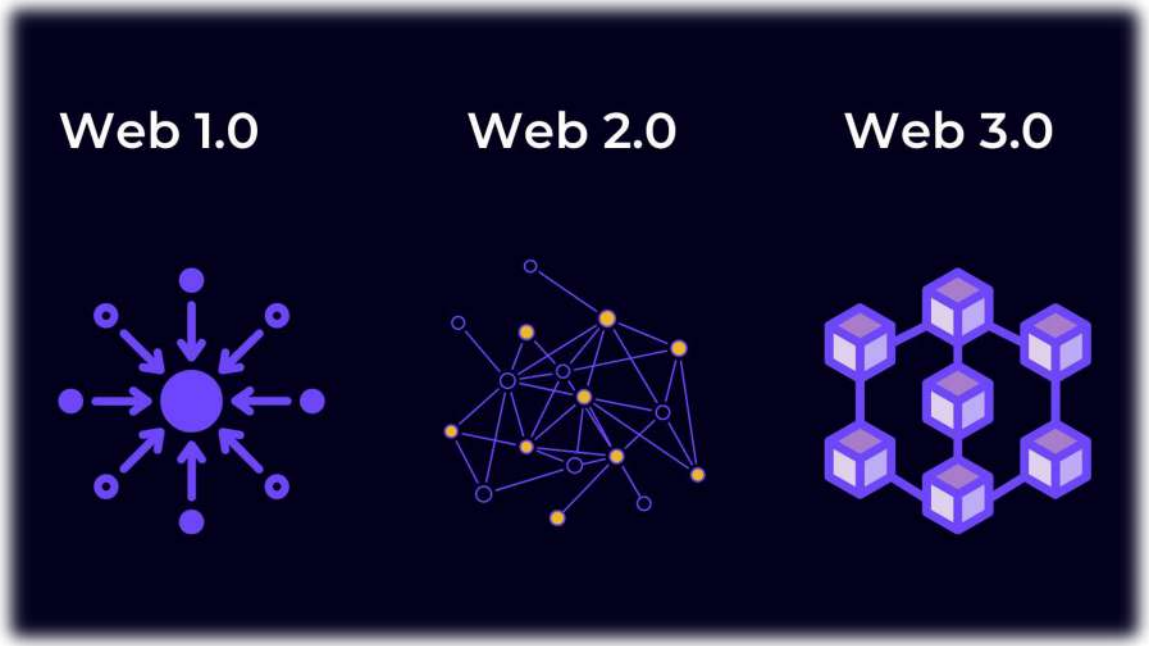
Web3.0



- Web3 is a new iteration of the internet that harnesses blockchain to "decentralize" management thus reducing the control of big corporations, such as Google or Meta, and making it more democratic. It is defined by open-source software, is trust less – doesn't require the support of a trusted intermediary – and is permissionless (it has no governing body).
- Web3 draws its named as the third iteration of the internet. The first iteration of the internet consisted of read-only, static webpages (view a BBC homepage from August 2000 as an example). Web 2.0 added the ability to interact with and produce content, making activities such as social media and online banking and shopping possible.
- The concept of Web3 has been around for over half a decade, originally coined by Ethereum co-founder Gavin Wood in 2014. It gained traction, however, in 2021 with the proliferation of blockchain technologies, expanding NFT markets, venture capital investments and ongoing calls to reign in the power of big tech.

The current internet, Web 2.0, relies on systems and servers owned largely by big corporations, raising concerns over system vulnerability and control.

In a Web3 world, activities and data would be hosted on a network of computers using blockchain rather than corporate servers.

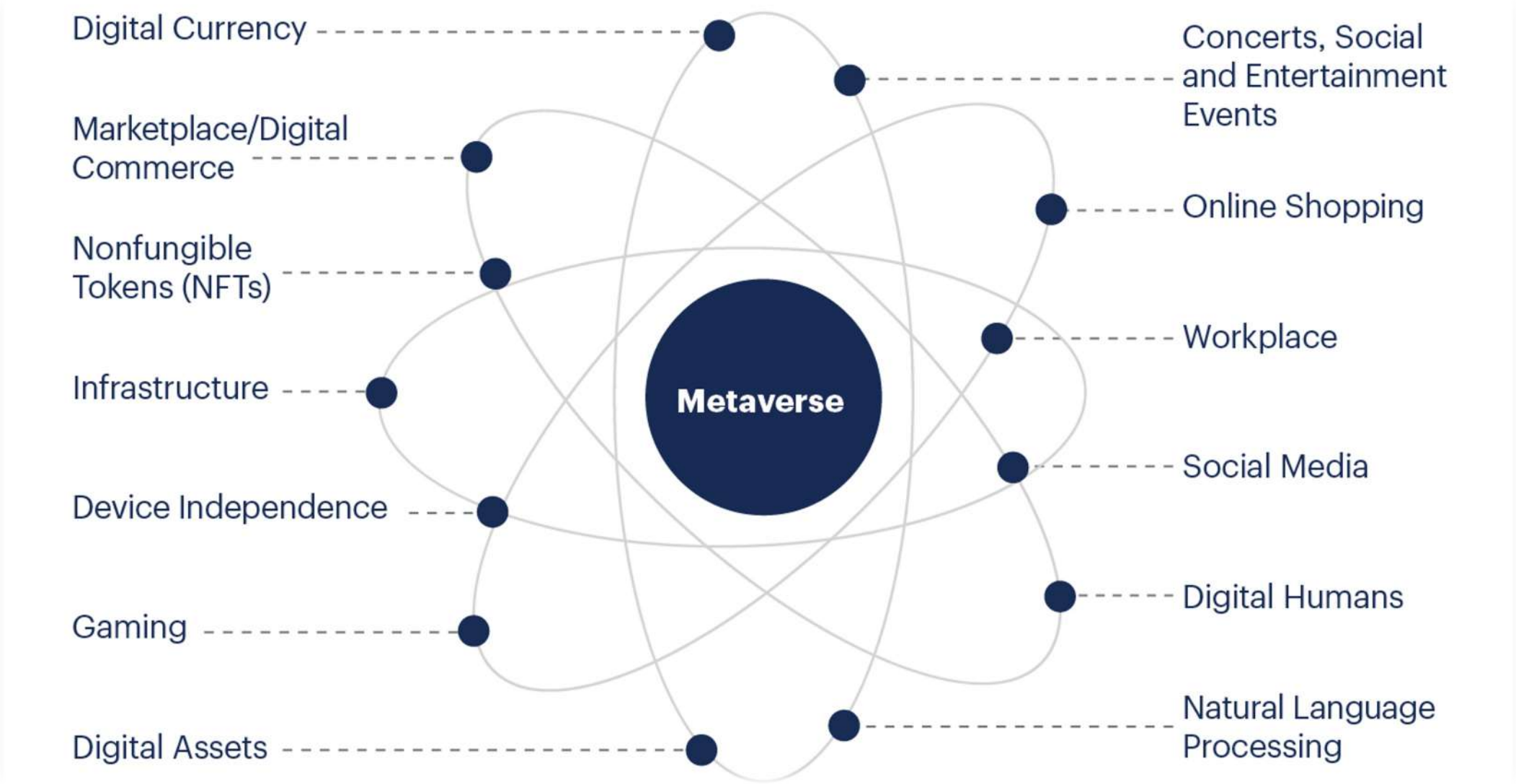
- **Anonymous single-sign-on**
- **Individual ownership and tokenization**
- **Self-governing**

Metaverse…

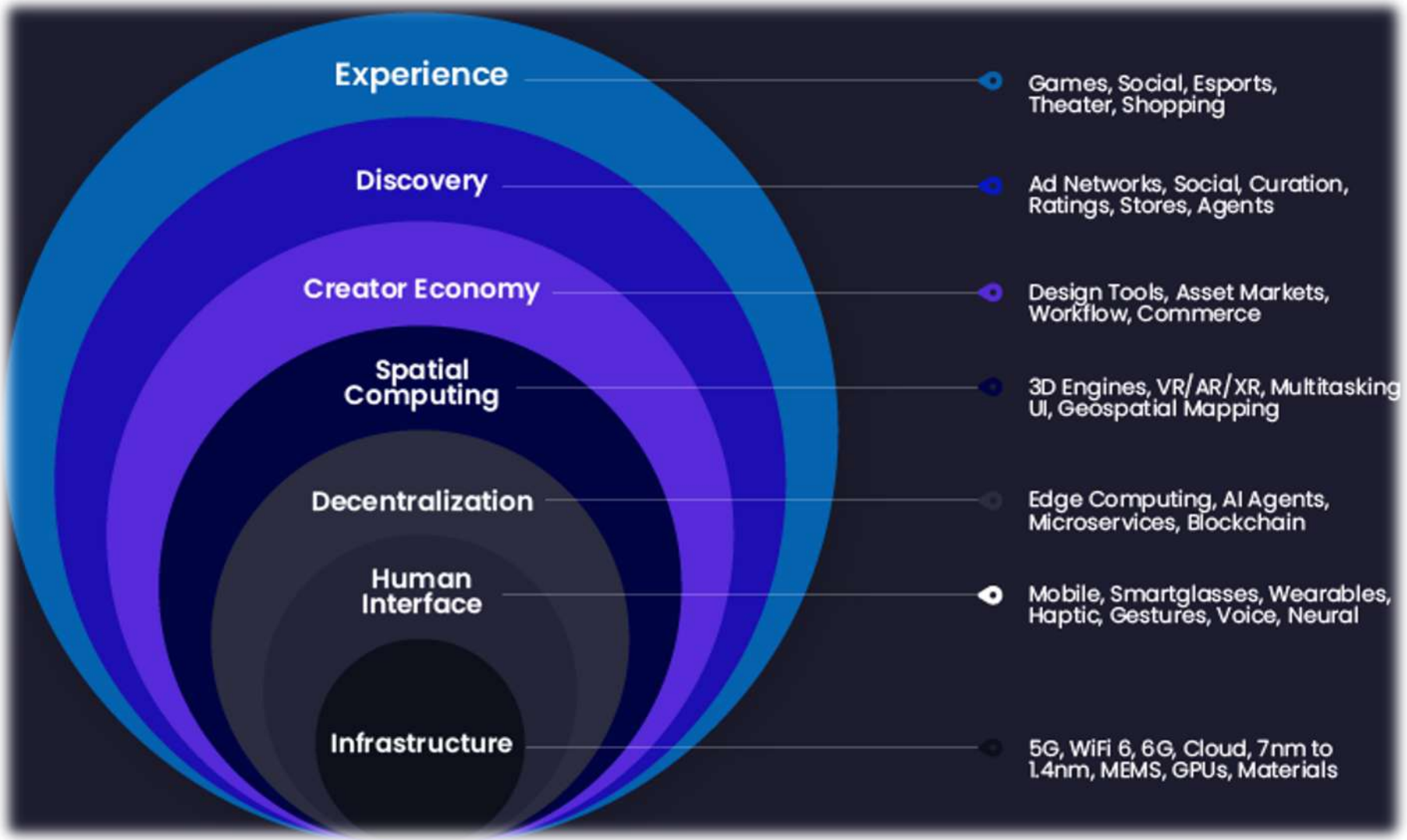
- A metaverse is a network of 3D virtual worlds focused on social connection. In futurism and science fiction, it is often described as a hypothetical iteration of the Internet as a single, universal virtual world that is facilitated by the use of virtual and augmented reality headsets.
- The term "metaverse" has its origins in the 1992 science fiction novel Snow Crash as a portmanteau of "meta" and "universe." Various metaverses have been developed for popular use such as virtual world platforms like Second Life. Some metaverse iterations involve integration between virtual and physical spaces and virtual economies, often including a significant interest in advancing virtual reality technology.
- The term has seen considerable use as a buzzword for public relations purposes to exaggerate development progress for various related technologies and projects. Information privacy, user addiction, and user safety are some of the concerns within metaverses, stemming from challenges facing the social media and video game industries as a whole.

The metaverse can be defined as **a simulated digital environment** that uses augmented reality (AR), virtual reality (VR), and blockchain, along with concepts from social media, to create spaces for rich user interaction mimicking the real world.

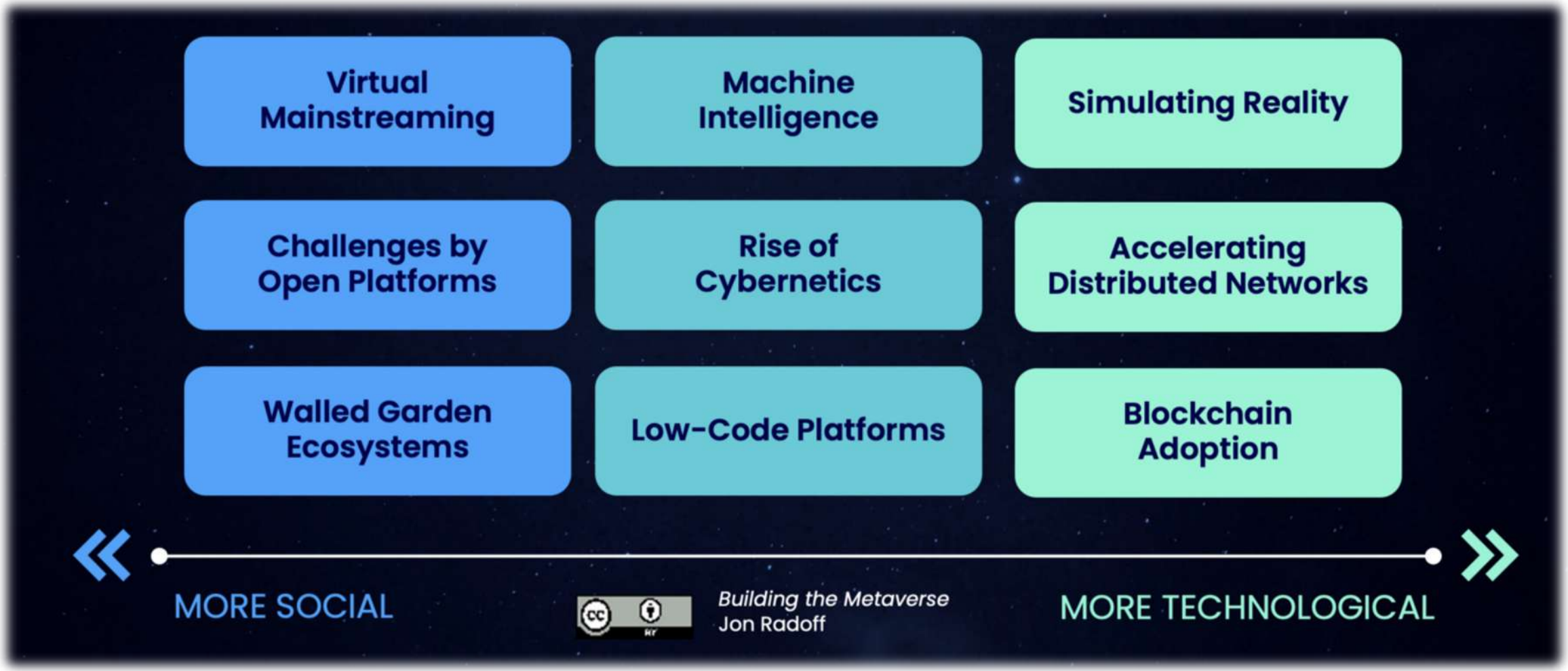
Elements of Metaverse…



Metaverse Value Chain…



9 Megatrends Shaping Metaverse…



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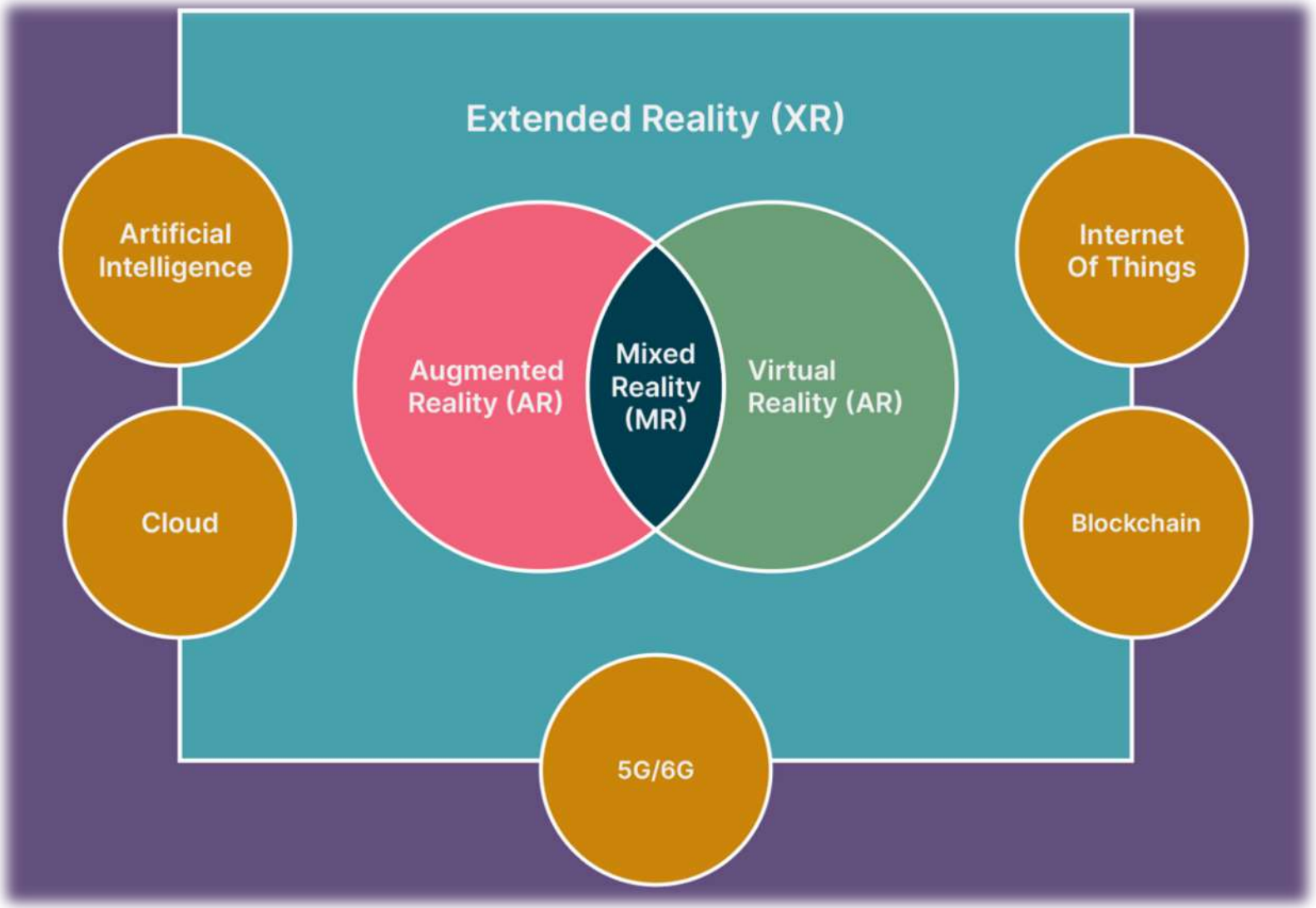
Metaverse – confluence of diverse technologies



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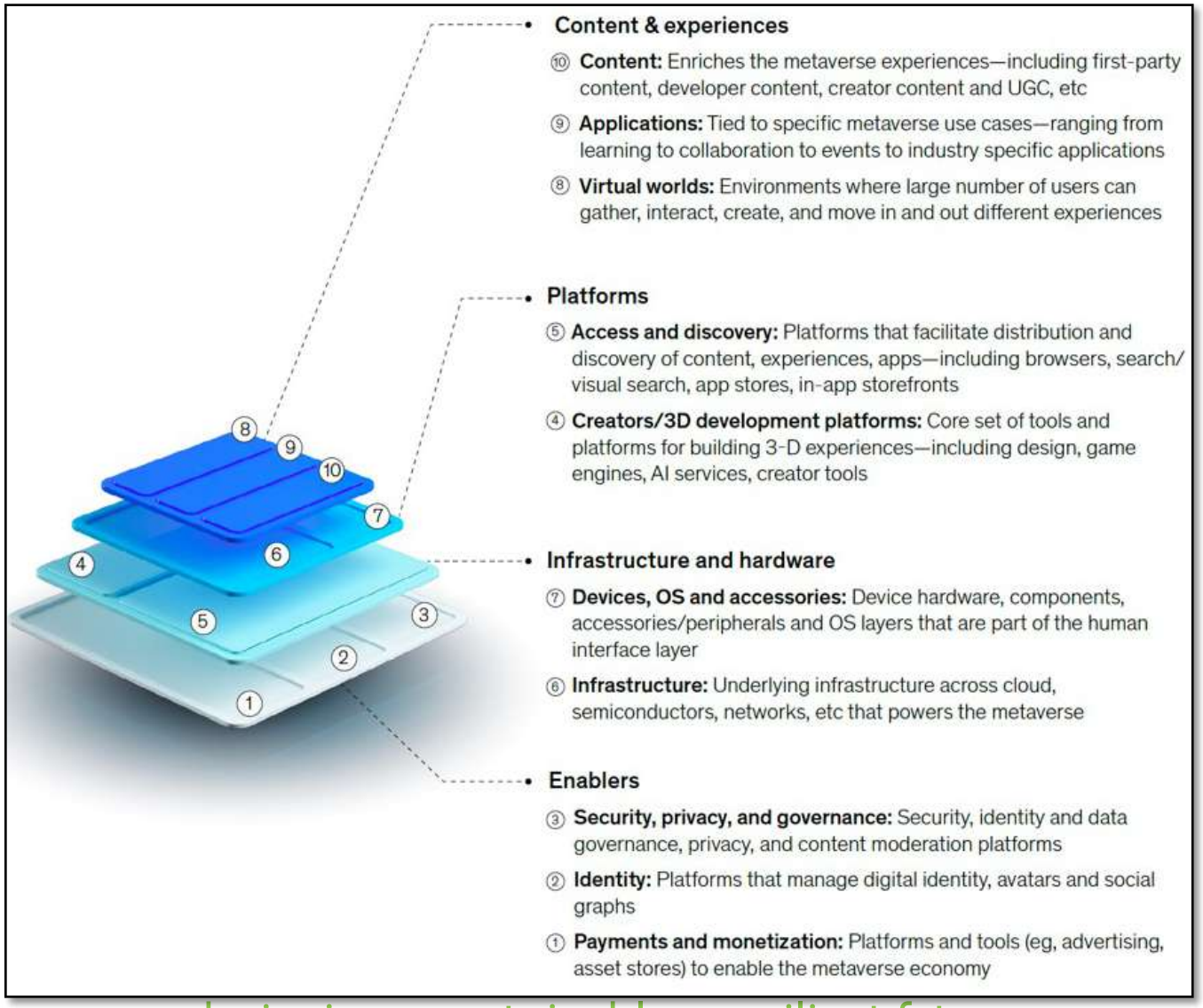
Metaverse – The Architecture…



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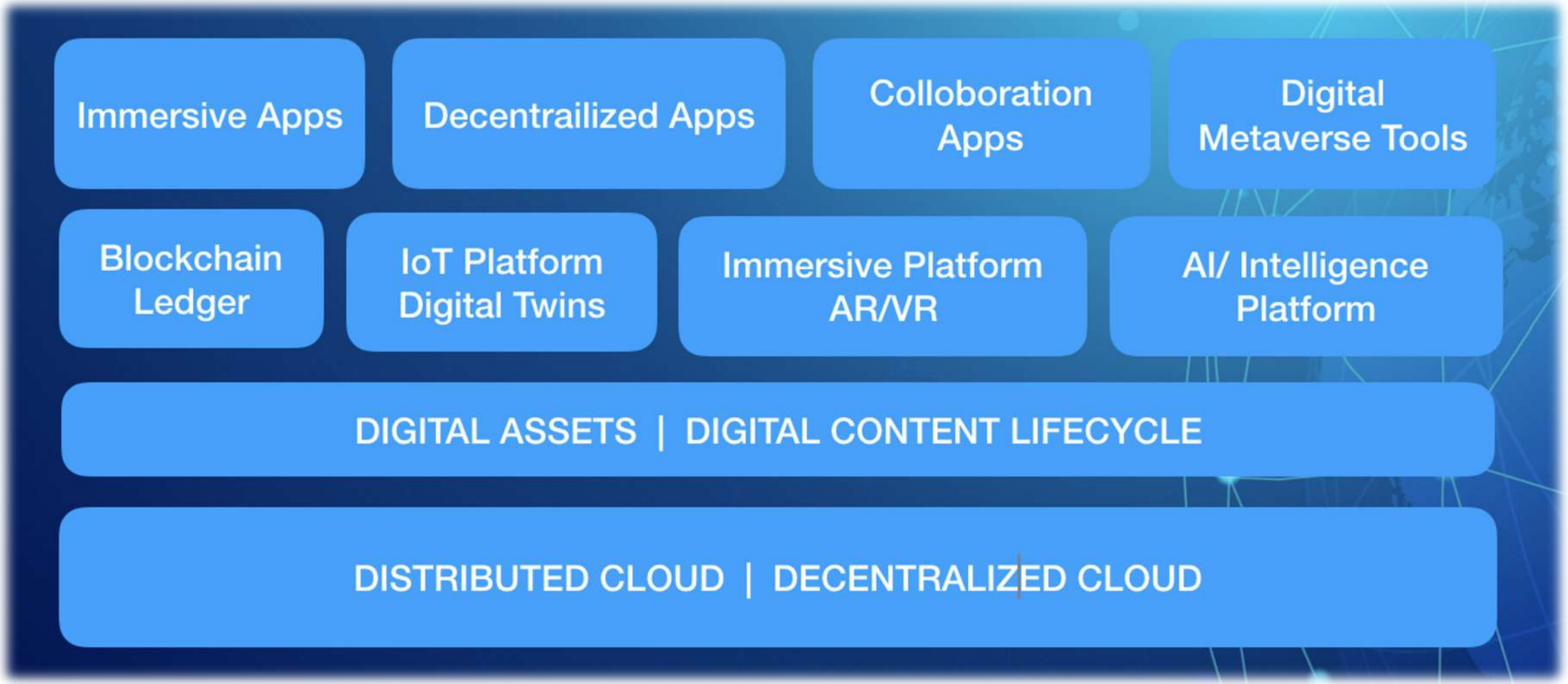
Metaverse Technical Stack…



Standards initiatives…

- **3rd Generation Partnership Project (3GPP)** has been developing and enhancing its specifications since Release 15 to meet the KPI for different versions of Extended Reality, a core technology for the Metaverse. 5G New Radio (NR) developed by 3rd Generation Partnership Project (3GPP) is designed to support emerging XR uses cases that require such Key Performance Indicators (KPI). While 5G NR benefits XR, potential enhancements for 5G and balanced KPIs require further end-to-end optimizations. Low latency, high reliability, lower power consumption and high capacity are key service requirements for the success of XR. Rel-15/Rel-16 offers a decent foundation for XR but has not been specifically designed or optimized for XR support.
- For Release 19, 3gpp SA1 approved a study on Localized Mobile Metaverse Services in Study Item Description (SID). These metaverse services would involve coordinating input perception/sensing data from different user devices (such as sensors and cameras) and coordinating output data to different devices at different destinations to support the same application.
- This study will investigate specific use cases and service requirements for 5GS support of enhanced XR-based services. XR-based services are an essential part of "Metaverse" services considered in this study, and potentially other functionality to offer shared and interactive user experience of local content and services, accessed either by users in the proximity or remotely.
- Sustainability, as the metaverse's computing infrastructure is resource intensive; this applies to multiple elements, from state-of-the-art VR—which may create about 2,000 pounds of carbon emissions over five years—to the massive amount of computing power (and energy) required to process blockchain transactions(as per a McKinsey expert); as the United Nations Environment Programme notes, policymakers may "need to adjust regulations to spur the development of future energy systems while mitigating environmental risks."

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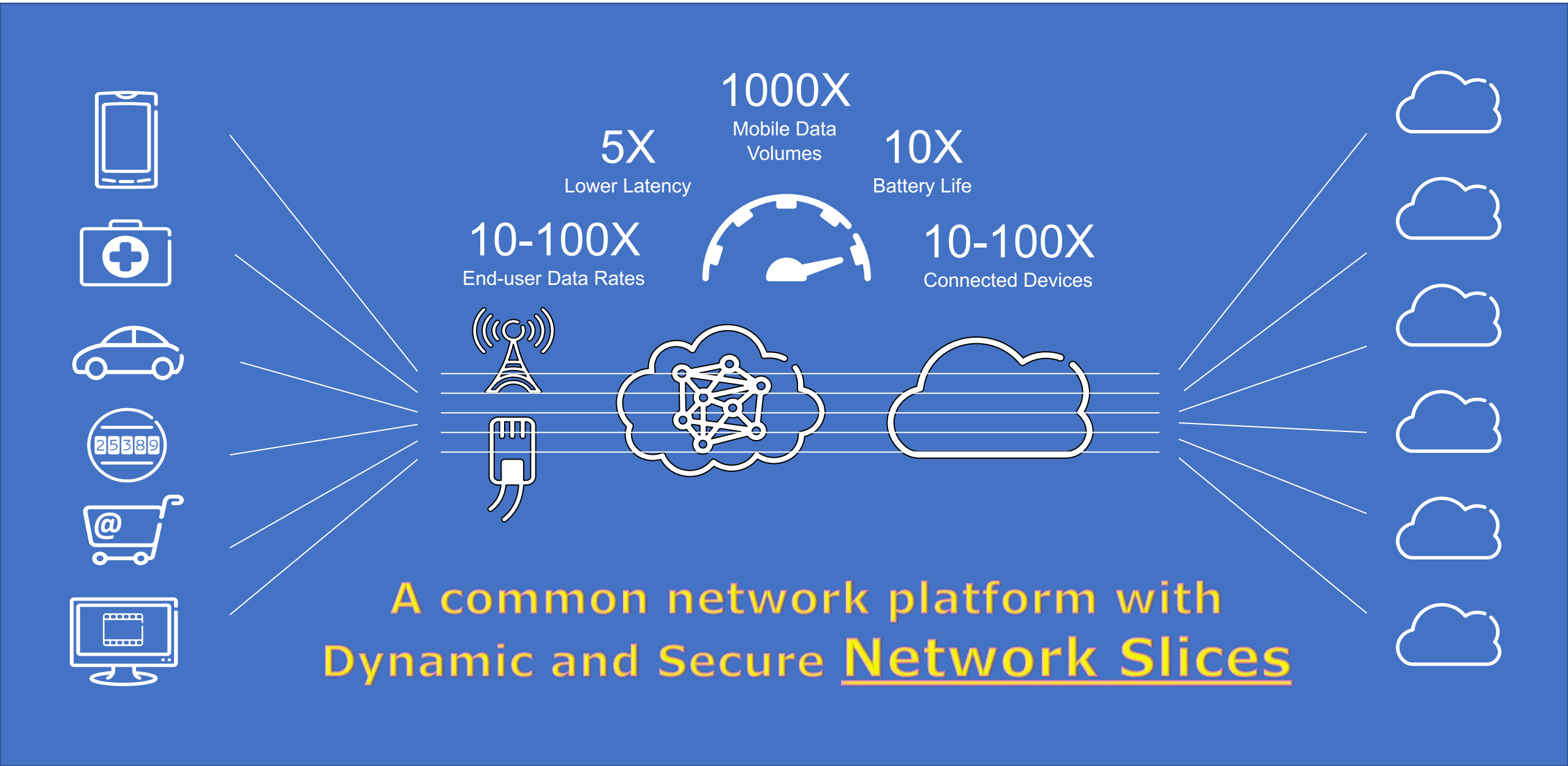
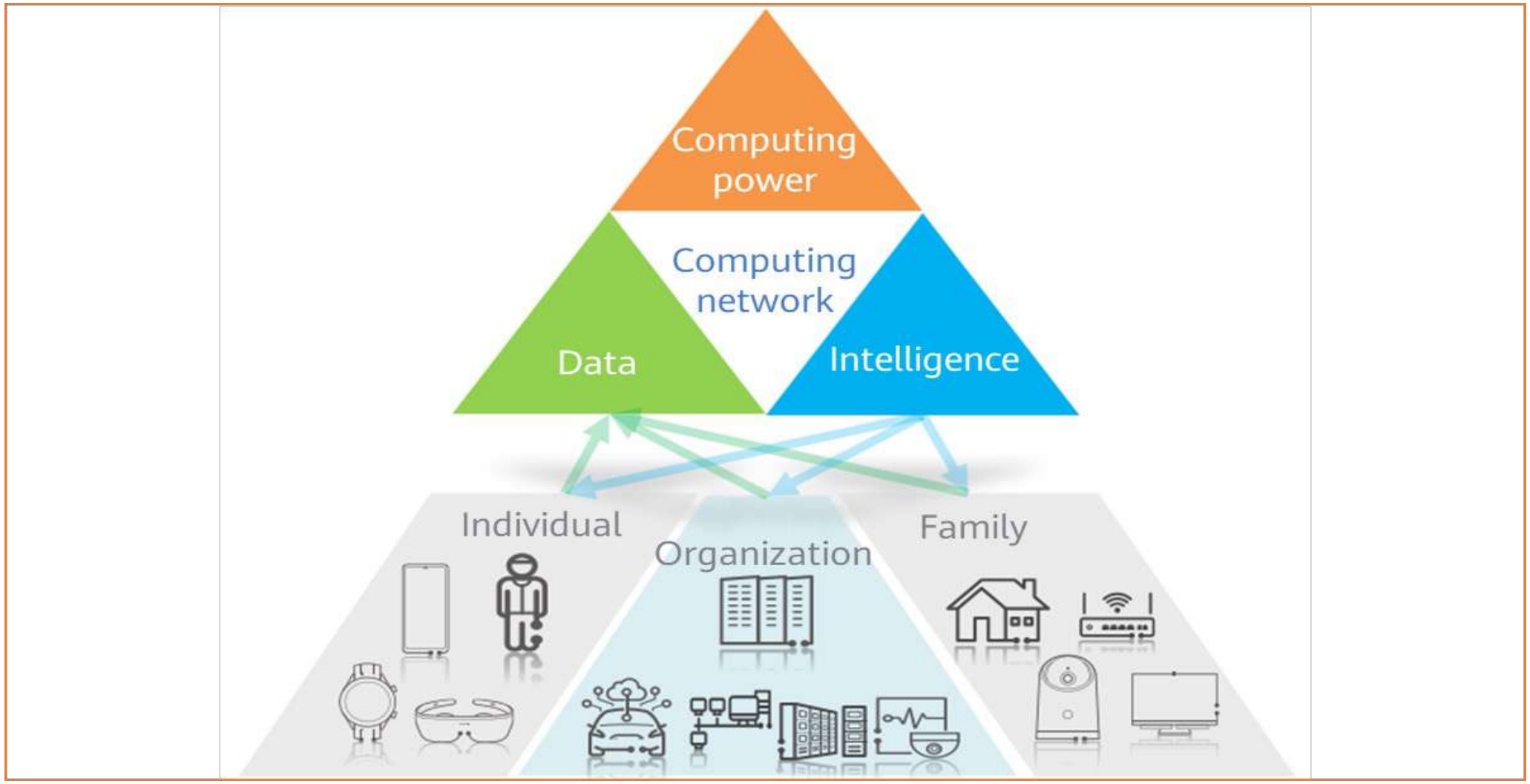
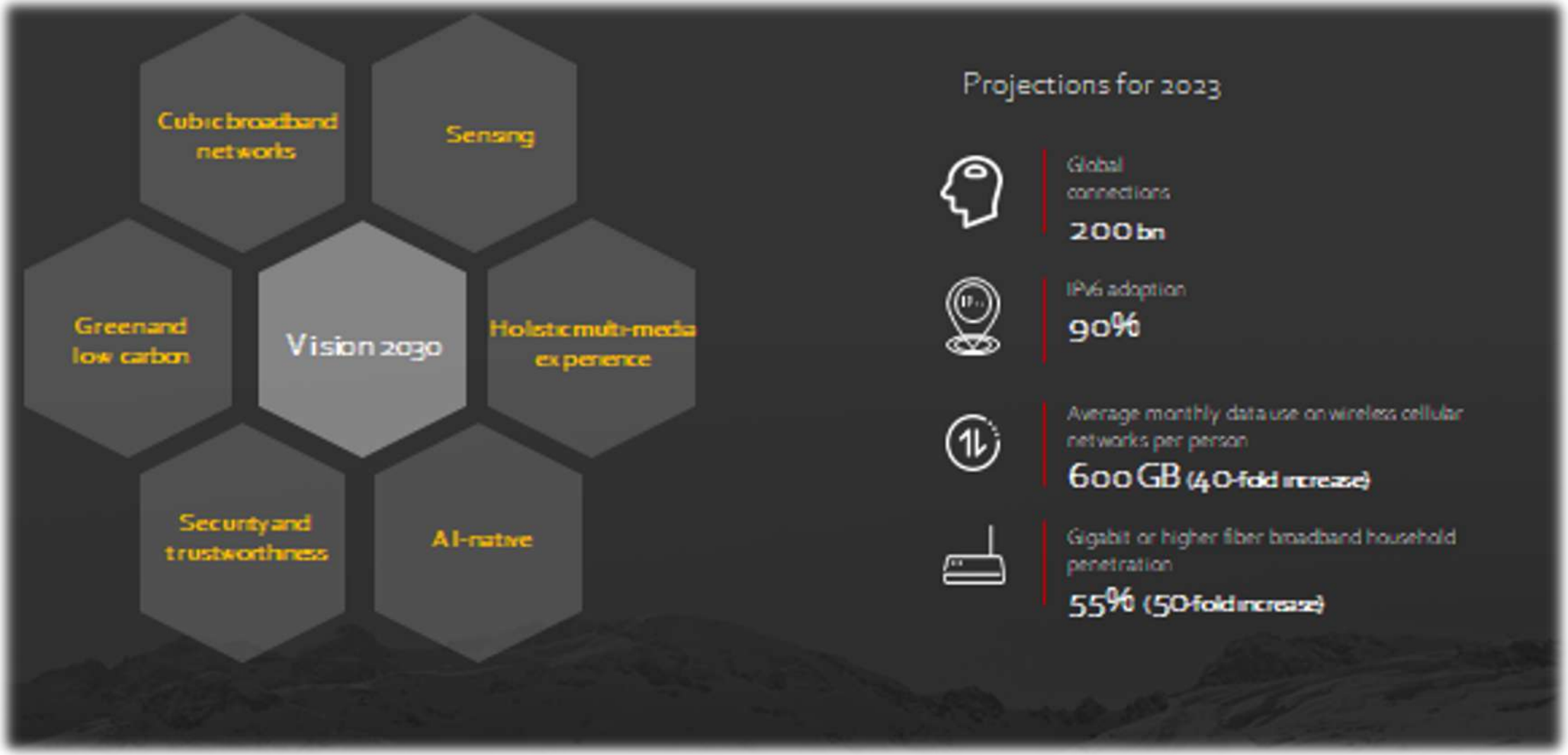
Future Architecture - One Network – Diverse Use Cases



Future Digital Infrastructure



Future Networks…



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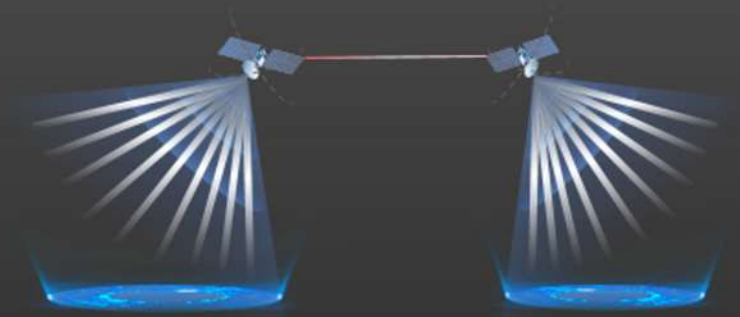
Future Networks…

Space-air-ground integrated coverage

Space-air-ground integrated networks: Seamless and continuous broadband experience



Ultra-high speed satellites 27,000 km/h	Satellite-terrestrial coverage radius > 300 km	Ultra-long distance intersatellite communication > 1,000 km
Handover based on ephemeris information/GNSS location/dual connectivity	Super beam	Laser dynamic tracking/aiming

10 gigabit access

10 gigabit connectivity for individuals, homes, and organizations

4–8K 60 FPS
~200 Mbps

64K 6D 120 FPS
~10 Gbps

2020	2025	2030
5G	5.5G	6G
F5G	F5.5G	F6G
Wi-Fi 6	Wi-Fi 7	Wi-Fi 8

Harmonized Communication & Sensing…

Wireless Sensing technology

Connected vehicles V2X

Drones Sensing beyond the line of sight

Smart factories High-precision positioning

High-speed rail Geo-fences

Integrated air interface and architecture for harmonized communication and sensing

Scenario-based super-resolution algorithm	Large bandwidth & large-scale antenna array	Crowdsensing & multi-source collaborative sensing
Centimeter-level outdoor position precision	**Millimeter-level** sensing and imaging resolution	**100M** geographic area sensing

Optical sensing


Oil and gas pipelines


Campus security


Power transmission and transformer stations


Rail transit

Optical sensing with intelligent vibration ripple analysis

Single-fiber, multi-parameter sensing	Strong blind-spot error correction algorithm	High-dimensional vibration ripple analysis algorithm
Meter-level position precision	**99.9%** effective signal acquisition rate	**99.9%** vibration identification accuracy

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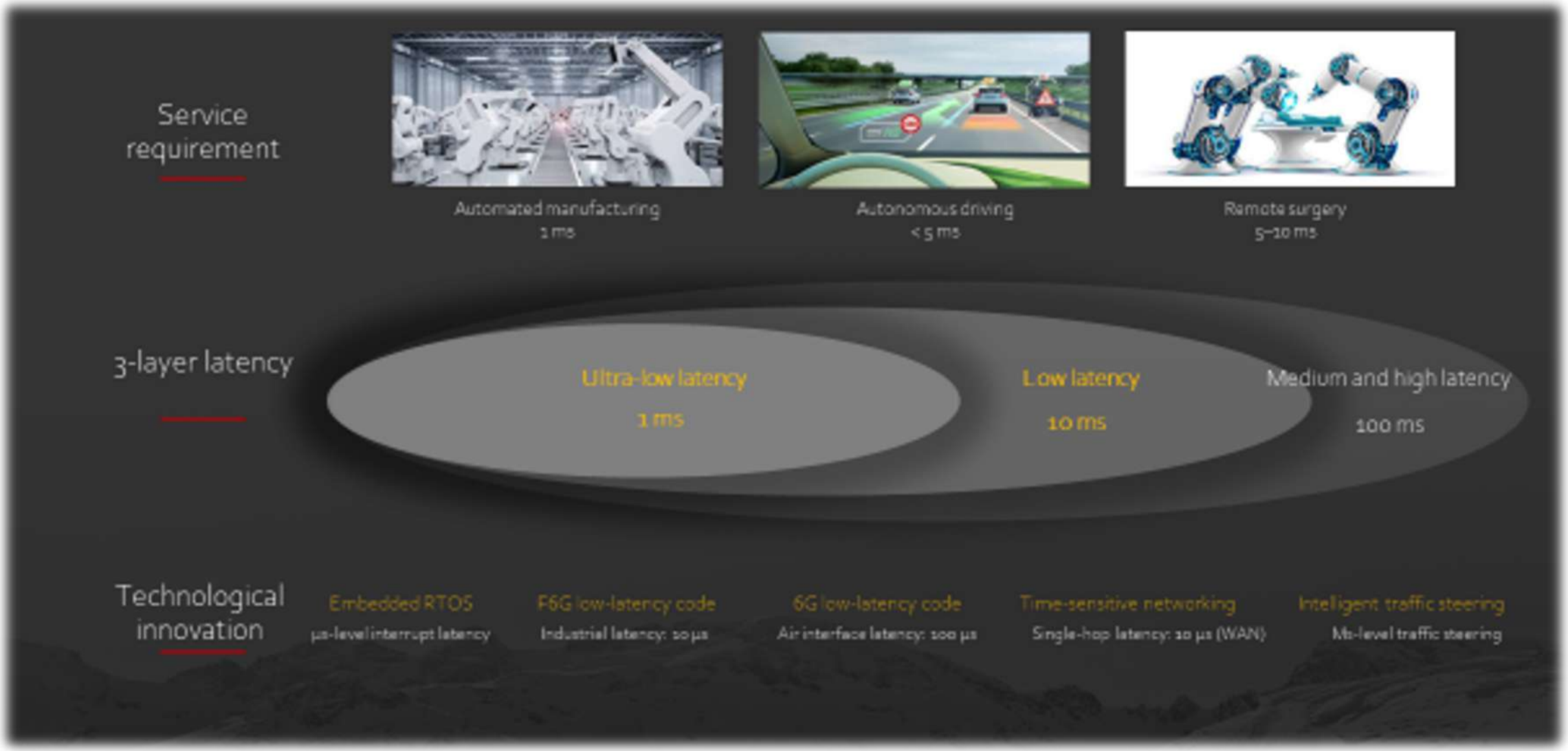
Low Latency…



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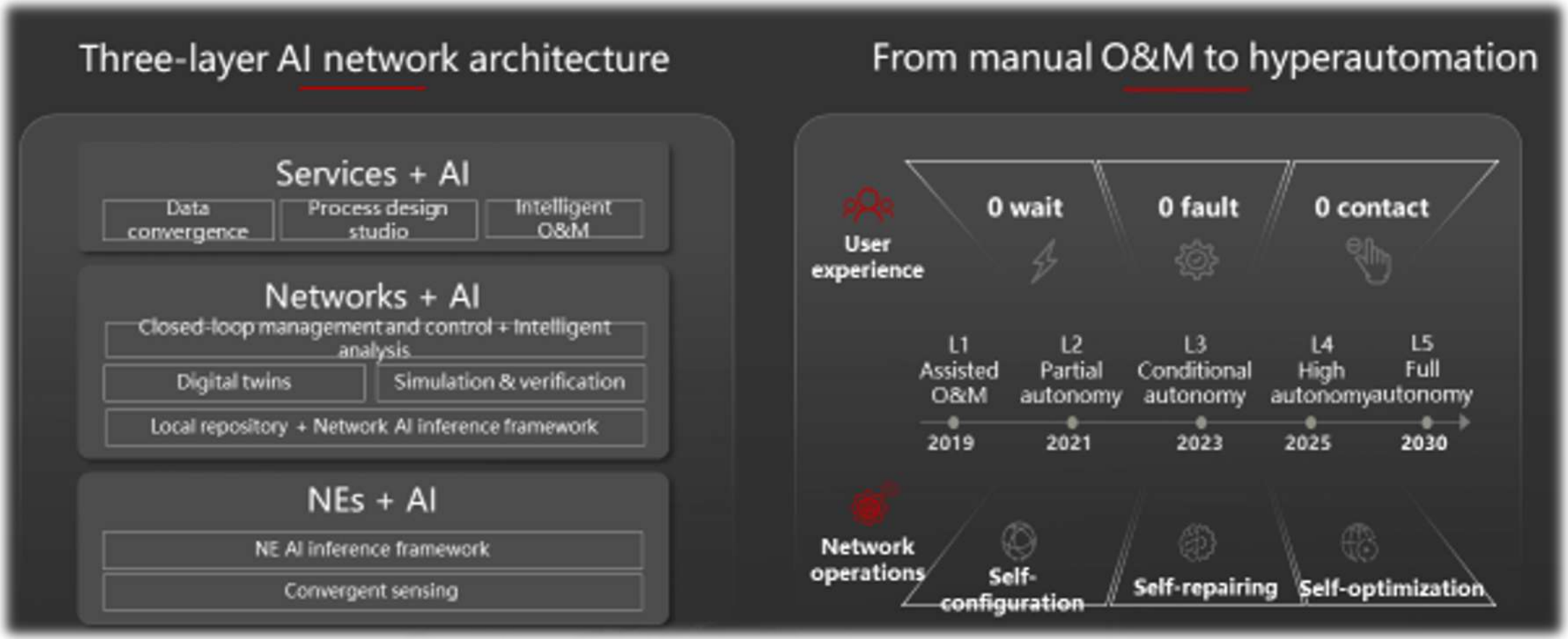
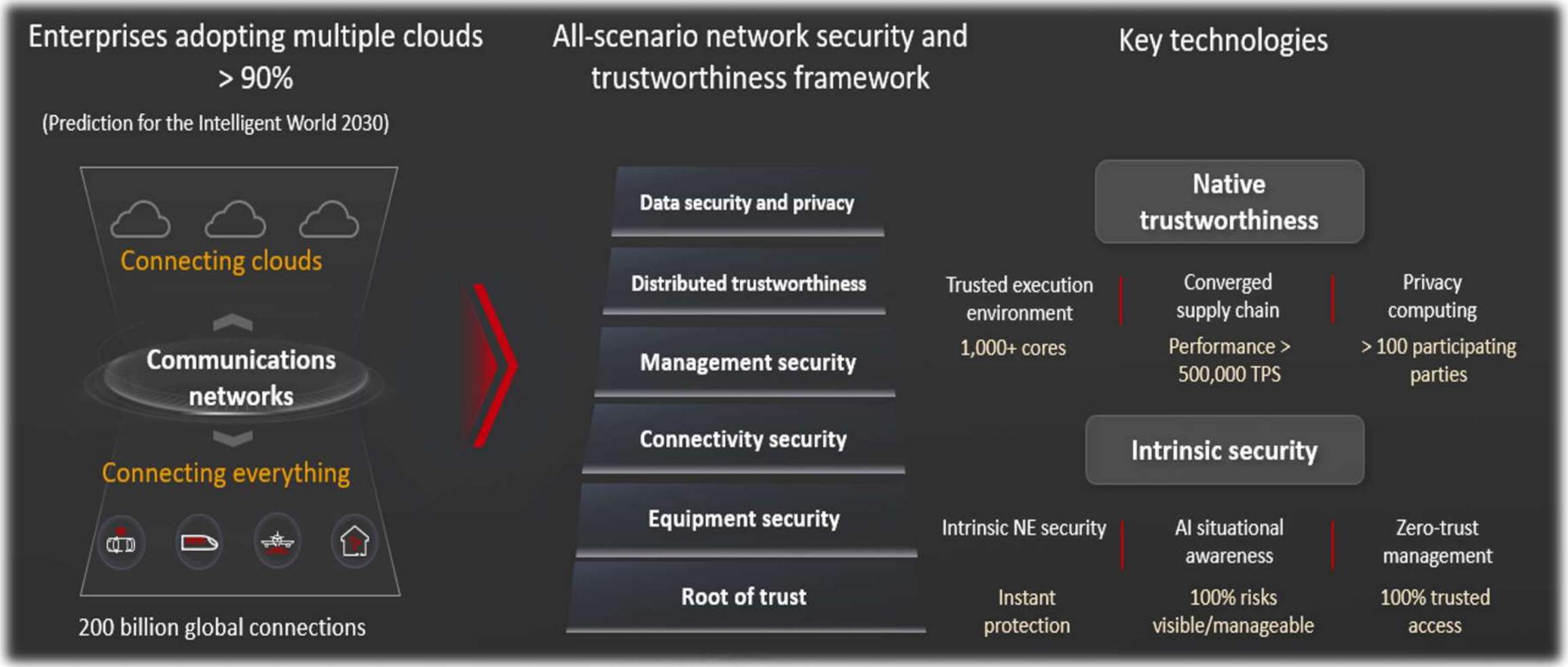
Towards Autonomous Networks…



Secure & Trustworthy Networks…



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Ethical Implications of Disruptive Technologies

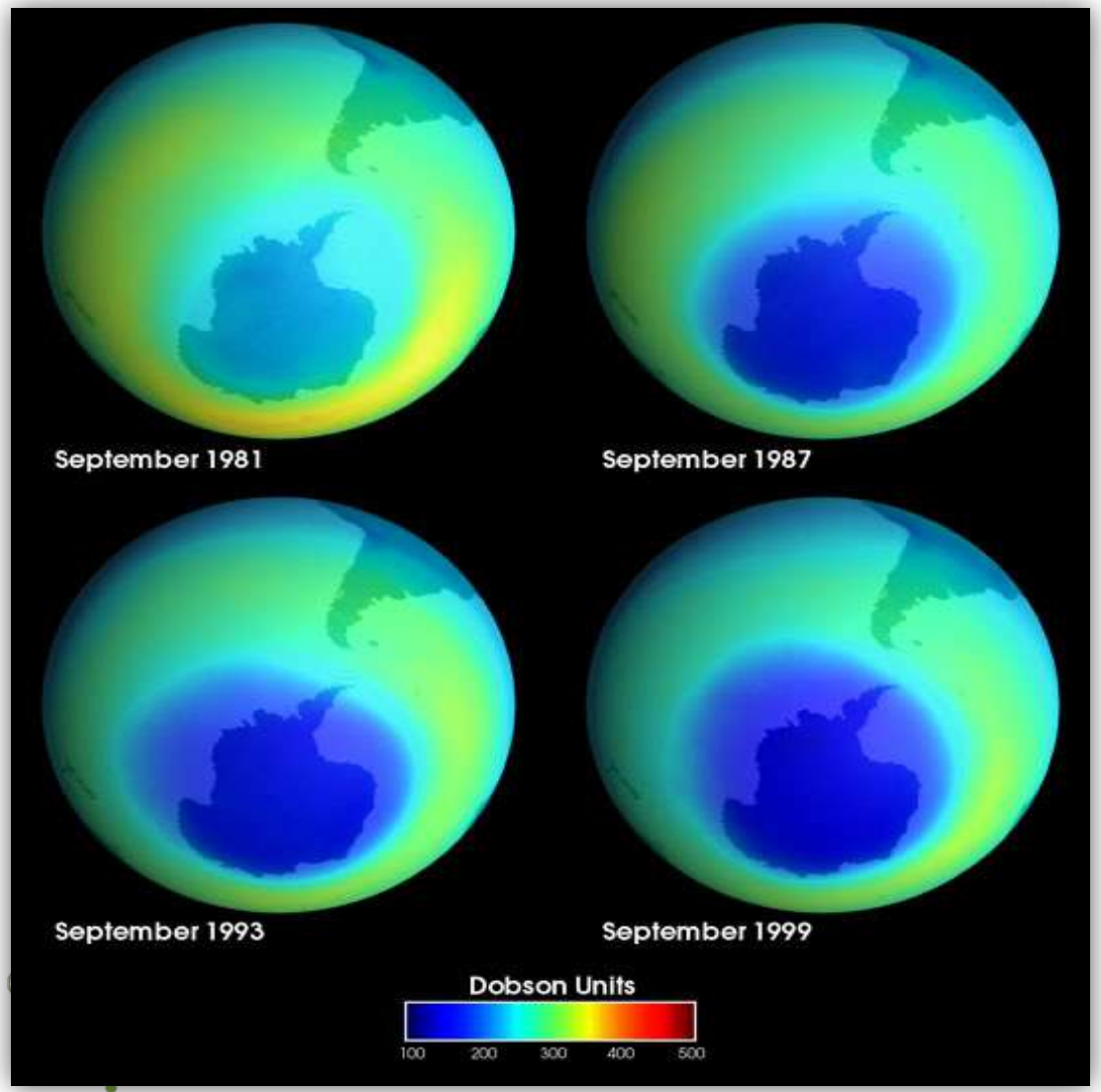
- With the ongoing development of powerful technologies and disruptive innovations such as artificial intelligence and autonomous systems (AI/AS) comes the need for greater social responsibility and accountability from the technology community.
- There is no doubt that AI is transforming how we work, play, and think in revolutionary ways. Recent developments in AI-focused areas herald its full-fledged arrival via autonomous automobiles, cognitive computing, and collaborative robotics.
- Like any disruptive innovation, AI presents a number of complex public policy challenges in terms of our moral values and ethical principles that require extensive knowledge of science and technology for effective decision-making.
- These issues span a diverse spectrum of applications including agriculture, communications, energy, the environment, health care, and transportation.
- With powerful innovations comes the need for greater social responsibility from the technology community


Ethical Imperatives
for
Disruptive Technologies
Is AI the New PLASTIC ?
designing a sustainable n resilient future

Is AI the New PLASTIC???

- How does AI work like plastic?
- It promises to be a cheaper and more effective alternative to business procedures that are commonly in place.
- But it has the potential to displace explicitly evident costs (fewer staff, more productive machinery, and procedures) into costs that are harder to perceive (massive energy costs generated at computational facilities).
- Also, will its implementation change the structure of our economy in ways that facilitate downstream burdens on the environment that are currently hindered by the limitations of our economy?

Learn from our past mistakes – History always repeats itself…



Past failures to consider environmental consequences early have been costly:

- Semiconductor Industry (Metals, Solvents)
- Synthetic Chemicals (PCB, DDT, Freon)
- Applications of Natural Compounds (Chlorine, Asbestos)
- Transportation, Energy (Air Pollution, Global Warming, Nuclear Wastes)

Six Principles of Sustainable Development

- Conservation of Ecosystem.
- Development of **Sustainable** Society.
- Conservation of Biodiversity.
- Control of Population Growth.
- Development of Human Resources.
- Promotion of Public Participation.

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Sustainability As Embedded Ethical Value

- AI is a tool for increasing sustainability. But it has innate costs too that can't just be subtracted from its savings.
- Sustainability isn't simply a technical concern – it is an ethical concern.
- Orient sustainability forward, towards protection of people

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Who is even concerned about Sustainable AI???

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2019: Measuring AI's Carbon Output

- Strubell, et al. evaluated the energy consumption required to train language skills into AI
- Energy consumption converted into carbon output estimate
- Estimates incorporated % of energy production generated renewably

Energy and Policy Considerations for Deep Learning in NLP

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Abstract

Recent progress in hardware and methodology for training neural networks has ushered in a new generation of large networks trained on abundant data. These models have obtained notable gains in accuracy across many NLP tasks. However, these accuracy improvements depend on the availability of exceptionally large computational resources that necessitate similarly substantial energy consumption. As a result these models are costly to train and develop, both financially, due to the cost of hardware and electricity or cloud compute time, and environmentally, due to the carbon footprint required to fuel modern tensor processing hardware. In this paper we bring

Consumption	CO_2e (lbs)
Air travel, 1 passenger, NY↔SF	1984
Human life, avg, 1 year	11,023
American life, avg, 1 year	36,156
Car, avg incl. fuel, 1 lifetime	126,000
Training one model (GPU)	
NLP pipeline (parsing, SRL)	39
w/ tuning & experimentation	78,468
Transformer (big)	192
w/ neural architecture search	626,155

Table 1: Estimated CO_2 emissions from training common NLP models, compared to familiar consumption.[1]

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“Green AI” vs “Red AI” = Efficiency vs Accuracy

- “Towards the Systematic Reporting of the Energy and Carbon Footprints of Machine Learning” by Henderson, et al. February 2020
- “Green AI” by Schwartz et al. December 2020
- “On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?” by Bender et al., March 2021
- Google Rejected “Stochastic Parrots” Findings, Fired Co-Author Timnit Gebru, Controversy Ensued

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Industry Pushback on Factual Claims

- "Carbon Emissions and Large Neural Network Training," Patterson et al., April 2021
- Considered "Google's Rebuttal" to "Stochastic Parrots"
- Endorses the principle of measuring energy consumption and carbon emissions
  - Contends Earlier Papers Misjudged Compute Cost
  - Contends Earlier Papers Misjudged Power Sources
  - Contends Earlier Papers Misjudged Hardware Used
- Fundamental Dispute Centers Around the Scale of Measurement and Analysis – Big Picture for Net Carbon Emission, Small Picture for Carbon Operations
- Which Metrics Are Needed to Guide Policy Decisions Across Levels? Which Metrics Confound Clear Analysis at Scale?

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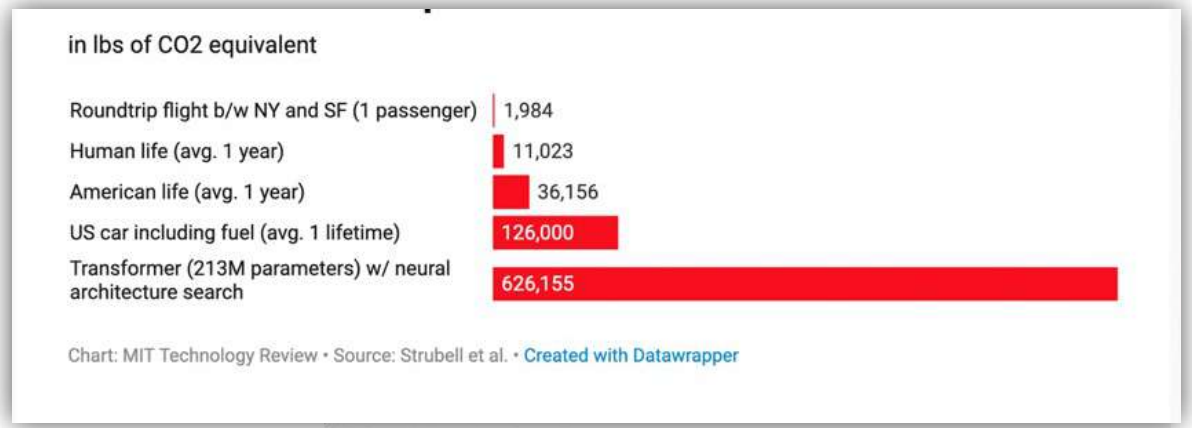
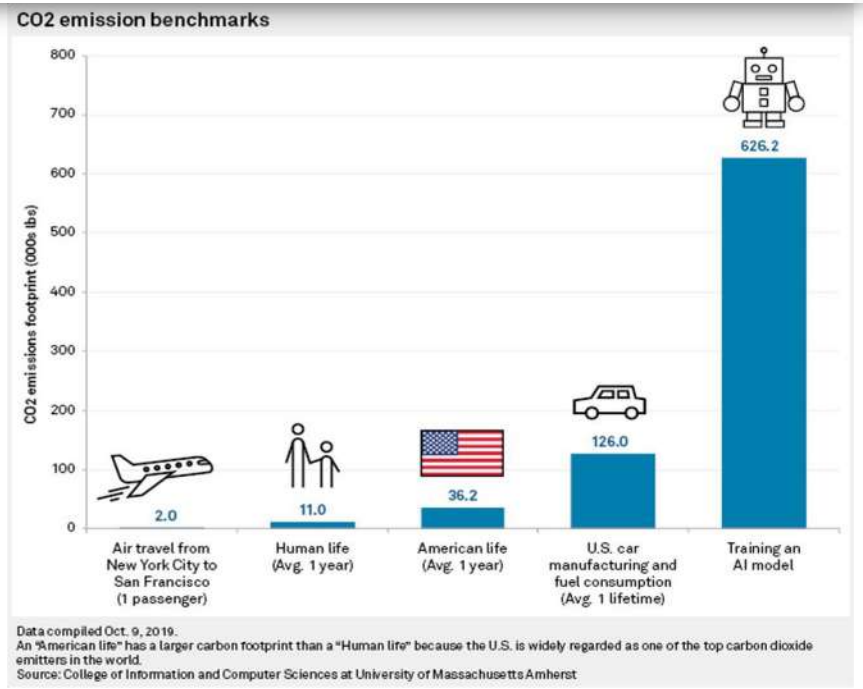
Why is this even a question?

Concerns relate to autonomous/intelligent systems standardization and ethics.

- **A/I:** A/I systems present unique circumstances relative to existing computational systems (300,000x computational cost increase of NLP models rising many times faster than Moore's Law rise of computational power)
- **Standards:** There is no common standard for evaluating the environmental cost of AI systems, but a diverse range of methods have been suggested
- **Ethics:** Environmental costs create a distribution of harms and benefits that have ethical implications. How those costs are measured can render some harms invisible or create misleading senses of scale for others. Measurement itself has an ethical dimension.

Resource and Energy Intensities of AI: Common Carbon Footprint Benchmarks





In practice, models are usually trained many times during research and development.

Estimated cost of Training a Model once

	Date of original paper	Energy consumption (kWh)	Carbon footprint (lbs of CO2e)	Cloud compu cost (L
Transformer (65M parameters)	Jun, 2017	27	26	$41-$1
Transformer (213M parameters)	Jun, 2017	201	192	$289-$
ELMo	Feb, 2018	275	262	$433-$1,472
BERT (110M parameters)	Oct, 2018	1,507	1,438	$3,751 $12,57
Transformer (213M parameters) w/ neural architecture search	Jan, 2019	656,347	626,155	$942,9 $3,201
GPT-2	Feb, 2019	-	-	$12,90 $43,00

Note: Because of a lack of power draw data on GPT-2's training hardware, the researchers weren't able to calculate its carbon footprint.

Table: MIT Technology Review • Source: Strubell et al. • Created with Datawrapper

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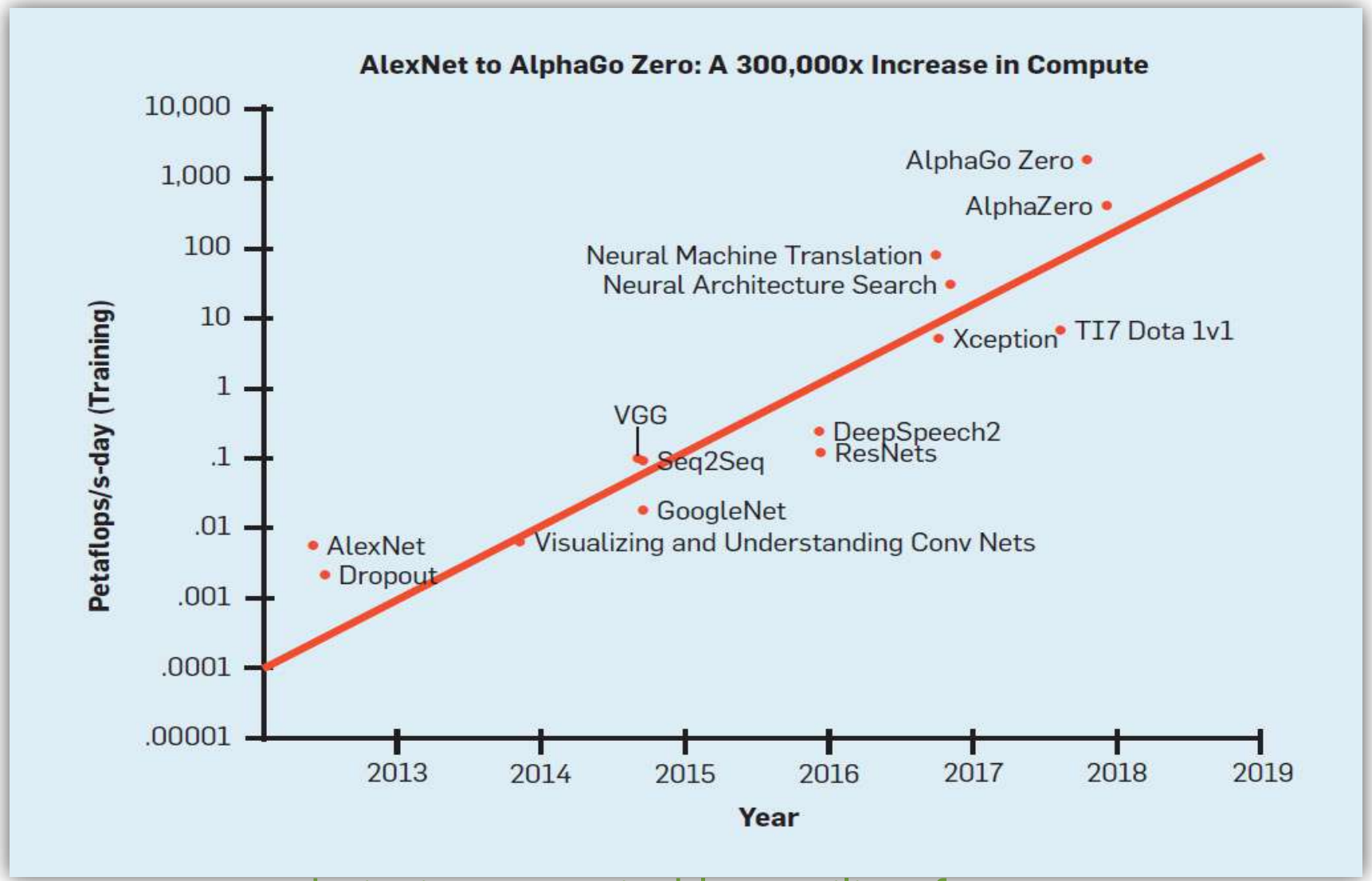
The amount of compute used to train deep learning models has increased 300,000x in six years.



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AI for Sustainability? Or Sustainable AI?

- AI as a BIG Hype, is a reality that scientists who worked on it for last four decades never ever thought of or envisaged..
- It is terrifying, scary n chilling…
- It is like riding the Tiger… shall we ever be able to get off safely? Or Tame the Tiger?
- To top it all, AI is NOW being leveraged to bring sustainability in different aspects… forgetting the Carbon Footprint it adds to anything when you apply AI to any Product, System or Solution…

Is it NOT a DICHOTOMY???

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Riding the AI Tiger…

Is it NOT a DICHOTOMY?

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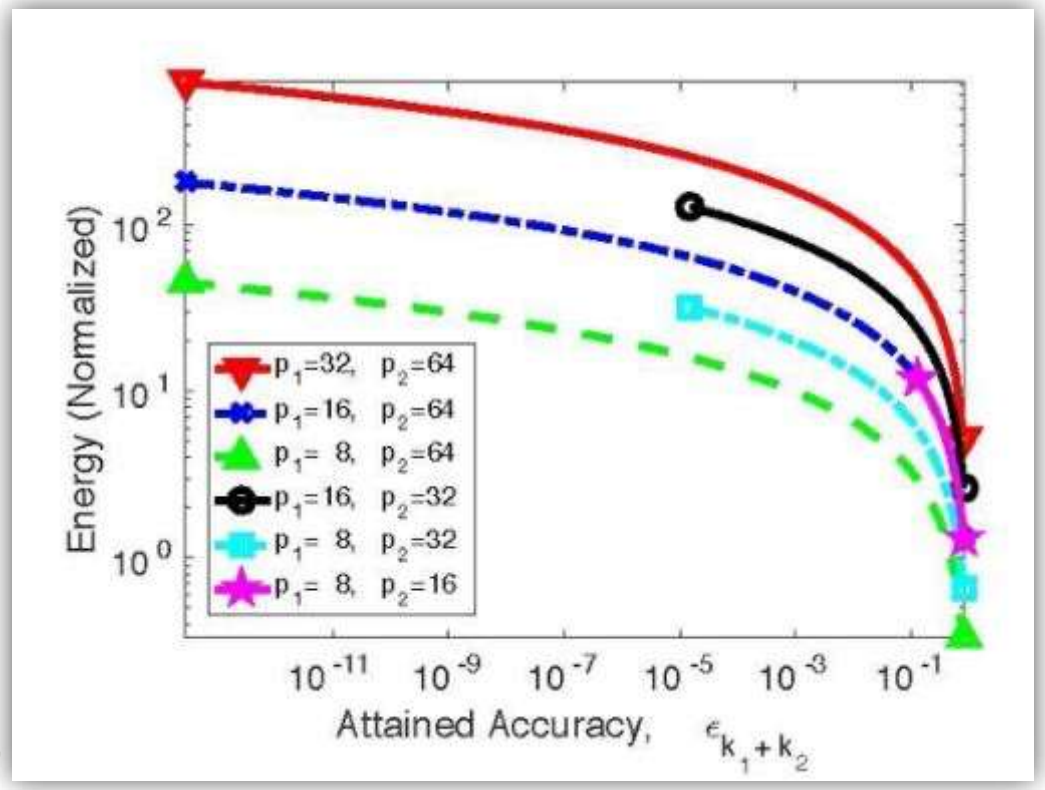
Who is even aware about Green AI???

- Some projects have poured large amounts of computation into tuning hyperparameters or searching over neural architectures, well beyond the reach of most researchers.
- Creating efficiency in AI research will decrease its carbon footprint and increase its inclusivity as deep learning study should not require the deepest pockets.
- The term Green AI refers to AI research that yields novel results while considering the computational cost, encouraging a reduction in resources spent. Whereas Red AI has resulted in rapidly escalating computational (and thus car-bon) costs, Green AI promotes approach-es that have favourable performance/efficiency trade-offs.

“Green AI” vs “Red AI” = Efficiency vs Accuracy

Inexact Computing…



- "The discipline of inexact computing centres on saving energy wherever possible by paying only for the accuracy that is required in a given situation."
- Accuracy and energy are exchangeable in computation and sacrificing minimal accuracy can yield tremendous energy savings.
- Computer scientists improve the quality of supercomputing answers 1,000x by using a method of 'inexact computing.' Sacrificing minimal accuracy can yield tremendous energy savings.

Palem, Krishna V. "Inexactness and a future of computing." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 372, no. 2018 (2014): 20130281.

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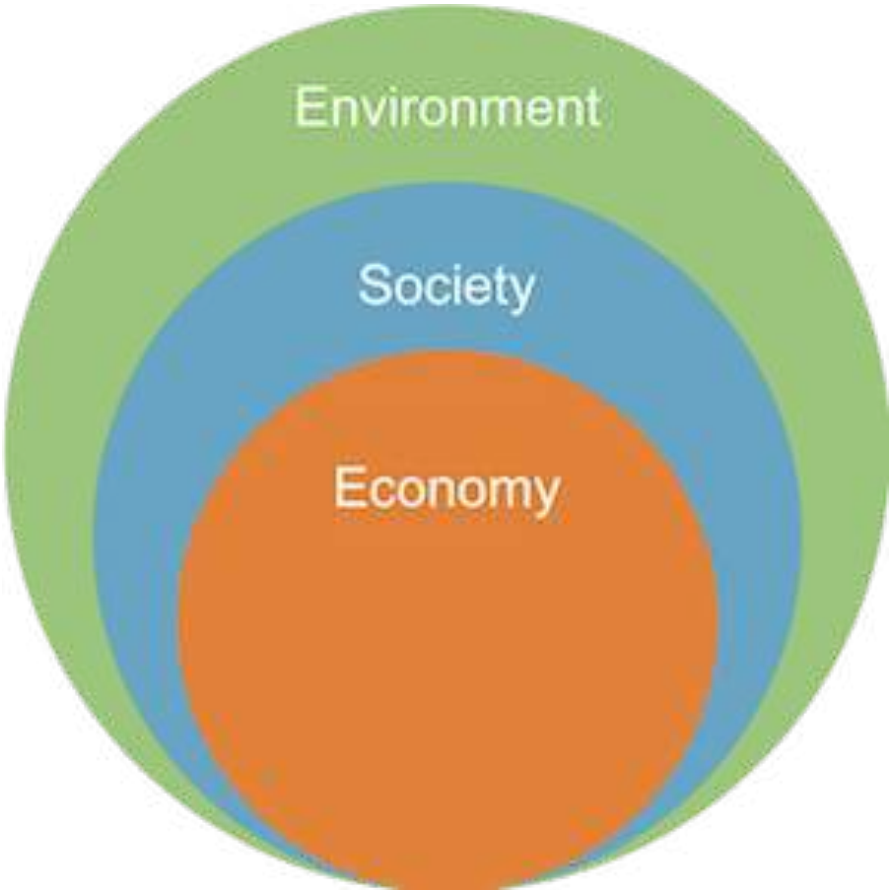
An Eco-centric Approach to Sustainability

Changing the Way, We Look at the Environment

3 Overlapping Circles Model

3 Nested Dependencies Model



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The 3 Nested Dependencies Model

- There are three key differences between the 3 Nested Dependencies Model and the 3 Overlapping Circles Model.
- In the 3 Nested Dependencies Model the three sectors are co-dependent: while the 3 Overlapping Circles imply the economy can exist without the environment, the 3 Nested Dependencies recognise the economy is a wholly-owned subsidiary of the society which in turn is a wholly-owned subsidiary of the environment. They not only co-exist but interact.
- The 3 Nested Dependencies Model reminds us that there is no planet B: Without the environment, the society and the economy cannot exist. The 3 Nested Dependencies remind us that we must live within our means or face the very real threat of ecological (and subsequently societal and economic) collapse.

In short, the 3 Nested Dependencies approach is eco-centric. In other words, it acknowledges the inherent value of the environment and prioritises the health of our planet over economic gains. Rather than the three sectors competing with each other, as might be the case in the 3 Overlapping Circles model, the 3 Nested Dependencies remind us that without clean water, fresh air and healthy ecosystems the society and the economy cease to function.

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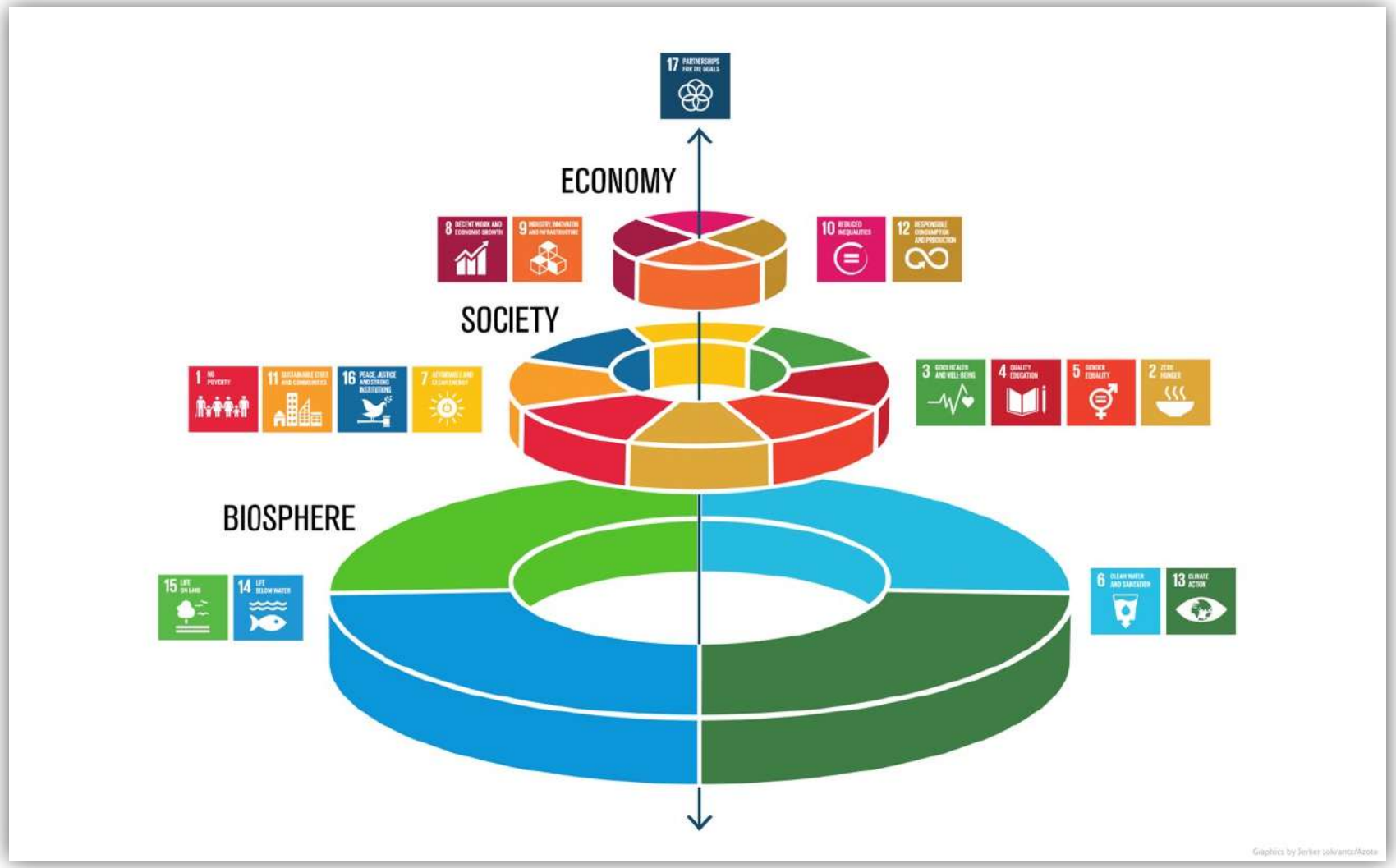
Attaining the SDGs within the planetary boundaries



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Attaining the SDGs within the planetary boundaries

- By being ‘integrated and indivisible’, the SDGs balance the three dimensions of sustainable development – economic, social, and environmental. Importantly, this implies that human economies and societies are embedded parts of the Biosphere. As such, the Biosphere provides the life support systems upon which prosperity and development ultimately rest. The economy is a subsystem of society - and, in turn, a subsystem of the Biosphere - that should serve humanity to thrive within the means of the Biosphere.

- As it turns out, recognizing the inherent value of the environment and our co-dependency with such can help us make better choices. Changing our perspective is a small but important step towards achieving positive environmental outcomes.

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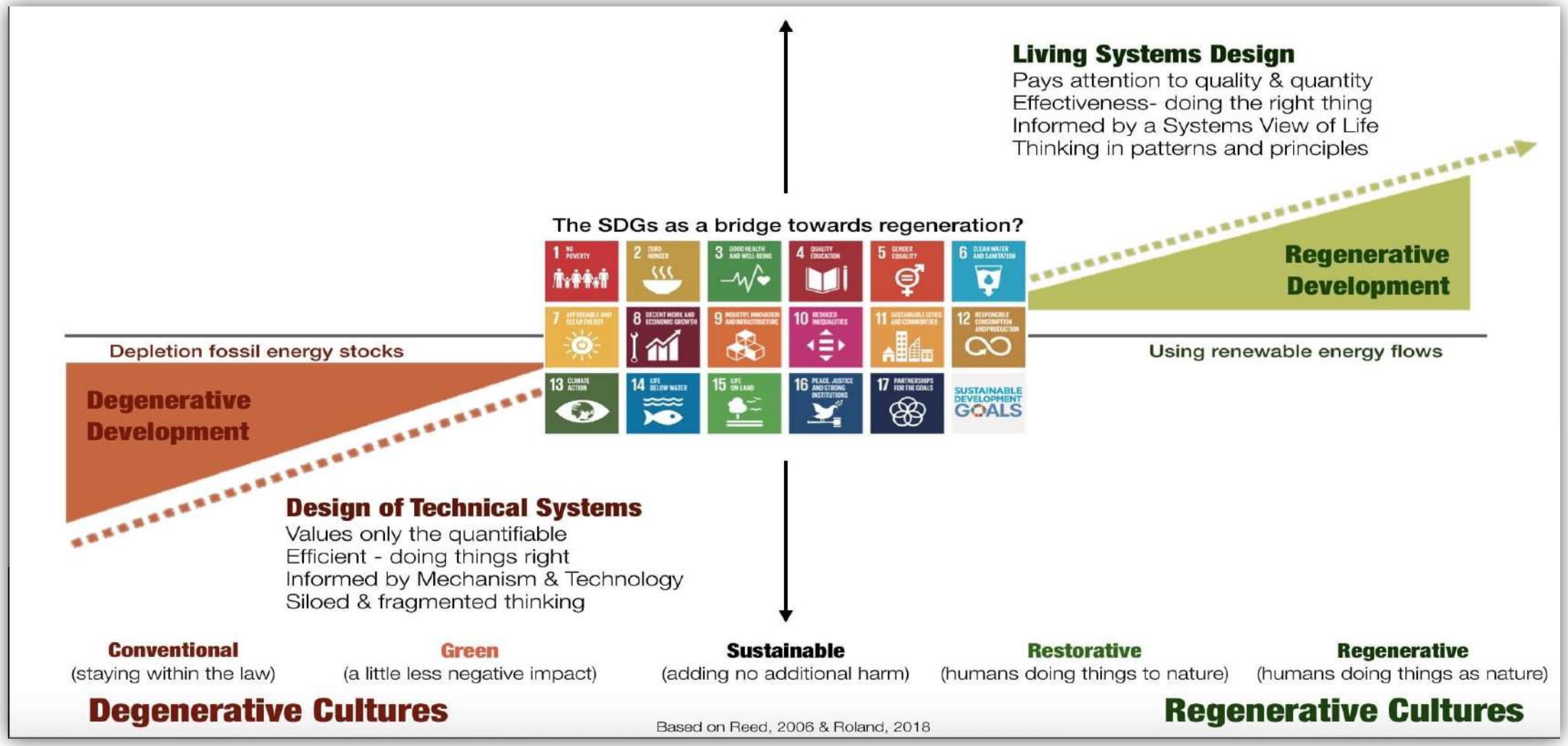
Beyond Sustainability:
Designing Regenerative Cultures



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CIRCULAR AI: RE-IMAGINING THE ARTIFICIAL INTELLIGENCE

- We need to explore a fresh approach by attempting to apply the principles of Circular Economy in leveraging AI and try to envision - what does a successfully circular AI look like, and how can this model unlock transformational economic, social, and sustainable change?
- Circular Economy is about Transformation: The circular economy is not just about recycling – it is about a transformation of the entire value creation system by decoupling growth from finite resources. Transitioning to a circular economy is about much more than just reducing the waste inherent in the linear economy. It's about sustainable growth that creates economic opportunities, environmental and social benefits and increases business resilience. This transition requires a systemic shift that closes, optimizes and values resource loops across the value chain which makes collaboration across organizations pivotal.
- Circular AI holds the key for transformational change and a paradigm shift in how we look at AI, unlocking a new economic model that will transition away from unnecessary compute and energy, provide a reliable platform for AI to become an efficient and sustainable resource and advance more equitable, inclusive value chains for our communities. Let's lead the charge towards a more sustainable, equitable and circular AI.

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Circularity & Sustainability Interplay…

- The practice of **circularity** is focused on and grounded in the technosphere - a human construct designed to support the conversion of raw materials for human consumption beyond simple survival needs of food and water. The intentional design of a system is what separates **circularity** from **sustainability**.

What is the difference between circularity and sustainability?

- **Circularity** focuses on resource cycles, while **sustainability** is more broadly related to people, the planet and the economy. **Circularity and sustainability** stand **in a** long tradition of related visions, models and theories.
- A **sustainable circular economy** involves designing and promoting products that last and that can be reused, repaired and remanufactured. ... This retains the functional value of products, rather than just recovering the energy or materials they contain and continuously making products anew.

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How does circular economy contribute to sustainability?

- The first advantage of a **circular economy** is the protection of the environment, reducing waste and the emissions of greenhouse gases, systematizing **recycling**, and ending planned obsolescence. The **circular economy** also allows to decrease the dependence on importation of resources (raw materials, water, energy).

- The **circular economy** represents an excellent opportunity for **economic development**. It contributes to the creation of new and more **sustainable** jobs, as well as it reduces dependence on non-renewable resources and the production of negative externalities. However, a commitment from the whole society is urgently needed.

5G & the Environment: Concerns & Challenges

- 5G Technologies being truly high-performance communication technologies have drawn attention to some major concerns of their adverse impact on the Environment and the mankind.
- The impact of Radiation is well known and acknowledged, however, what is conspicuous by its absence in the discussions is - the growing carbon footprint of 5G Networks & Infrastructure.
- All the high-performance aspects need very high amount of compute at Core, as well as the Edge.
- Also, to make the 5G Infrastructure & Networks Autonomous, AI & ML is being used extensively.

Blockchain & Bitcoin…

- Carbon emission of *Bitcoin* mining and *Blockchain* operations are being estimated using the system dynamics (SD) based model which is widely used for carbon emission flow estimation of a specific area or industry.
- It was found that the annualized energy consumption of the *Bitcoin* industry in China will peak in 2024 at 296.59 TWh based on the *Benchmark* simulation of BBCE modeling.
- This exceeds the total energy consumption level of Italy and Saudi Arabia and ranked 12th among all countries in 2016. Correspondingly, the carbon emission flows of the Bitcoin operation would peak at 130.50 million metric tons per year in 2024."
- "It is estimated that between the period of January 1st, 2016, and June 30th, 2018, up to 13 million metric tons of CO_2 emissions can be attributed to the Bitcoin blockchain."

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Will the internet of things sacrifice or save the environment?

- The internet of things (IoT) – that ever-expanding ecosystem of digital sensors, home appliances and wearable smart devices – attracts its fair share of attention. Speculation is rife on how the 25 bn-odd (and counting) "things" will improve quality of life, streamline business operations and ultimately fuel economic benefits to the tune of up to $11tn per year by 2025.
- Less often considered is the cost to the environment of such a vast network of devices. With the full extent of the IoT far from being realized, even experts are divided on whether it will spell doom or salvation for the environment. One thing that experts can agree on is that we shouldn't wait around to find out.

Drops+++ can make an Ocean…

- The problem of energy consumption will be a pernicious one. “These technologies on a device-by-device basis, or even a house-by-house basis, are not a significant additional contribution to overall power consumption”. However, multiply that across any country though and “that’s going to boil down to another power station or another two power stations”.

- **Internet of Things (IoT) and Artificial intelligence (AI) technologies can help us fight climate change – but they also come at a cost to the planet. To truly benefit from the technology’s climate solutions, we also need a better understanding of IoT’s & AI’s growing carbon footprint. IoT & AI need to be developed and deployed so it can meet society’s needs and protect the environment by saving more energy than it expends.**

Green ICT…

- Green ICT is **about reducing the impact of ICT on the environment**. It is about reducing the energy use of computers, servers and data centres. You might even consider the whole life cycle of ICT equipment and look at the rare material use or think about e-waste and recycling.

- Green IT (green information technology) is **the practice of environmentally sustainable computing**. Green IT aims to minimize the negative impact of IT operations on the environment by designing, manufacturing, operating and disposing of computers and computer-related products in an environmentally-friendly manner.

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How Clean is your Clean Energy?

- Solar Panels and Inefficient Production of Efficient Processes. Back in 2011 or so, one of the political controversies surrounding the national move in the US to adopt solar panel was the discovery that some solar panel systems were so environmentally costly that their production and disposal cost more than the benefits they provided during their product life cycle.
- For one thing, the infrastructure required for renewable energy generates its own emissions. For another, many renewable technologies require metals in limited supply, such as the silver needed for solar panels.

Is NET ZERO truly ZERO?

- Net-zero generally refers to balancing your corporate emissions by permanently removing the equivalent amount of carbon from the atmosphere. Technically this means one can be net-zero **without taking any action** to reduce emissions by simply purchasing carbon credits.
- The term net zero means achieving a balance between the carbon emitted into the atmosphere, and the carbon removed from it. This balance – or net zero – will happen when the amount of carbon we add to the atmosphere is no more than the amount removed.

Common Greenwashing Issues

1. **Hidden Trade Off**	Is the "green" claim restricted to just one, or a narrow set of environmental issue(s)?
2. **Vagueness**	Is the meaning of the claim specific and self-evident?
3. **Irrelevance**	Could all other products in this category make the same claim?
4. **Fibbing**	When I look into it, is the claim true?
5. **Lesser of Two Evils**	Is this claim trying to make consumers feel 'green' about a product category that is of questionable environmental benefit?
6. **No Proof**	Does this claim help me find more information and evidence?
7. **Worshipping False Labels**	Does this claim (or image) give me the wrong impression of third-party endorsement?

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What needs to be measured?

- **Run Cost:** Most AI will be deployed in cases that reduce operating costs relative to current approaches. This is the most evident benefit, and thus most tempting to calculate.
- **Production Cost:** Many A/I systems have high training/development costs that can be overlooked by focusing on run cost alone. A/I processes may have shorter lifecycles than traditional processes, requiring repeat production.
- **Expansion Cost:** Cheaper and more efficient solutions may unlock demand that is presently unmet, increasing the net burden on the environment, even as each implementation is more efficient than previous approaches.

Current scholarship is looking in three general areas

- **Financial Cost** as a proxy for environmental consumption: To the extent that money is fungible, placing a $ value on computational complexity can allow for meaningful comparisons in unlike domains. Non-economic factors can disappear from view.
- **Electric Consumption:** In current policy debates, electric consumption is most closely linked to carbon output – a key concern. Actual carbon output is highly dependent on extraneous factors (hardware, local energy grids, carbon offsets, etc).
- **Net Operations/Heat Production:** The computational process directly produces heat (creating the need for energy-intensive cooling), so actual operations performed, or the heat generated by them may be a more

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THE POLICY CHALLENGE

stakeholders must be identified, including the relative allocation of threats/harms and promises/benefits among them

- **Local Magnitudes:** Do system-level metrics adequately account for uneven distributions in magnitude of harms/benefits. Does distribution of harms unduly burden vulnerable communities? Do benefits exacerbate controversial social inequalities?
- **Impersonal Interests:** Are there abstract or non-human interests (eco-systems, animals, etc.) that deserve independent ethical consideration? If so, how should they be balanced against the needs of human communities?
- **Identify Stakeholders:** Who bears the environmental threat/harm of computational carbon cost, and are those threats/harms captured by metrics? Who stands to benefit?

AI ecosystem's imperatives

- Balancing Environmental Costs with Social benefits
- Balance of the environmental impacts of AI
- How to keep AI at the optimal level and not have it over-used
- Would it be accurate that there are often system barriers between developers of AI and the usage of power that makes the latter invisible to the former?
- Small adjustments early in the trajectory of a technology have large consequences.
- Must introduce the environmental perspective early into the culture of emerging technologies
- The idea is of optimization and measurement quite well –

Aligning AI to human values means picking the right metrics

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AI ecosystem's imperatives

- AI poses collective challenges like the widespread introduction of plastics half a century ago - providing cheap and seemingly efficient solutions to a wide range of contemporary problems while creating (and displacing) new aggregate costs that will impact all of society.
- I propose that a holistic ethical and policy approach should be taken towards the design and deployment of AI technologies.
- It should embed an awareness of key ethical and policy goals throughout the ecosystem and value chain - from researchers to engineers to corporations to global policymakers - to better generate and distribute metrics that can inform policies oriented towards ethical and sustainable practices.

Think Piece on “Is AI the New PLASTIC?”

OCEANIS: https://ethicsstandards.org

Photo Credit: Von Wong https://www.vonwong.com

This Think Piece provides a meta-analysis of the environmental challenges presented by emerging technologies collectively referred to as *machine learning* (ML) and *artificial intelligence* (AI). The Think Piece is a call for action for the SDOs, Governments, Policy Makers & Regulators, System Developers & Business Organizations, Academia & Researchers, and Intergovernmental & Non-Governmental Organizations. In this think piece, we argue that AI poses collective challenges like the widespread introduction of plastics half a century ago - providing cheap and/or seemingly efficient solutions to a wide range of contemporary problems while creating (and displacing) new aggregate costs that will impact all of society. We argue that a holistic ethical and policy approach needs to be taken towards the design and deployment of AI technologies. It is imperative to embed an awareness of key ethical and policy goals throughout the ecosystem and value chain - from researchers to engineers to corporations to global policymakers - to better generate and distribute metrics that can inform policies oriented towards ethical and sustainable practices.

OCEANIS Think Piece

Is AI the New Plastic?

Think Piece on “Is AI the New PLASTIC?”

OCEANIS
OPEN COMMUNITY FOR ETHICS IN AUTONOMOUS AND INTELLIGENT SYSTEMS

Download it from: https://ethicsstandards.org/news/

This “Think Piece” is developed by OCEANIS (Open Community for Ethics in Autonomous and Intelligent systems) - A Global Forum for discussion, debate and collaboration for organizations interested in the development and use of standards to further the development of autonomous and intelligent systems. Author (N. Kishor Narang) is the Chair of ‘Advancing Research Work Group’ in OCEANIS and leading the initiative of identifying gaps, establishing policies, and adapting new technology solutions that will solidify global economic prosperity by driving important research and policy to help close some of the most significant gaps in technology expansion.

OCEANIS Think Piece

Is AI the New Plastic?

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The Impact of Future Networks on Sustainability

- Sustainability has been established as a cornerstone of the 6G era.
- As investigations of 6G architecture are explored in various communities, energy and broader sustainability challenges have been identified.
- The use of virtualized platforms for Radio Access Network processing imply greater energy use, and more cloud platforms to be managed.
- The introduction of AI/ML everywhere in 6G suggests energy hungry computations, and specialized power-hungry processors.
- What are the power sources of all these cloud platforms?
- Especially on a global basis, and with computing so widely distributed - not solely in giant well managed data centres.

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The Impact of Future Networks on Sustainability

- A longer-term goal of 6G is communications everywhere, including various non-terrestrial networks.
- How will they affect global sustainability with airborne, non-satellite platforms?
- As we look at these future networks based around 6G and its successors we are faced with a paradox - we need these architectural and technical changes to bring greater function and benefit and sustainability.
- And yet the methods used may negatively affect sustainability.
- As a second perspective, 6G with its richer, more widespread functionality can also help solve other sustainability issues as a tool.
- Consequently, 6G may consume sustainable resources but also save more indirectly through its employment in new solutions.

The imperative…

- Climate change/Sustainability are wicked problems.
- Dealing with them means we find solutions at the intersection of Social, Technological, Economic and Natural Systems…
- But when we solve one problem using technology, we must not create new problems.
- That is why we are sustainable in everything we do - both environmentally, economically and socially.
- • Network Efficiency
- • Small Cell Migration
- • Base Station Power
- • Economic Factors
- • Grid/Utility….

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Systems Approach: Holism

Aristotle (300 B.C.)

"The Whole is Greater than the Sum of its Parts"

Systems Approach imperatives

- The multiplicity of technologies and their convergence in many new and emerging markets, however, particularly those involving large-scale infrastructure demand a top-down approach to standardization starting at the system or system-architecture rather than at the product level.
- Therefore, the systemic approach in standardization work can define and strengthen the systems approach throughout the technical community to ensure that highly complex market sectors can be properly addressed and supported.
- It promotes an increased co-operation with many other standards-developing organizations and relevant non-standards bodies needed on an international level.
- Further, standardization needs to be inclusive, top down and bottom up; a new hybrid model with a comprehensive approach is needed.

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System and Systems Approach

- System: *A group of interacting, interrelated, or interdependent elements forming a purposeful 'WHOLE' of a complexity that requires specific structures and work methods in order to support applications and services relevant to the stakeholders.*
- Systems Approach: *A holistic, iterative, discovery process that helps first defining the right problem in complex situations and then in finding elegant, well-designed and working solutions. It incorporates not only engineering, but also logical human and social aspects.*

Systems Approach demystified…

- Identify and understand the relationships between the potential problems and opportunities in a real-world situation.
- Gain a thorough understanding of the problem and describe a selected problem or opportunity in the context of its wider system and its environment.
- Synthesize viable system solutions to a selected problem or opportunity situation.
- Analyze and trade off between alternative solutions for a given time/cost/quality version of the problem.
- Measure and provide evidence of correct implementation and integration.
- Deploy, sustain, and apply a solution to help solve the problem (or exploit the opportunity).
- All of the above, are considered within a life cycle framework which may need concurrent, recursive and iterative applications of some or all of the systems approach.

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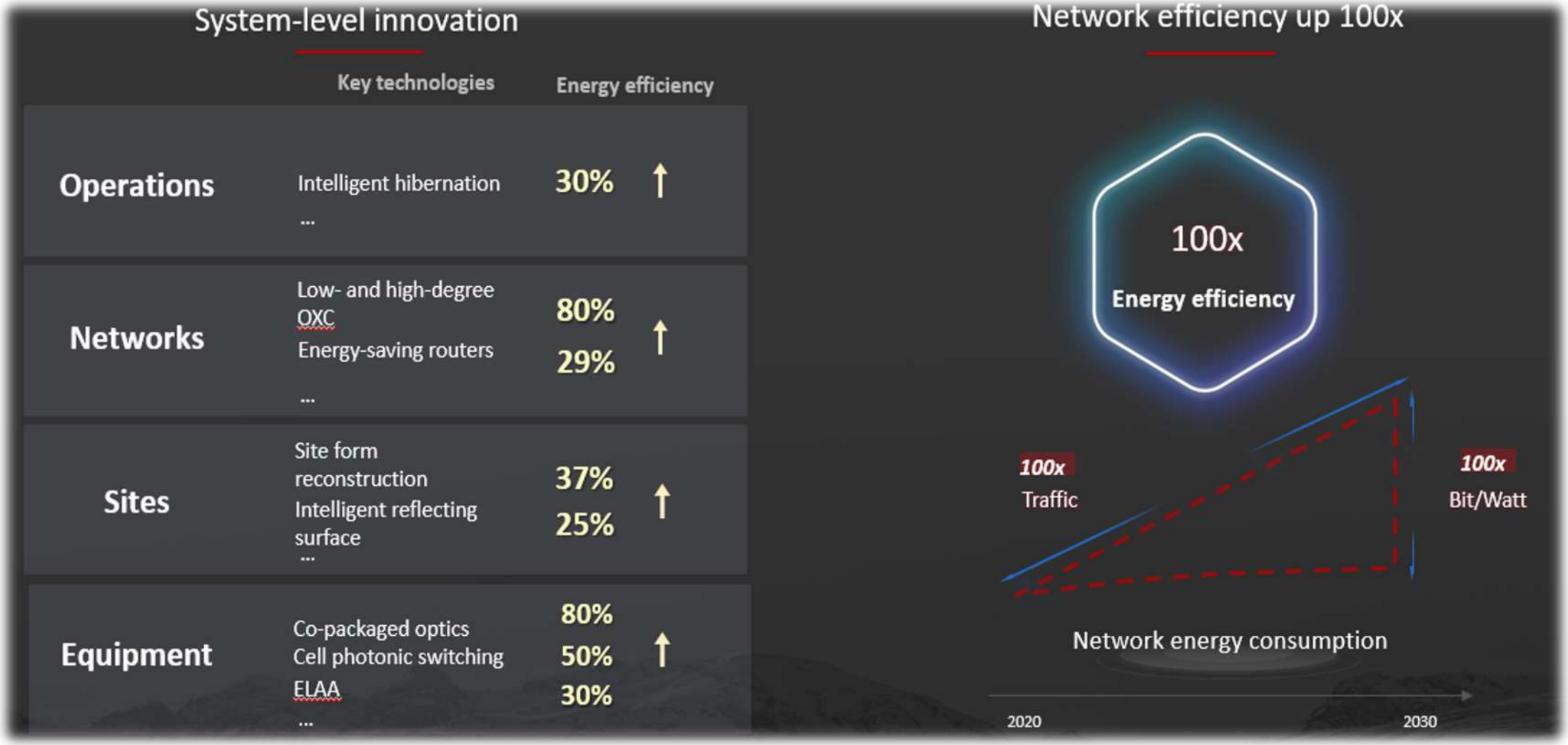
Energy Efficiency Imperatives….



My understanding and learning…

The emergence of disruptive digital technologies has already begun profoundly reshaping our lives, our interactions, and our lived environments. As adoption of these technologies becomes widespread, they have started to play a substantial independent role in society's energy consumption and environmental impact.

- This pandemic has catapulted two diametrically opposite paradigms to the focus of the mankind –

  DIGITALIZATION & SUSTAINABILITY

- **Disruptive Technologies - Their impact on different aspects of society, industry & business including but not limited to ethical and sustainability aspects.**
- **Growing Carbon Footprint of Digital Infrastructure – Impact of growing digitalization**
- **Resource & Energy intensity of Digital Technologies**
- **Climate Crisis, Energy Access, Energy Security, Clean/Green Energy, UN SDGs, Green Washing, Industry 4.0 to Industry 5.0**

The complexity of the ecosystem and the traditionally siloed approach within the Industry has often prevented the adoption of a holistic approach to addressing the fundamental problem of energy, which is the ultimate constraint to any complex deployment.

- Need to understand the Sustainability comprehensively, Granularly and all its nuances.
- Foundational Cornerstones of Sustainability Strategy for Digital Infrastructure –
  - Carbon Footprint
  - Energy Efficiency
  - Circularity
  - Architecture & Modelling
  - Systems Approach

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Some thoughts... Perspective…

- Need to look at the Digital Infrastructure as a SYSTEM rather ”System of Systems” - the need for a comprehensive “Systems-of-Systems” (SoS) analysis to address the complex inter-relations among the multiple layers, which the infrastructure leverages.
- Need to apply the **Systems Approach -** *A holistic, iterative, discovery process that helps first defining the right problem in complex situations and then in finding elegant, well-designed and working solutions. It incorporates not only engineering, but also logical human and social aspects.*
- *Need to leverage Systems Approach to understand the Sustainability with all its nuances and granularity @system modules level…*
- The scope of an assessment can be set against one of three general supply chain boundaries:
  - Scope 1 includes performance of directly owned and operated organization’s assets.
  - Scope 2 includes Tier 1 suppliers, those suppliers who supply parts or services directly to the organization including contractors of the organization’s products or services.
  - Scope 3 include impacts from the full lifecycle of the products, sites and organizations participating in the supply chain, delivery and use of the product or service.
- Circularity in each sphere needs to be assessed on the Five basic aspects:

  Material, Energy Usage, Air Emissions, Water Flow & Social Impacts
- WHAT IT WILL TAKE TO REDUCE the CARBON FOOTPRINT
  - **NO to Power Hungry Architectures, Models & Algorithms…**
  - **MOORE WITH LESS: THE VIRTUES OF INEXACT COMPUTATION**
  - **Develop Enabling Technical Environments for The Green Transition**
  - **Develop a Climate Aware Data Science Practice**
  - **Focus on Climate Justice**
  - **Sustainability must be at the center of a digital strategy – not a sideshow or an afterthought.**
- Comprehensive Frameworks and Indices for measurement of GHG Emissions, Carbon Footprint, Circularity, Net Zero, Energy Efficiency

System Standardization imperatives

- Harmonization in Communication standards, Protocols and Data Models can help optimize the Carbon Footprint of the Digital Infrastructure…
- Interoperability standards go a long way in reducing the Compute and communication needs hence reducing the Energy Consumption and GHG emissions…
- Comprehensive Frameworks and Indices for measurement of
  - Circularity
  - GHG Emissions
  - Carbon Footprint
  - Net Zero
  - ….

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Conclusion

- We have a unique opportunity to harness the ongoing Disruptive Technologies' Revolution, and the societal shifts it triggers, to help address environmental issues and redesign how we manage our shared global environment. The disruption we are witnessing could, however, also exacerbate existing threats to environmental security or create entirely new risks that will need to be considered and managed.
- Harnessing these opportunities and proactively managing these risks will require a transformation of the "enabling environment", namely the governance frameworks and policy protocols, investment and financing models, the prevailing incentives for technology development, and the nature of societal engagement. This transformation will not happen automatically. It will require proactive collaboration between policymakers, scientists, civil society, technology champions and investors. If we get it right, it could create a sustainability revolution.
- Confronting these challenges requires political will, as well as a new approach to business - one that puts human welfare on an equal footing with profits. It also calls for innovative technology. We are already starting to see how the Autonomous and Intelligent Systems can help us transform our world (and the Environment) for the better.
- Though, for last one decade, we have been witnessing isolated initiatives in different domains like Green ICT, Inexact Computing, Green Data Centers etc. however, it is time to consolidate such siloed efforts into a comprehensive crusade to understand and mitigate the looming calamity that disruptive technologies bring along with systems thinking and systemic approach. The fragmented landscape of sustainability standards should be modernized to get the most benefit from the digital revolution to help achieve climate and sustainability goals.

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Key Takeaways

Need to develop a Comprehensive approach to

- Sustainability
- Security & Resilience
- Leveraging Disruptive Technologies
- Ethically Aligned Designs

And adopt Systems approach to Design in complex paradigms…

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CALL FOR ACTION

- SDOs
- Governments, Policy Makers & Regulators
- System Developers & Business Organizations
- Academia & Researchers
- Intergovernmental & NGOs

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18th SDG(?) – A meaningful Safe Digital Life

- A Meaningful and Safe Digital Life. More than 4.5 billion people now use the internet and over 3.8 billion are active on social media, Data shows the average internet user now spends 6 hours and 42 minutes online each day, which equates to more than 100 days of connected time per internet user per year, or roughly 40 percent of our waking lives.
- "It became clear to me that we live in a digital-first, work-from-home world, yet not one of the 17 Sustainable Goals addresses a fair, more liveable digital future for our fast-evolving and technology-driven world,"
- "What if we could significantly enhance our quality of life with an additional UN Sustainable Development Goal that encourages companies to use data for mutual benefit rather than for unwelcomed intrusion or manipulation?"

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ONLY ONE EARTH

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UPCYCLE YOUR DIGITAL WASTE

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UPCYCLE YOUR DIGITAL WASTE…
and Avoid DATA OVERLOAD in your Life

- 4 grams of carbon are emitted for every outgoing email, which implies that if 5 billion internet users each deleted just 10 emails, this would account for 3.7 million gigabytes of energy saved on data archiving.

- The least people can do is help reduce digital waste by clearing out their email inboxes, unnecessary images, videos & data, right?"

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Mentor's Musings…

- Climate change is a wicked problem. Dealing with it means we find solutions at the intersection of Social, Technological, Economic and Natural Systems…
- If we don't succeed in constraining climate change, we will also lose most of the natural world as we know it.
- Nature is perhaps the most complex word in the language.
- We need true nature-positive solutions to address climate change.
- Today, you need a **technology-led business strategy**, not a business strategy supported by technology.
- Societies should be judged on their ability to deliver to citizens most of their human needs: food, shelter, education, a clean environment, a sense of community and a sense of purpose in life.

Key takeaway from my Technology journey:

We humans need to radically change our relationship, not just with the planet, but with the objects with which we fill our lives.

We need to change how we think about technology and innovation.

Rather than allowing technological advancement to steer our narratives, innovation and technology should help us build bridges between the worlds we inhabit now and the ones we imagine for tomorrow.

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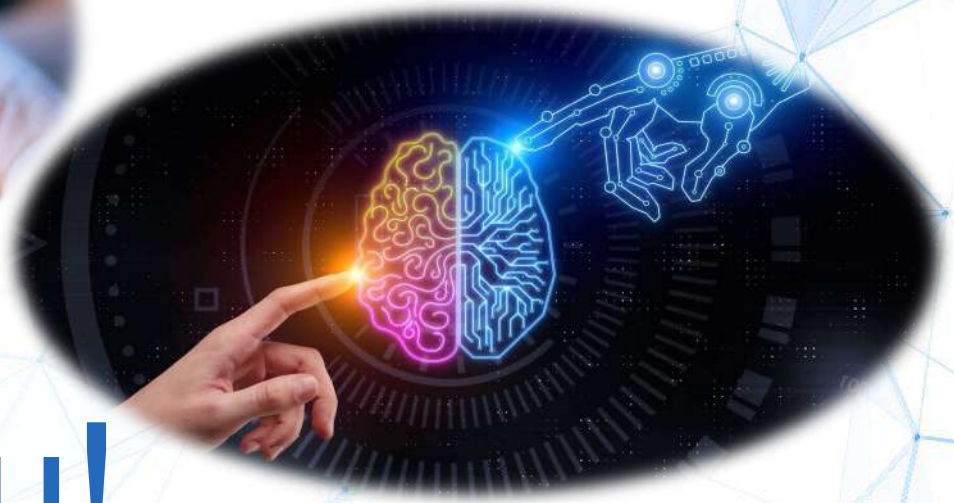

Thank you!

For a Sustainable & Resilient Future

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About me…

Technology Philanthropist, Innovation, Standardization & Sustainability Evangelist…

Technology Advisor, Mentor & Design Strategist & Architect in Electrical, Electronics & ICT; running an Independent Design House – NARNIX since 1981.

- Over 45 years of professional experience in education, research, design and advisory .
- Over 35 years of hardcore Research and Design Development Experience in Solutions, Systems, Products - Hardware, Software & Firmware (Embedded Software) in fields of Industrial, Power, IT, Telecom, Medical, Automotive, Aerospace, Defense, Energy and Environment. Over 10 years of Advisory Experience to different segments of business & industry.
- Over 250 Research & Design Mentees in the Electronics & ICT & STI Ecosystems. Mentoring many Deep Tech & Disruptive Tech Startups.
- Leading & contributing to multiple National & Global Standardization Initiatives at BIS, Niti Aayog, TSDSI, IEC, ISO, ITU, IEEE etc.…
- For the last 10 years, been deeply involved in standardization in the electrical, electronics, communications, information technology, digital infrastructure and cyber security domains with a focus on identifying gaps in standards to bring harmonization through system standards and standardized interfaces to ensure end-to-end Interoperability.
- Standards based on 10 years of Pre-Standardization Research Published Recently (December 2020) –
  - Unified Digital Infrastructure ICT Reference Architecture – IS 18000
  - Unified Last Mile Communication Protocol Stack Reference Architecture – IS 18010.

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