6G-life

6G-life: Future Communication Systems

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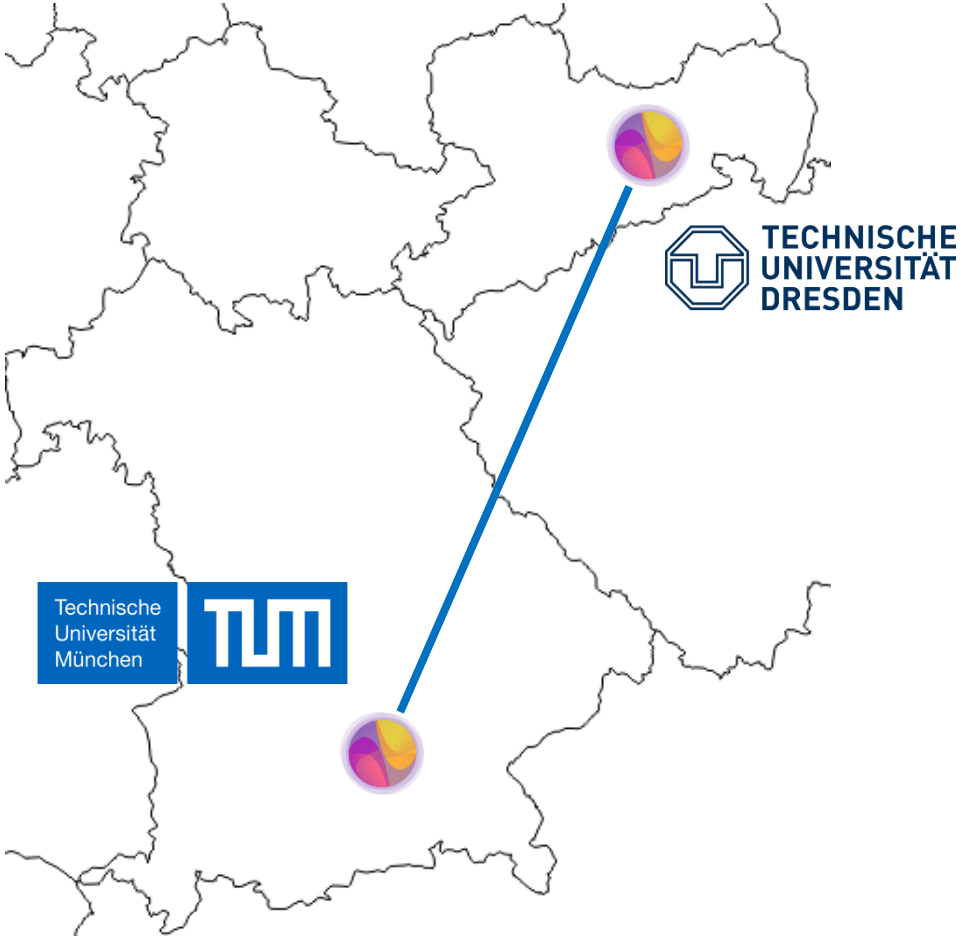
CeTI Speaker /6G-life coordinator
TUD Dresden University of Technology

BMBF 6G Research Hub 6G-life

- Started August 15, 2021
- 70 Million € for 4 years
  - 50 Million € for 4 years
  - 20 Million € for 3 years
- 61 Principal Investigators + 163 researchers
- 6G: focus is on humans and their communication and interaction with machines and the virtual world → holistic research on innovative concepts for scalable communication, novel methods, flexible software concepts and adaptive hardware
- Important fields of application: Industry 4.0 and healthcare (extending with industry projects)
- Four key performance indicators: Latency, Resilience, Security and Sustainability
- Technological Sovereignty and Digital Transfer
- 10 Million € for Startups



6G-life

1,005 Publications	19 Startups	49 Patents	553 Theses
200 Fairs & Conferences	1 Standards	151 Cooperations	63 Awards
50+ Industry Partners	105 Lectures	163 Researchers	47 Testbeds & Demonstrators

Vision toward Cooperative Networked Robotics

New Demands of Robotics and Automation Engineering

Current

Individual & Stationary Robots

Wired

Hardware Focus

Fixed, Structured

Vision toward Cooperative Networked Robotics

New Demands of Robotics and Automation Engineering

Current

- Individual & Stationary Robots
- Wired
- Hardware Focus
- Fixed, Structured

Demands

- **Faster changing products**
- **More variants**
- **Smaller lot sizes**

Vision toward Cooperative Networked Robotics

New Demands of Robotics and Automation Engineering

Current

- Individual & Stationary Robots
- Wired
- Hardware Focus
- Fixed, Structured

Demands

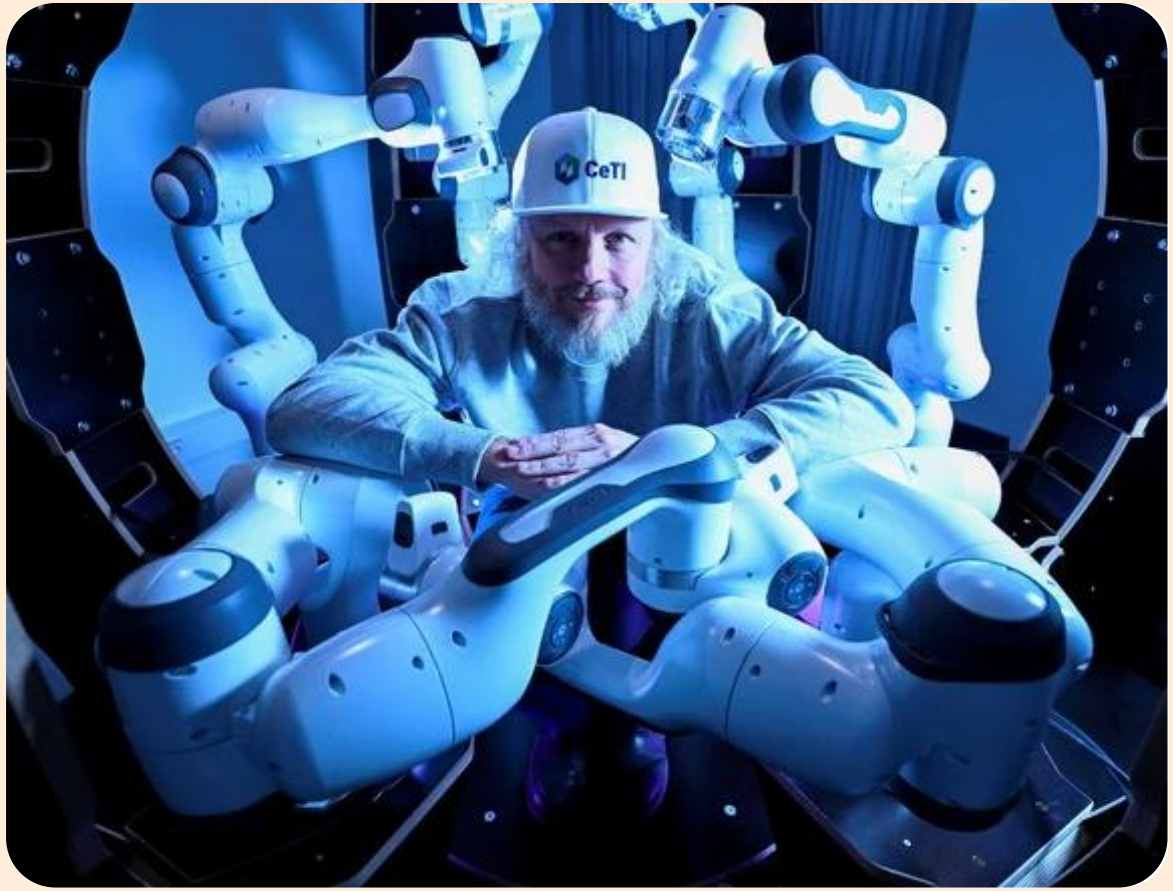
- Faster changing products
- More variants
- Smaller lot sizes

Future

- **Multiple & Mobile Robots**
- **Wireless**
- **Software-based and AI**
- **Dynamic, Unstructured**

New cool robotics ? – Networked Collaborative Robotics

Humanoid and Mobile



Massive

Robotics and Automation

The Latency Challenge – My Nemesis

Robotics and Automation

The Computing Bottleneck

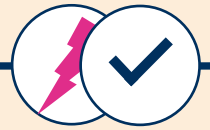
Closed-loop control

(input) → **Controller** → **Actuator** → **System** → *(output)*

Closed-loop control

Sensor

(feedback loop)



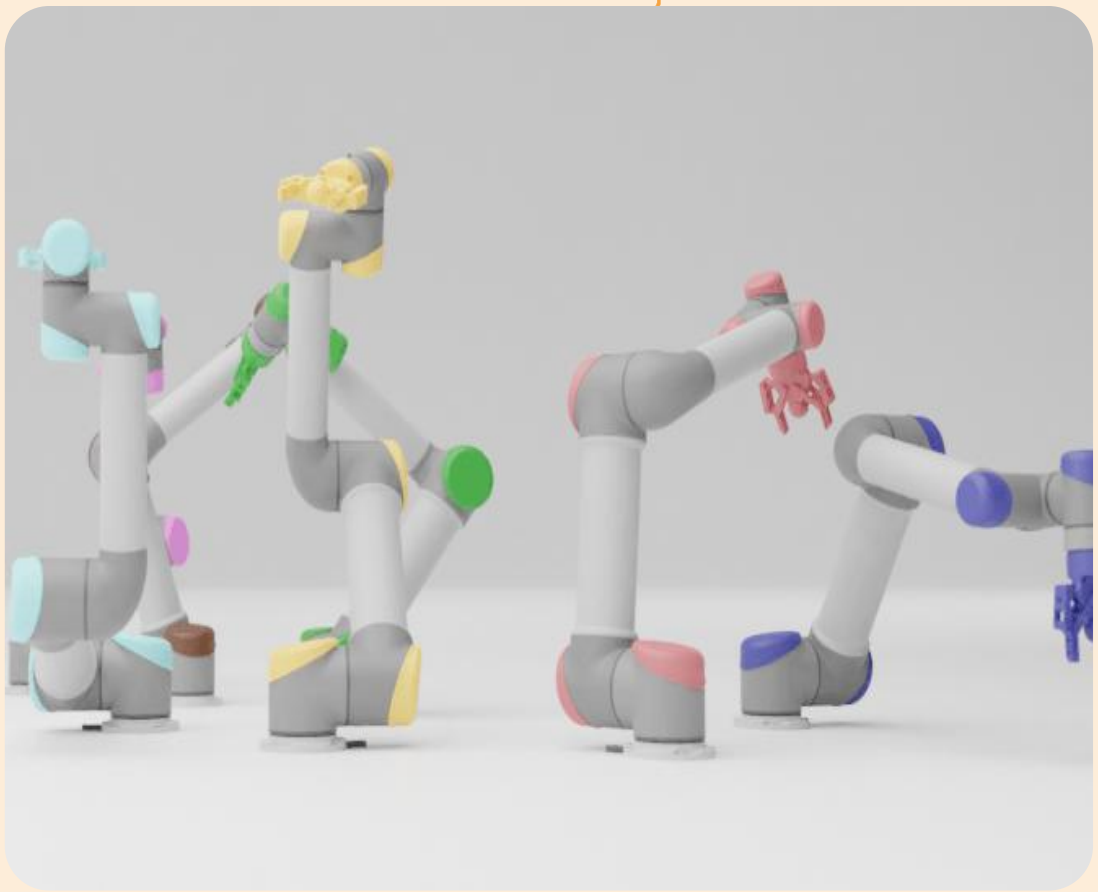
Solutions

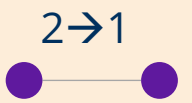
- 6G
- Time-Sensitive Networking

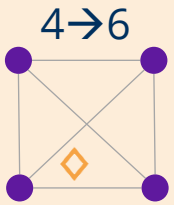
Problems

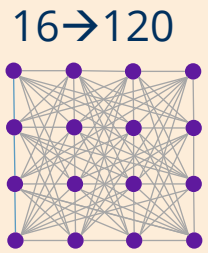
- Loss
- Delay
- Jitter

Challenge in massive mobile robotics



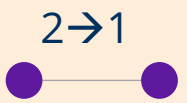


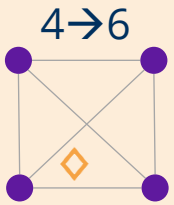


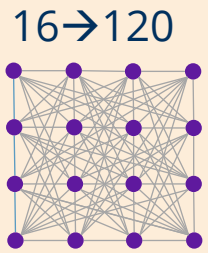


Multi-robot interaction $O(n^2)$

Challenge in massive mobile robotics







Multi-robot interaction $O(n^2)$

Networked Robotics

Oct 2024 Three–armed robot skill transfer

Networked Robotics

March 2024 Multi–armed robot skill transfer

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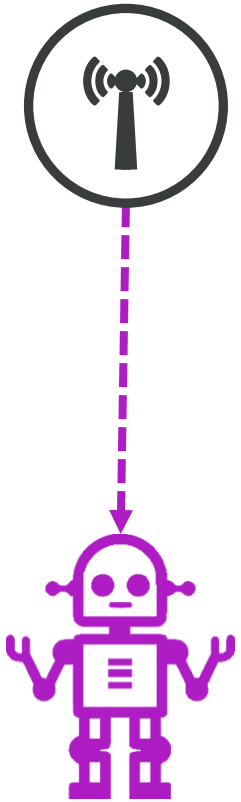
101 on Communication Architecture



TSN Time Sensitive Networking Powered by IEEE 802

5G 6G

WiFi 6 WiFi 7

point-to-point

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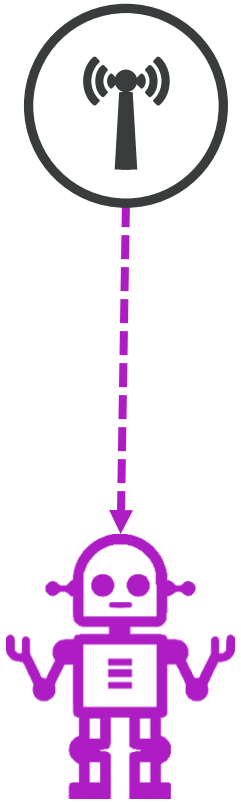
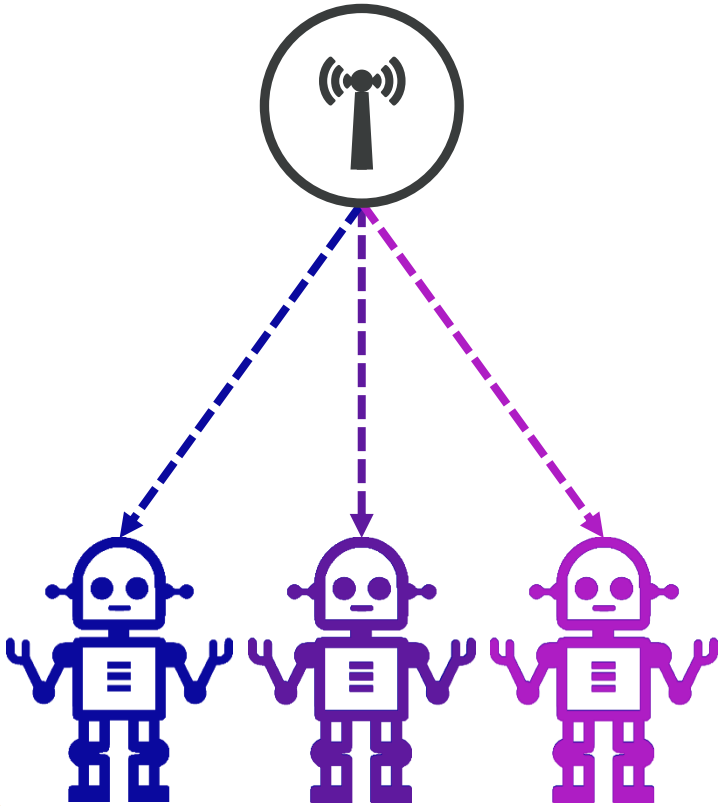
101 on Communication Architecture



point-to-point



TSN Time Sensitive Networking Powered by IEEE 802

5G

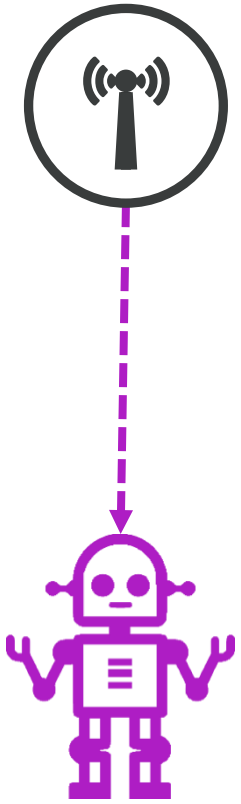
6G

Wi Fi 6 ?

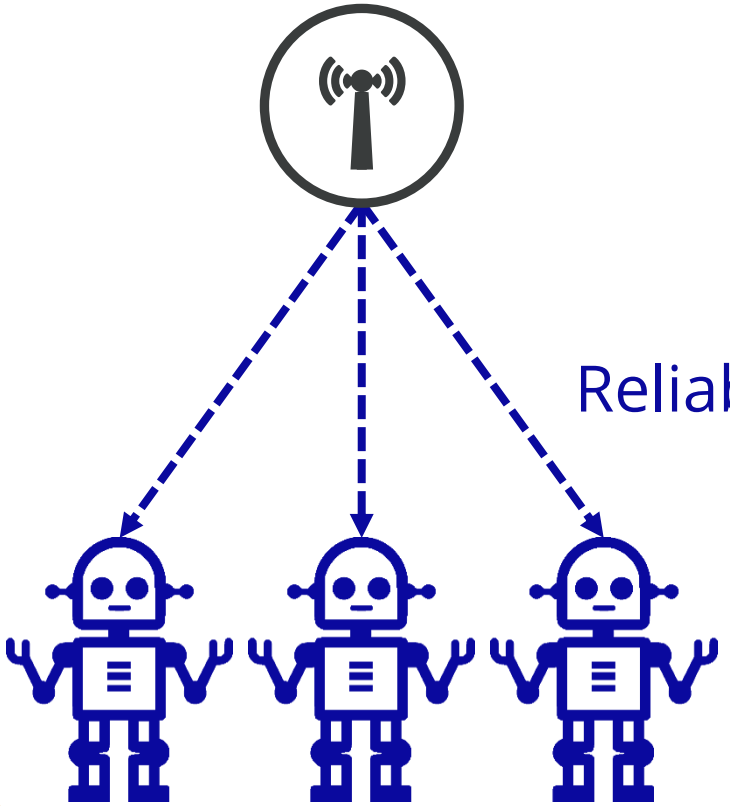
Wi Fi 7 ?

point-to-multipoint

101 on Communication Architecture



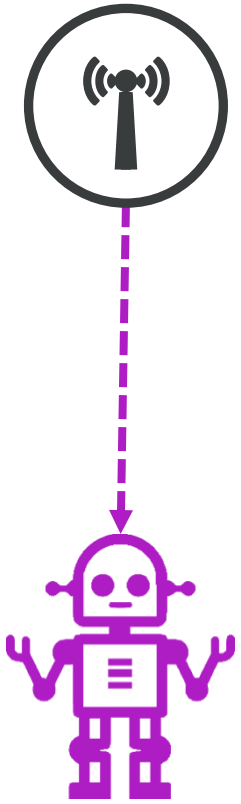
point-to-point



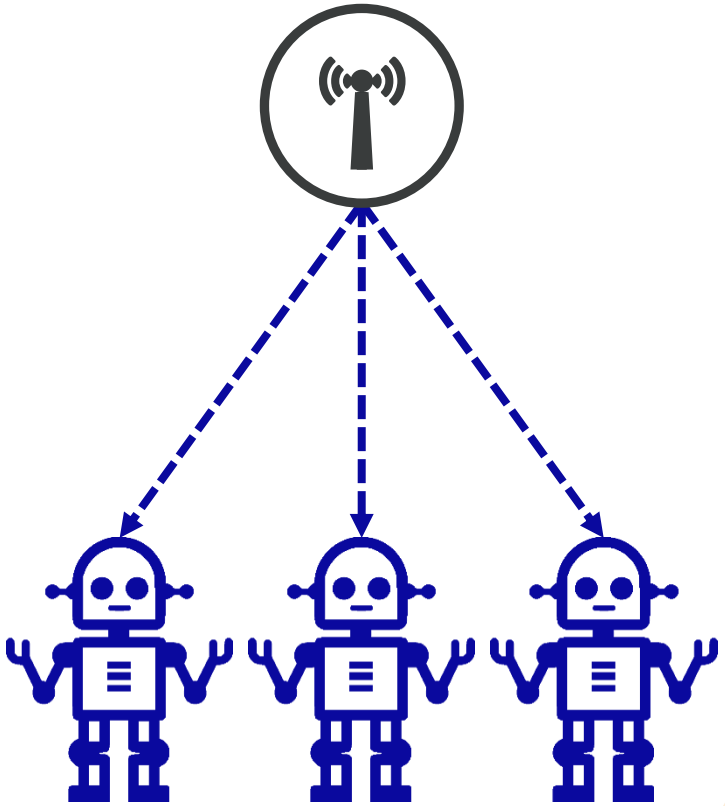
Reliable Multicast for IP

point-to-multipoint

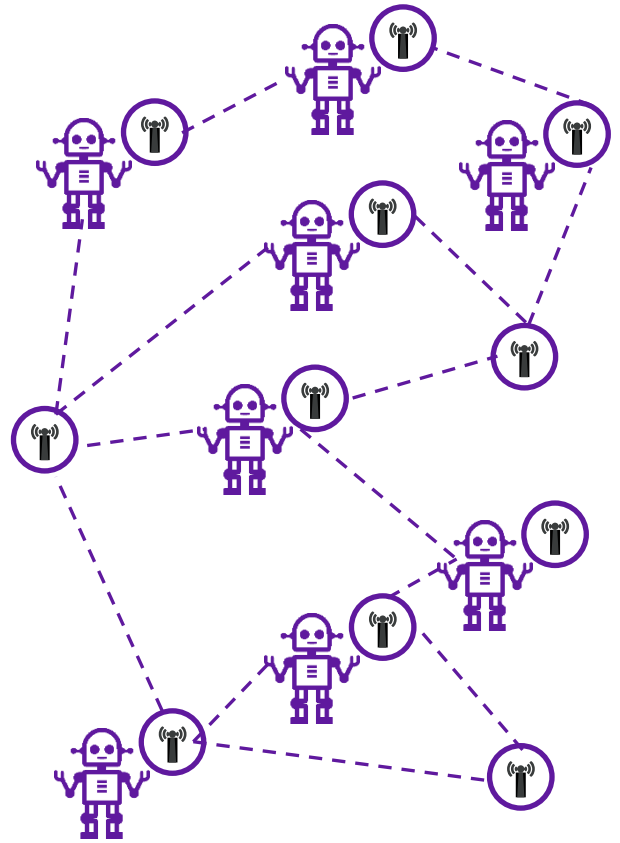
101 on Communication Architecture



point-to-point

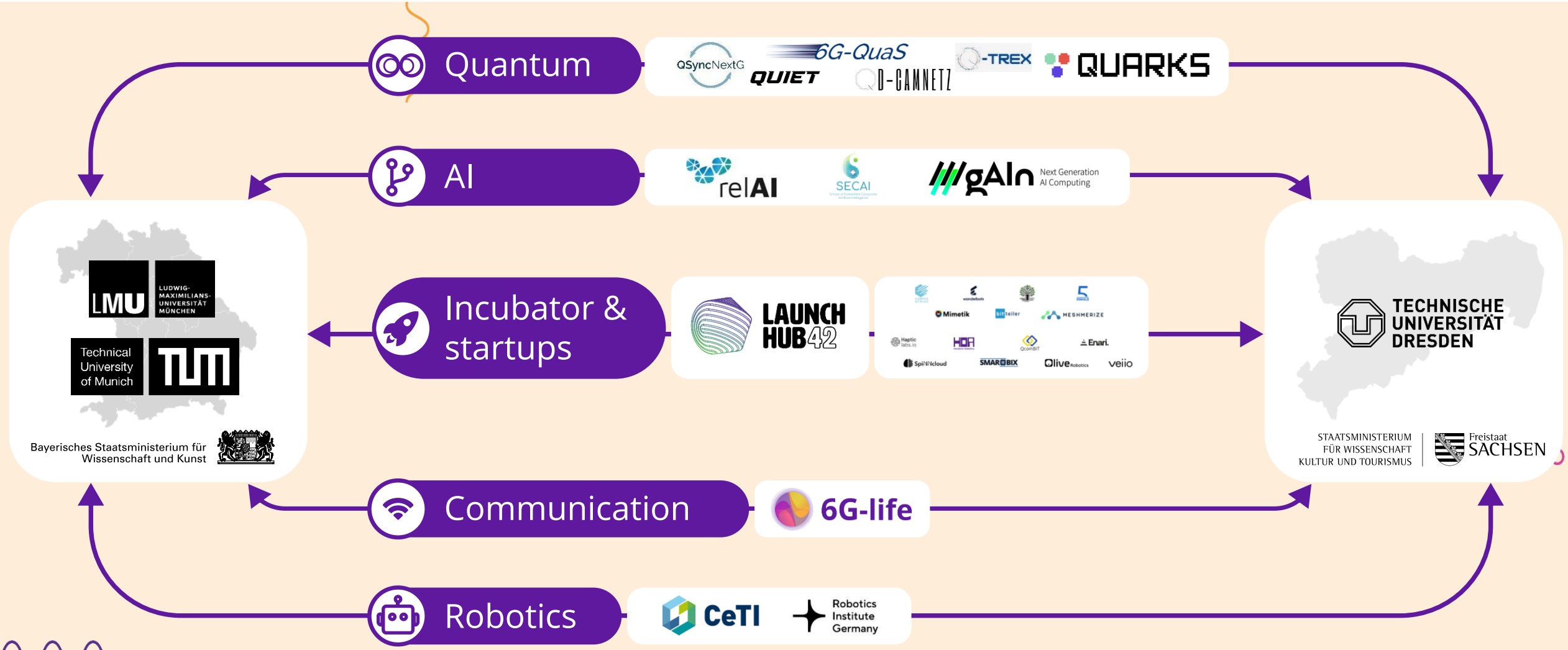


point-to-multipoint



fully mesh

Why us? – Innovation Network




WE SCALE TRUSTWORTHY
6G-TECHNOLOGIES
FOR A SUSTAINABLE
AND SOVEREIGN WORLD.
LAUNCH HUB 42
MADE IN GERMANY

DE launchhub42, im Herzen der Technischen Universität Dresden gelegen, ist ein innovativer Startup-Inkubator der beiden Exzellenzuniversitäten TU Dresden und TU München, der die Lücke zwischen ambitionierten Studenten und der Spitze des technologischen Fortschritts schließen soll. Mit dem Hauptaugenmerk auf der Entwicklung von hochmodernen Kommunikationsnetzwerken für Robotik, das Metaversum und menschliche Interaktion steht launchhub42 an vorderster Front bei der Förderung der nächsten Generation von Technologiepionieren.

Der Inkubator, der derzeit mit 30 Startups zusammenarbeitet, bietet ein umfassendes Angebot an Ressourcen, darunter spezialisierte Schulungen, wichtige Informationen und einen unvergleichlichen Zugang zu fortschrittlichen Technologien, die für aufstrebende Unternehmen normalerweise unerreichbar sind. In einem prägnanten Gebäude auf dem Universitätsgelände untergebracht, bietet launchhub42 eine Fülle von Einrichtungen wie Tagungsräume, Büroräume und Demonstrationsbereiche, die alle sorgfältig darauf ausgelegt sind, den Kontakt zu potenziellen Kunden und Partnern zu erleichtern.

EN launchhub42, positioned at the heart of the University of Technology Dresden, is an innovative startup incubator of the two universities of excellence – TU Dresden and TU Munich – designed to bridge the gap between ambitious students and the forefront of technological advancements. With a primary focus on the development of cutting-edge communication networks for robotics, the metaverse, and human interaction, launchhub42 is at the forefront of fostering the next generation of tech pioneers.

Currently collaborating with 20 startups, the incubator provides an exhaustive suite of resources including specialized training, essential information, and unparalleled access to advanced technologies that are typically out of reach for burgeoning enterprises. Housed in a conspicuous building within the university's premises, launchhub42 offers a plethora of facilities, including meeting spaces, office areas, and demonstration zones, all meticulously designed to facilitate engagement with potential customers and partners.

Why?

Ein wichtiger Teil unserer Aufgabe besteht darin, die Kluft zwischen Forschung und Industrie zu überbrücken, bahnbrechende Partnerschaften zu fördern und Lösungen zu entwickeln, die sowohl wissenschaftlich als auch wirtschaftlich von Bedeutung sind. Mit jedem Durchbruch und jeder Zusammenarbeit arbeiten wir daran, die Industrie zu revolutionieren und eine von technologischen Spitzenleistungen geprägte Zukunft zu gestalten.

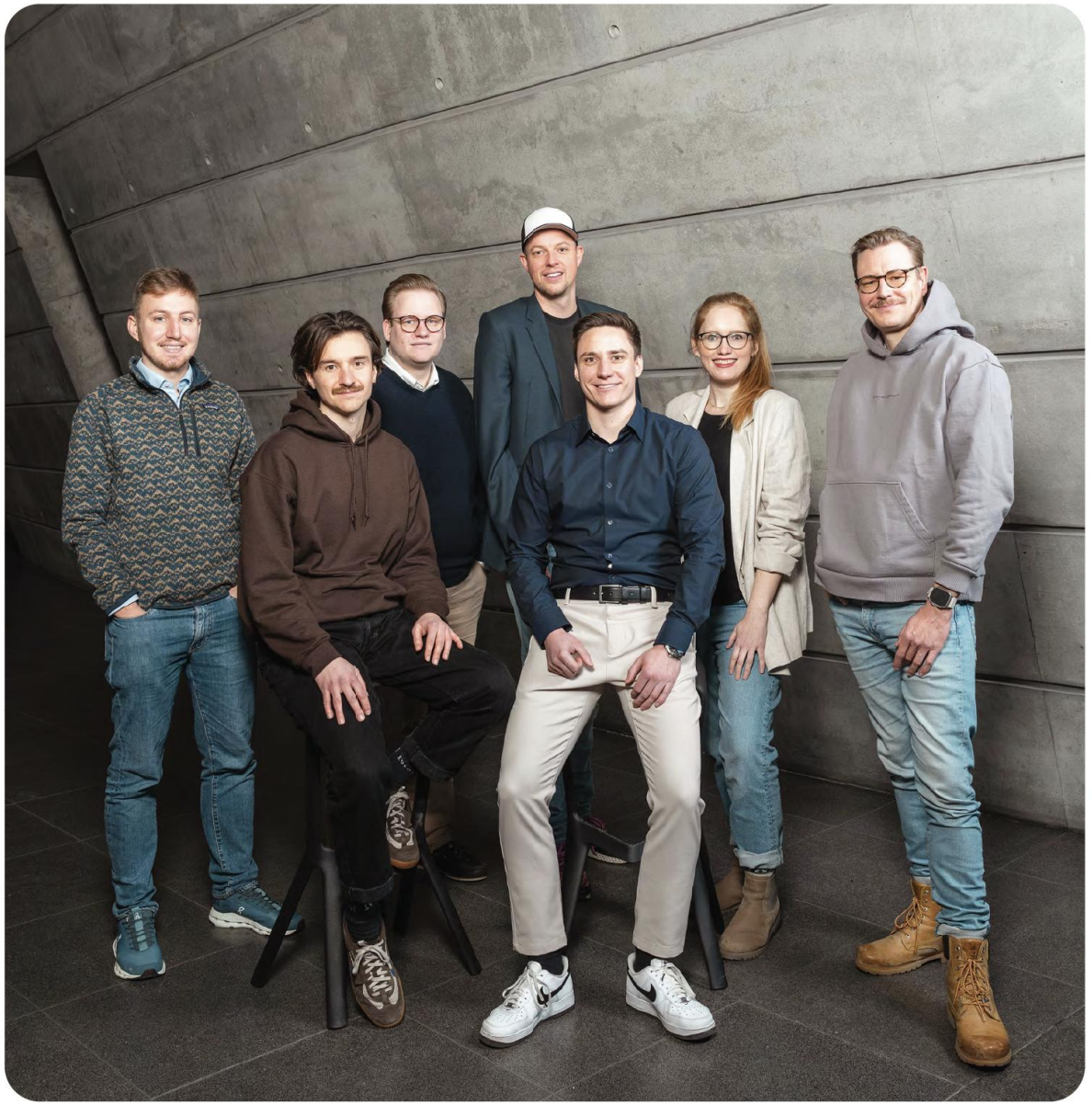
A key part of our mission is to bridge the gap between research and industry, fostering groundbreaking partnerships and developing solutions that carry both scientific and economic significance. With every breakthrough and collaboration, we work towards revolutionizing industries and shaping a future defined by technological excellence.

What?

Mit einem klaren Fokus auf die Entwicklung der nächsten Generation von Kommunikationsnetzwerken für Robotik, das Metaverse und die Mensch-Maschine-Interaktion bieten wir eine Umgebung, in der visionäre Ideen zu marktreifen Innovationen werden. Modernste Infrastruktur und ein starkes Netzwerk machen uns zum idealen Ausgangspunkt für die Tech-Pioniere von morgen.

With a clear focus on developing the next generation of communication networks for robotics, the metaverse and human-machine interaction, we provide an environment where visionary ideas become market-ready innovations. State-of-the-art infrastructure and a strong network make us the ideal starting point for the tech pioneers of tomorrow.

SENSIBILISIERUNG
TEAMSCOUTING
QUALIFIZIERUNG
DESIGN
CONSULTING
GRÜNDUNG
FINANZIERUNG
FUNDING
CLIENTING
WACHSTUM



DE Bei launchhub42 vereint unser vielfältiges Team Fachwissen aus den Bereichen Technologie, Forschung und Unternehmertum, um die nächste Welle von bahnbrechenden Startups zu unterstützen und zu inspirieren. Diese einzigartige Kombination von Talenten und Fähigkeiten gewährleistet, dass wir perfekt aufgestellt sind, um die Herausforderungen und Chancen dieses Projekts zu meistern.

MEET THE TEAM

Florian Sägebrecht
Coordinator

David Köhler
Design and Startup Consulting

Simon Schmitt
Design and Startup Consulting

Thekla Herzog
Communications and Events

Christian Hermeling
Design and Startup Consulting

Leonard Balbig
Finance

EN At launchhub42, our diverse team combines expertise from tech, research, and entrepreneurship to support and inspire the next wave of game-changing startups. This unique assembly of talent and skills ensures that we're perfectly positioned to tackle the challenges and opportunities this project presents.

YOUR JOURNEY WITH US

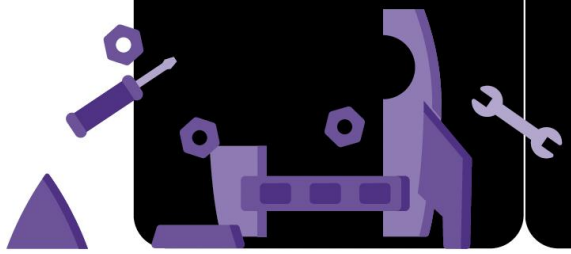
PROCESS TO SUCCESS

DE Jedes erfolgreiche Startup beginnt mit einer Idee – doch der Weg von der Vision zur Unternehmensgründung ist anspruchsvoll. Wir begleiten Gründer:innen in jeder Phase ihres Startups, von der ersten Konzeptentwicklung bis zur Skalierung. Mit praxisnaher Unterstützung, individueller Förderung und einem starken Netzwerk aus Branchenexpert:innen schaffen wir die perfekte Umgebung, um visionäre Ideen in marktreife Innovationen zu verwandeln.

EN Every successful startup begins with an idea – but the journey from vision to company formation is challenging. We support founders at every stage of their startup, from initial concept development to scaling. With hands-on guidance, personalized support, and a strong network of industry experts, we create the perfect environment to transform visionary ideas into market-ready innovations.

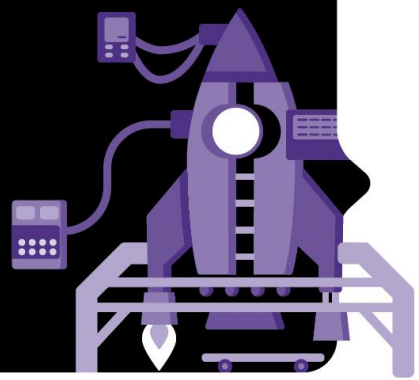
Lab

In this early stage, the focus is on research and idea generation. Start-ups develop initial demonstrators and analyze market potential.



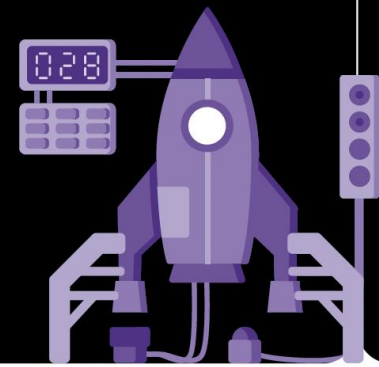
Validation

Now it gets serious: The goal is to identify clear use cases and convince investors of the viability of the idea.



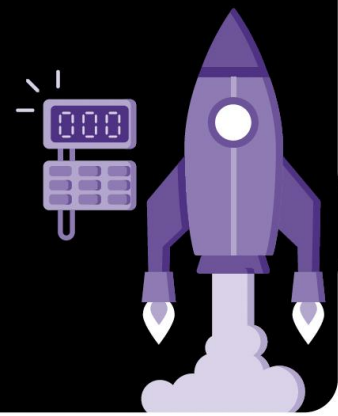
Implementation

The technology is further developed, infrastructure is built, and initial pilot projects are implemented with partners.



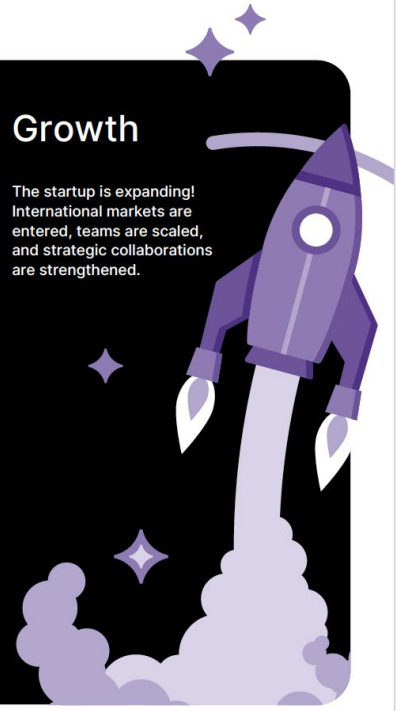
Seed

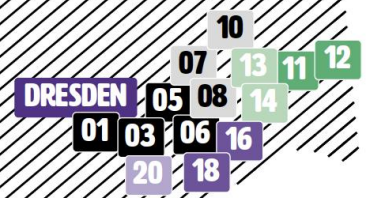
The validated business model is in place, and the first customers are onboard. Now it's time to generate initial revenue, establish strategic partnerships, and prepare the startup for scaling.



Growth

The startup is expanding! International markets are entered, teams are scaled, and strategic collaborations are strengthened.





- Communication Technologies and Networks
- Robotics and Automation
- Sensor and Haptics Technologies
- Neuromorphic and Sustainable Technologies
- AI and Software Platforms
- Health and Assistance Systems

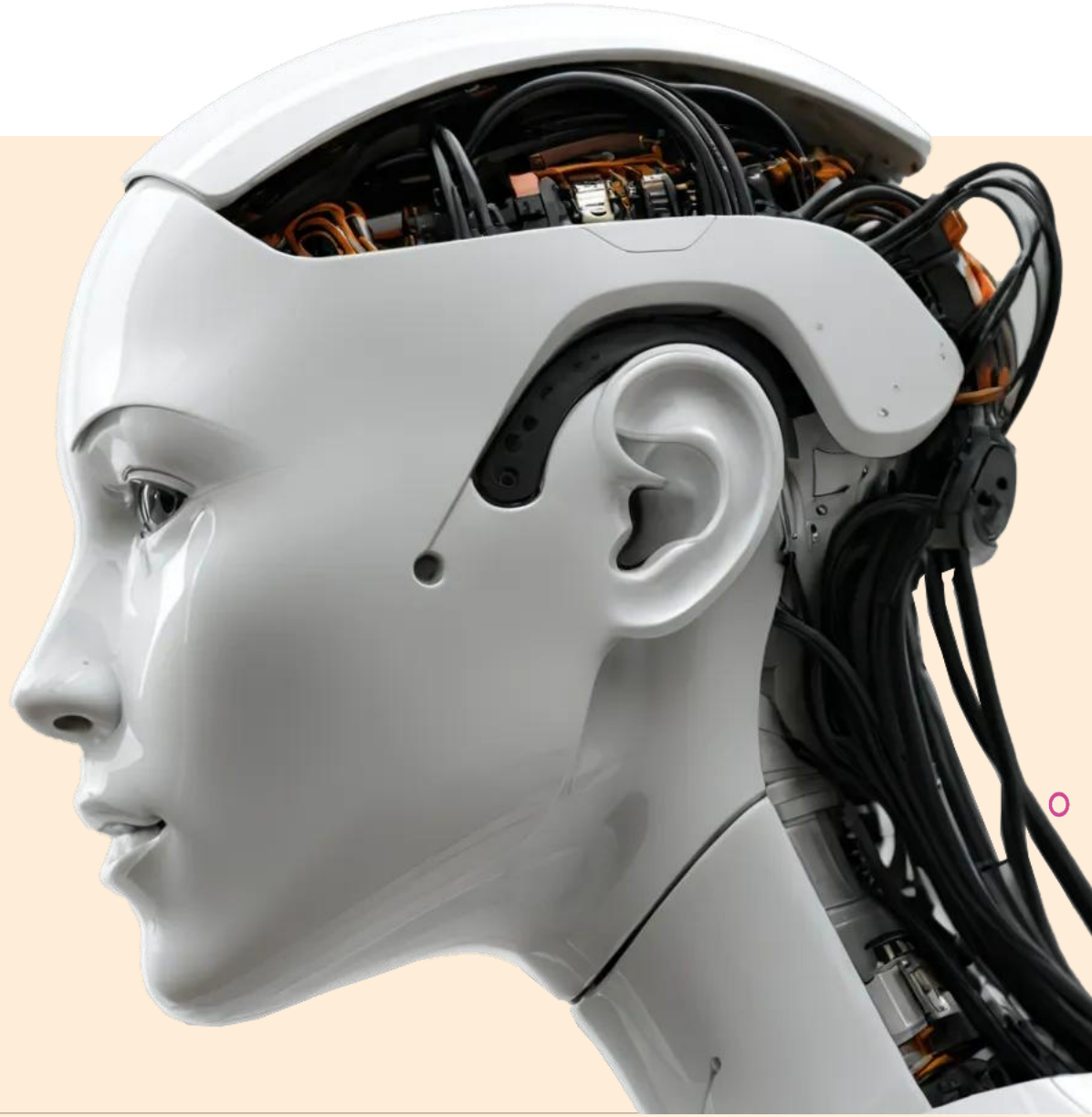
OUR PIONEERS OF TOMORROW*

*As of 2025. Early-stage startups are not included in this overview.

01	QcomBIT	*Future-Proof Networks – Quantum Solutions for 5G and 6G*	qcombit.com	Lab
02	aeroLiFi	*Light-Speed Data Transfer – On Ground and In Flight*	aerolifi.com	Growth
03	Campus Genius	*Private 5G Infrastructure – Flexibly Scalable for Enterprises*	campusgenius.com	Seed / Growth
04	AISAC	*Integrated Sensing, Communication and AI for Future 6G Hyperconnectivity*	incooperating	Lab
05	Meshmerize	*Robust Mesh Networks for Mobile Autonomy*	meshmerize.net	Growth
06	Fünfeinhalb Funksysteme	*Real-Time Communication for Demanding Industrial Environments*	funfeinhalb.de	Implementation
07	Smarobix	*High-Performance Robotics Solutions – Accessible to All Developers*	smarobix.com	Validation
08	Evasive	*Multiple Robots, One System – Perfectly Orchestrated*	evasive-robotics.com	Validation / Implementation
09	Olive Robotics	*AI-Powered Sensors for Intelligent Robotics*	olive-robotics.com	Seed
10	HandsOn Robotics	*Efficient Kitchen Automation – Optimizing Culinary Operations*	handsonrobotics.org	Lab / Validation
11	Hapticlabs	*Haptic Technology – Tangible for Everyone*	hapticlabs.io	Seed
12	Mimetik	*Digitizing Hand Movements – Optimizing Production*	mimetik.com	Seed
13	EcoLogic Computing	*Innovative Solutions for Environmentally Conscious Computing*	ecologic-computing.com	Validation
14	SpiNNcloud	*AI Reimagined - Inspired by Nature*	spinncloud.com	Validation
15	Enari	*End-to-End Data Integration and Innovation for Enterprises*	enari.com	Growth
16	wandelbots	*Simplifying Robot Programming - Accessible to All*	wandelbots.com	Growth
17	YNotAI	*Mastering 6G Networks – With Digital Twins*	incooperating	Validation
18	bitteiler	*Efficient and Secure Data Management for IoT Systems*	bitteiler.com	Validation
19	CADAMI	*Efficient Content Delivery and Bandwidth Optimization for Media Networks*	cadami.net	Validation
20	Veiio	*Personalizing Physiotherapy - Through Innovative Vibration Technology*	veiio.de	Lab

The What!

Artificial Thinking Machines



Shannon/Turing 1942

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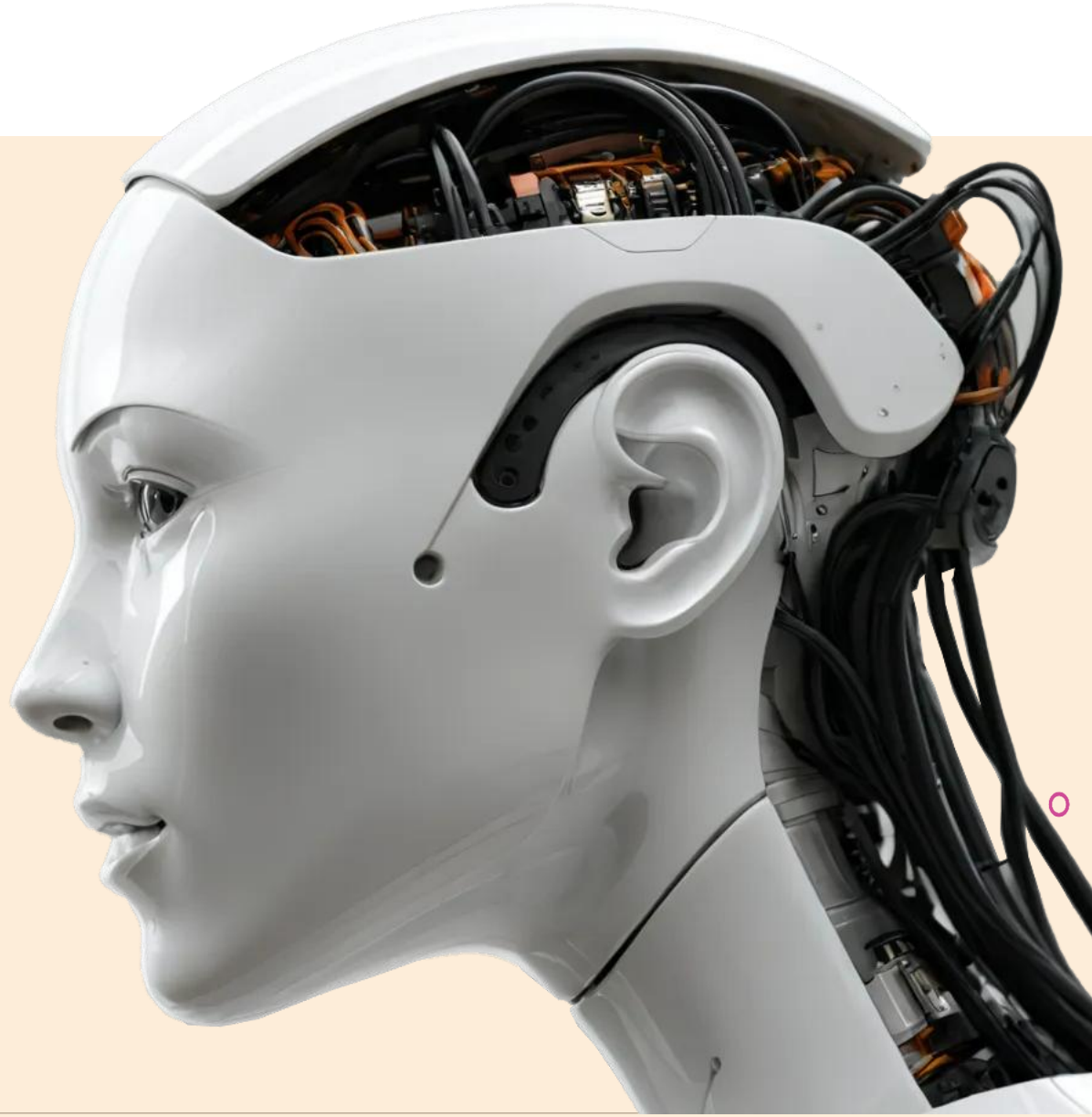
The What!

AI



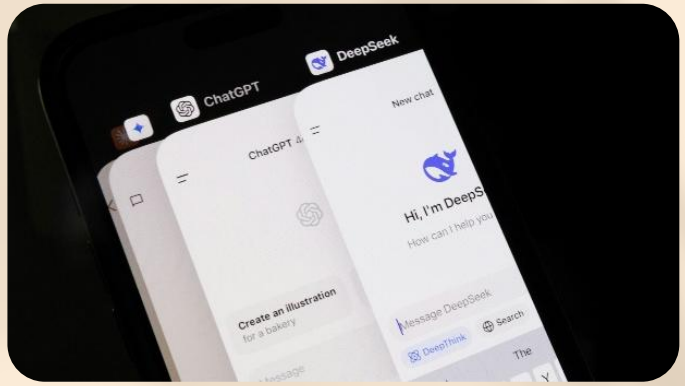
The What!

AI

Arts

Medicine

Robotics



Text

The What!

AI =

- Data
- Compute
- Energy

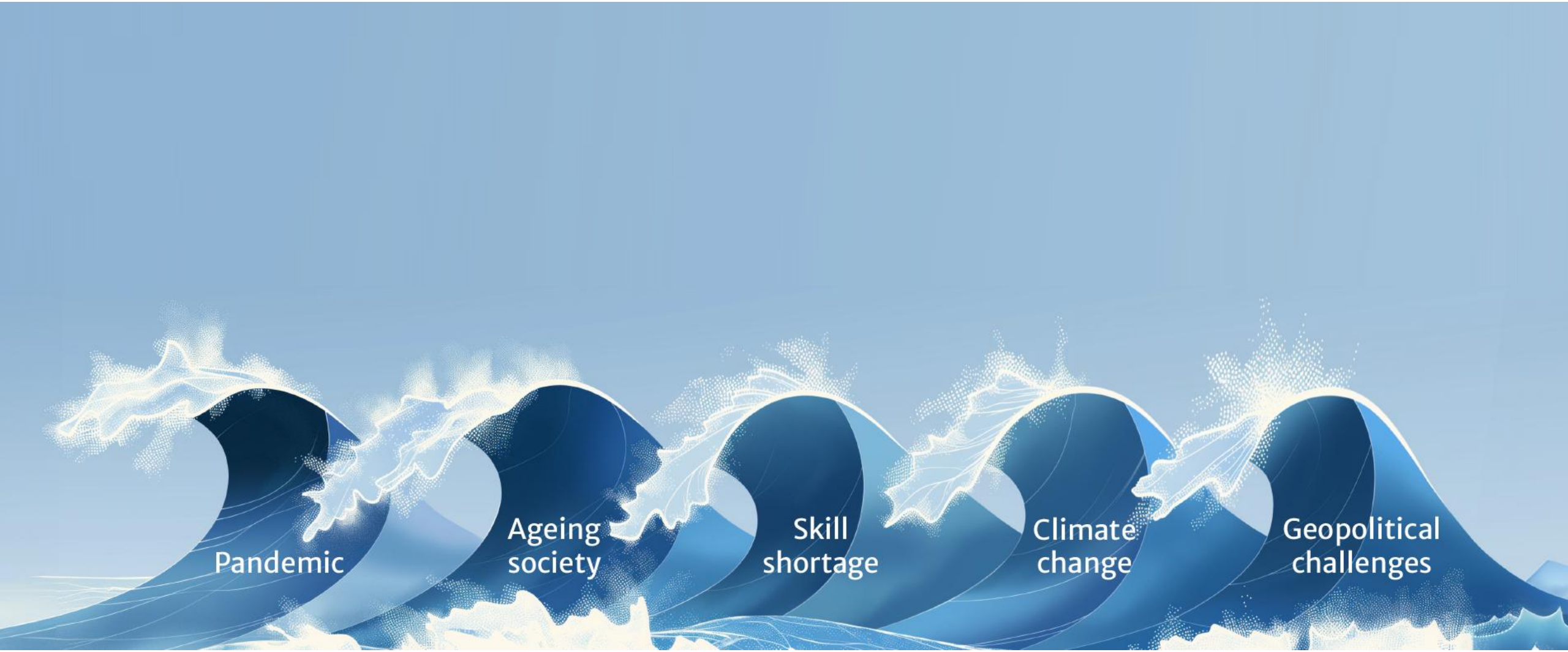
The What!

AI =

- Data
  - Collecting
  - Storage
  - Communication
- Compute
- Energy

Challenges and limits

Grand challenges of the 21st century – We create impact!



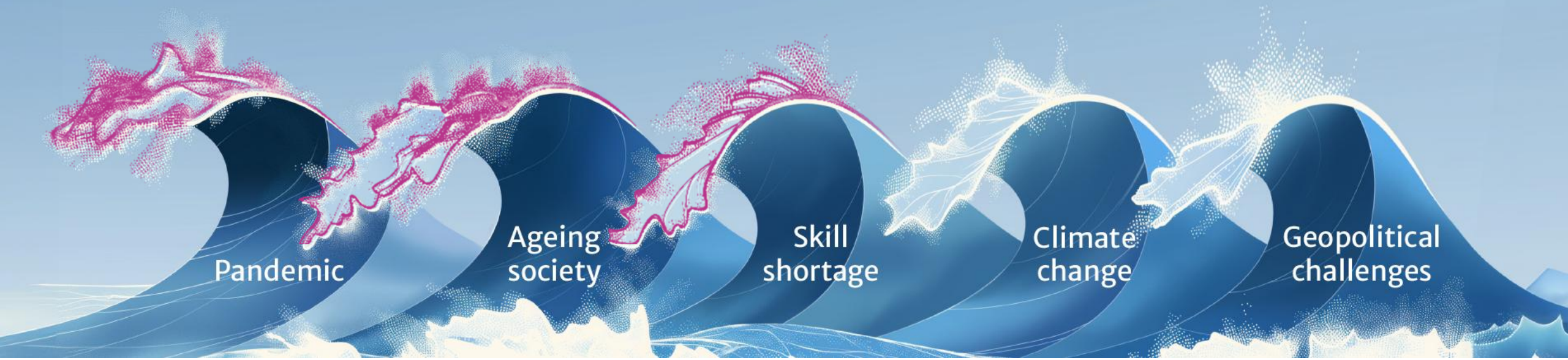
Challenges and limits

Grand challenges of the 21st century – We create impact!

Human

Trustworthiness

- Human–Machine Interface
- Network of Networks
- Robotics
- Metaverse



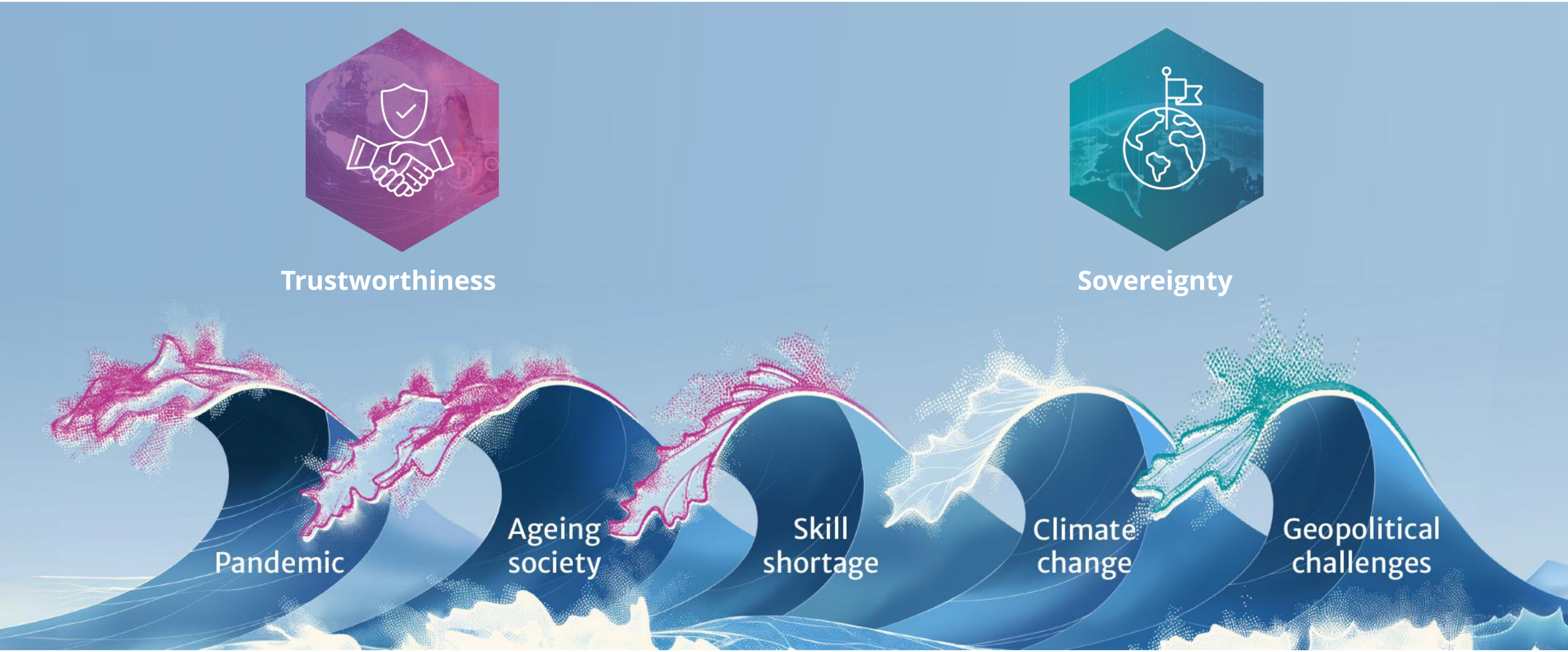
CeTI

Slices for gAIn Next Generation AI Computing

6G-life

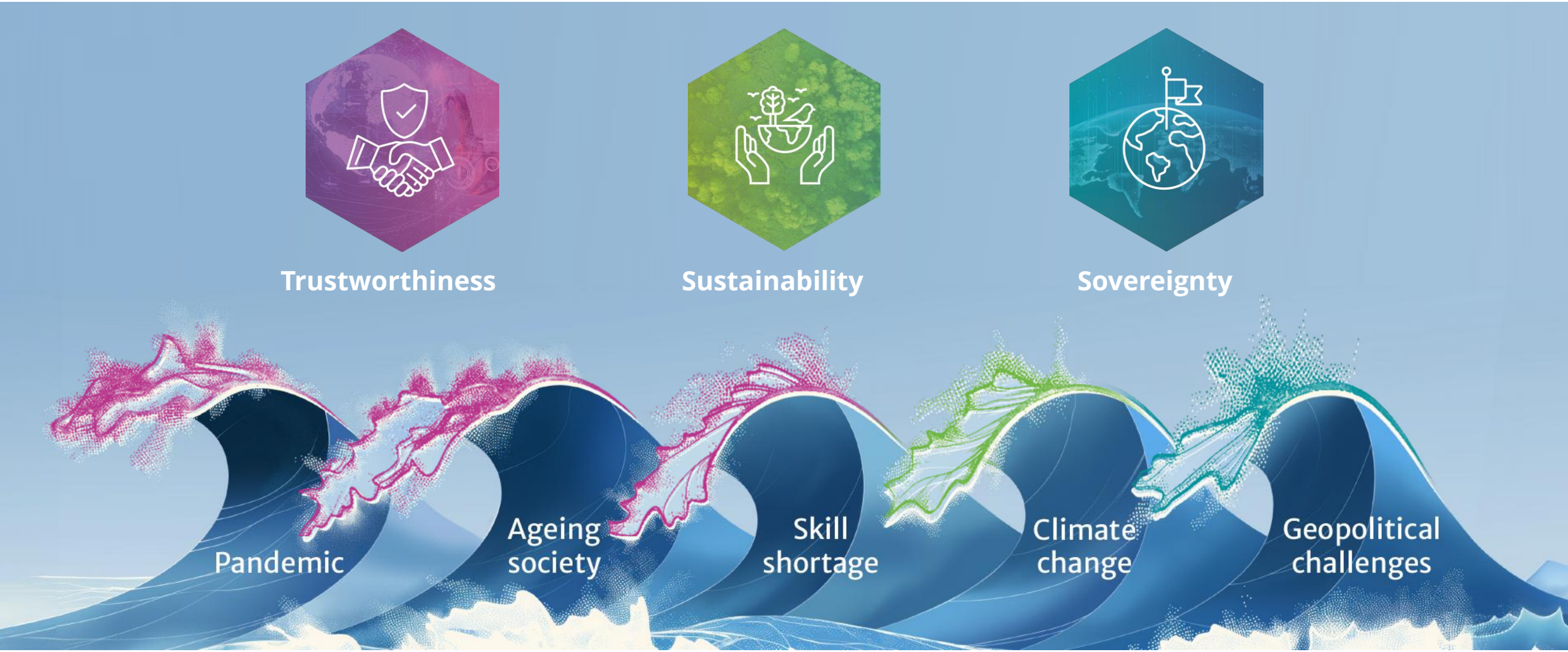
Challenges and limits

Grand challenges of the 21st century – We create impact!



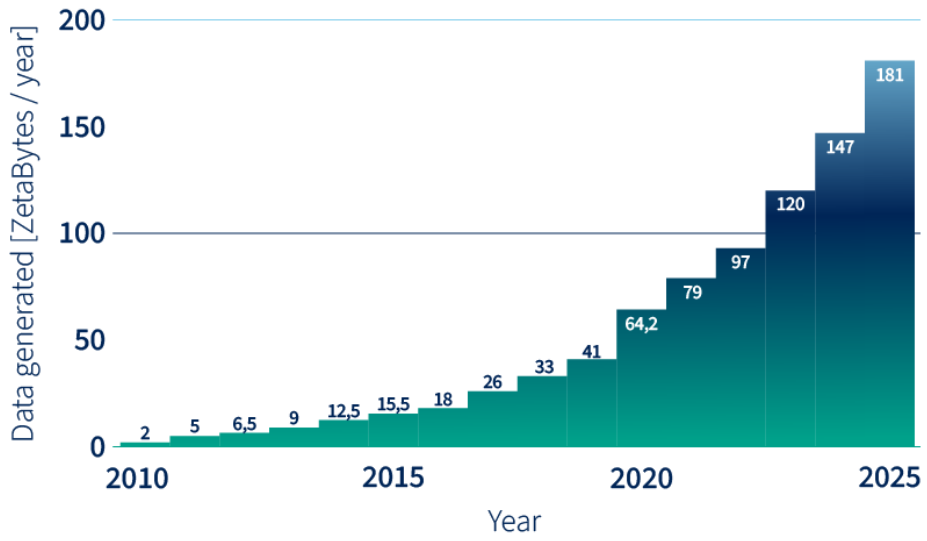
Challenges and limits

Grand challenges of the 21st century – We create impact!



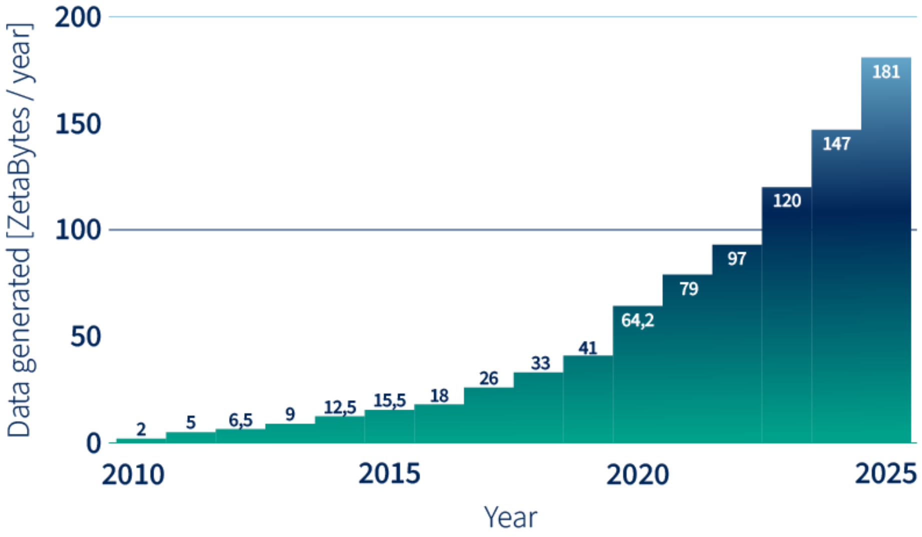
Challenges and limits

Limits in communication and computing



Challenges and limits

Limits in communication and computing

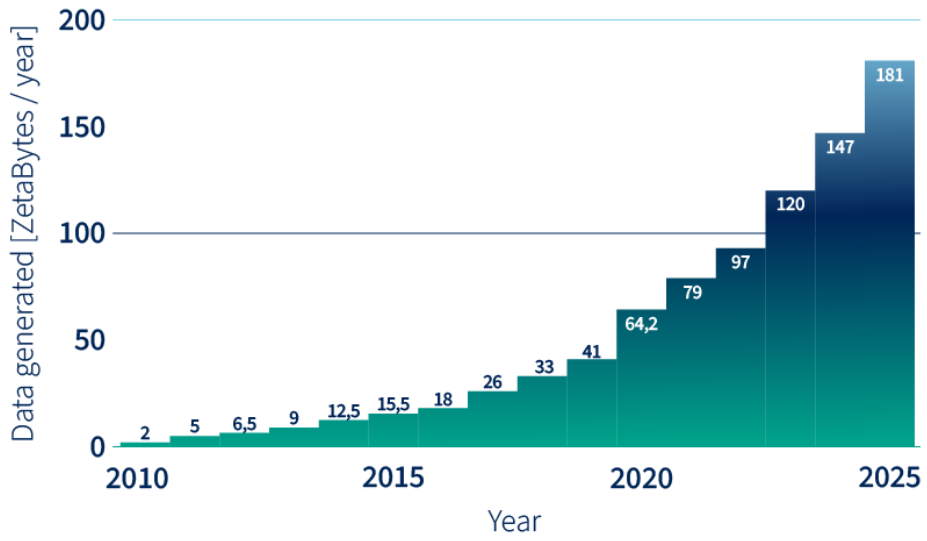


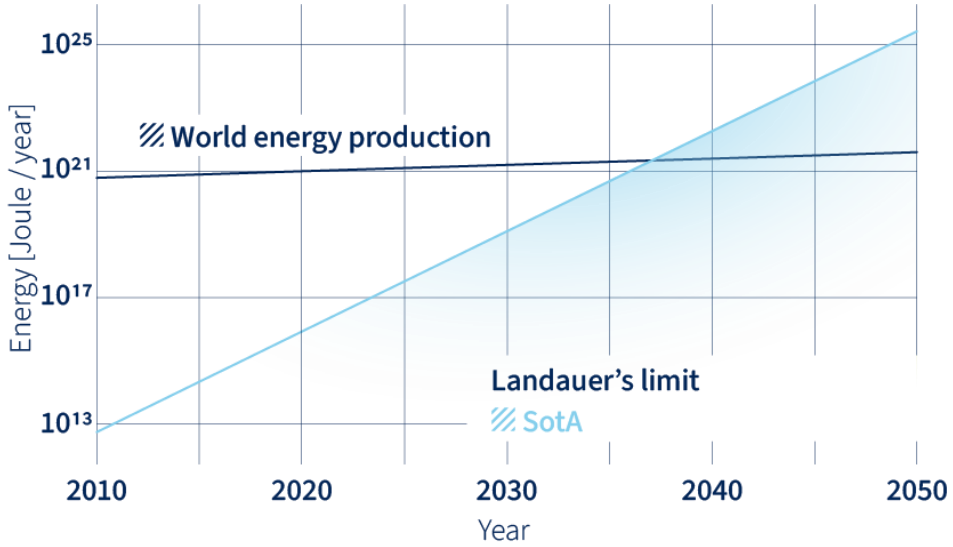
"information capacity is limited"
– Claude E. Shannon

"information is physical"
– Rolf Landauer

Challenges and limits

Limits in communication and computing





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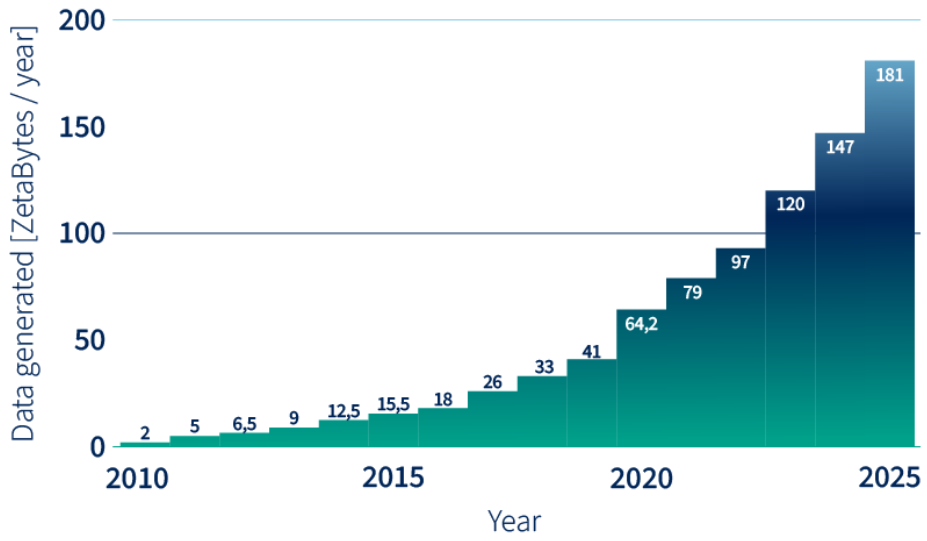

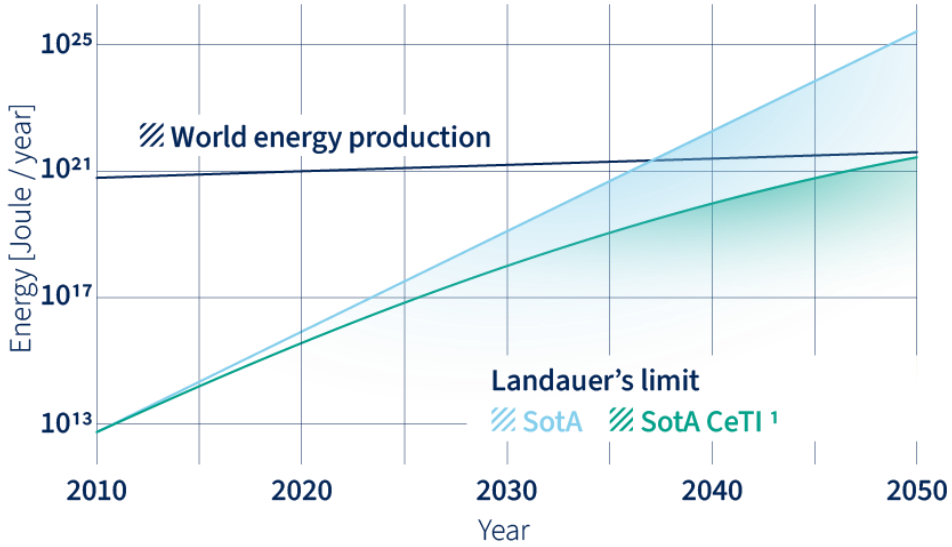

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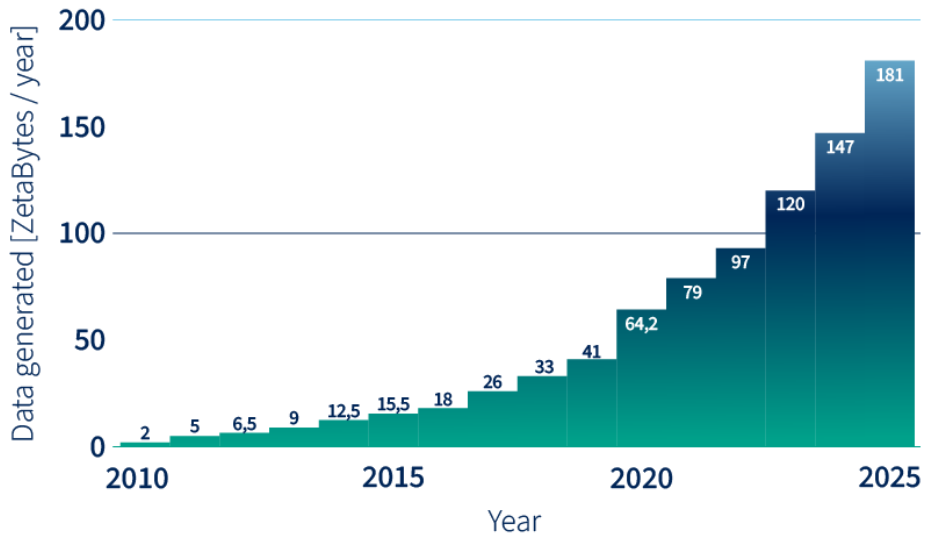

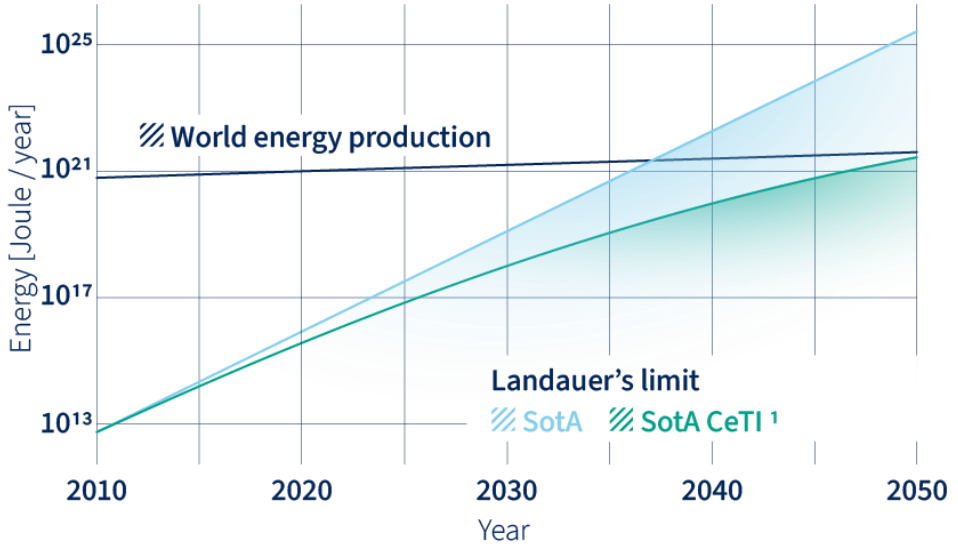

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Google to buy nuclear power for AI datacentres in 'world first' deal

The Guardian

Tech company orders six or seven small nuclear reactors from California's Kairos Power

Challenges and limits

Limits in communication and computing

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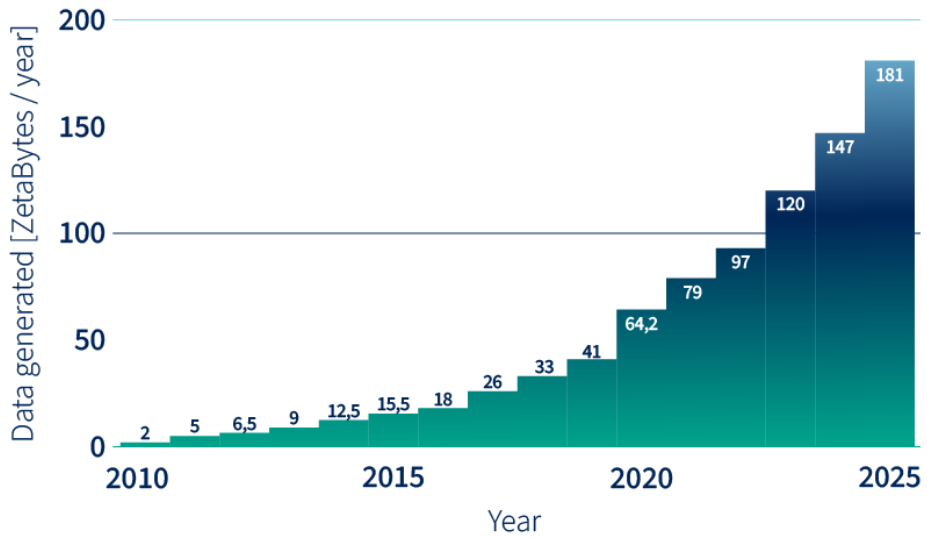

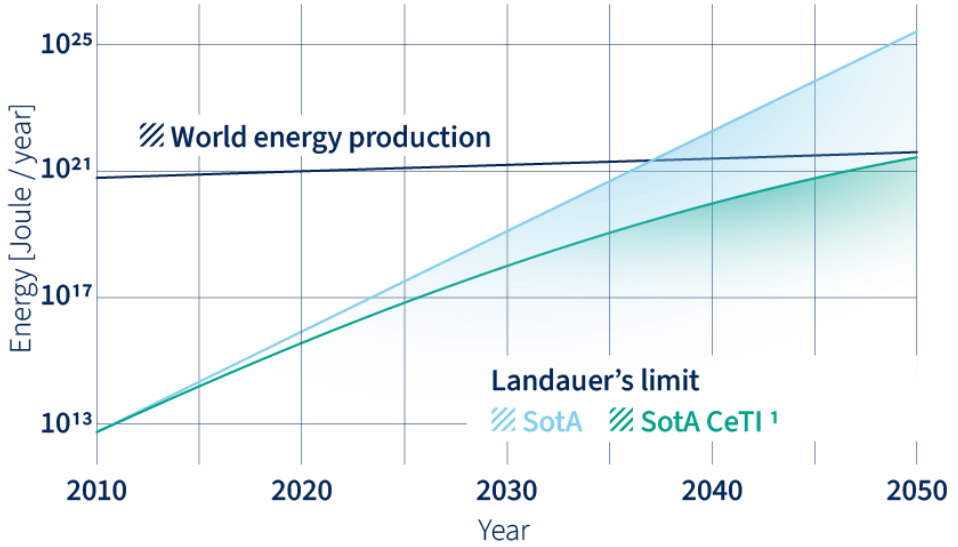

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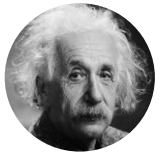
"non-computability in digital worlds"
– Alan M. Turing



"information speed is limited"
– Albert Einstein

Challenges and limits

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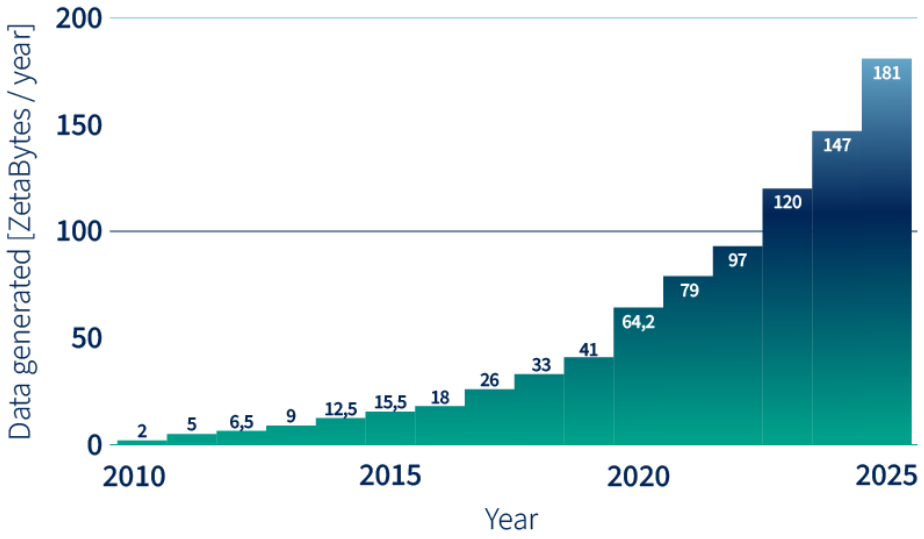

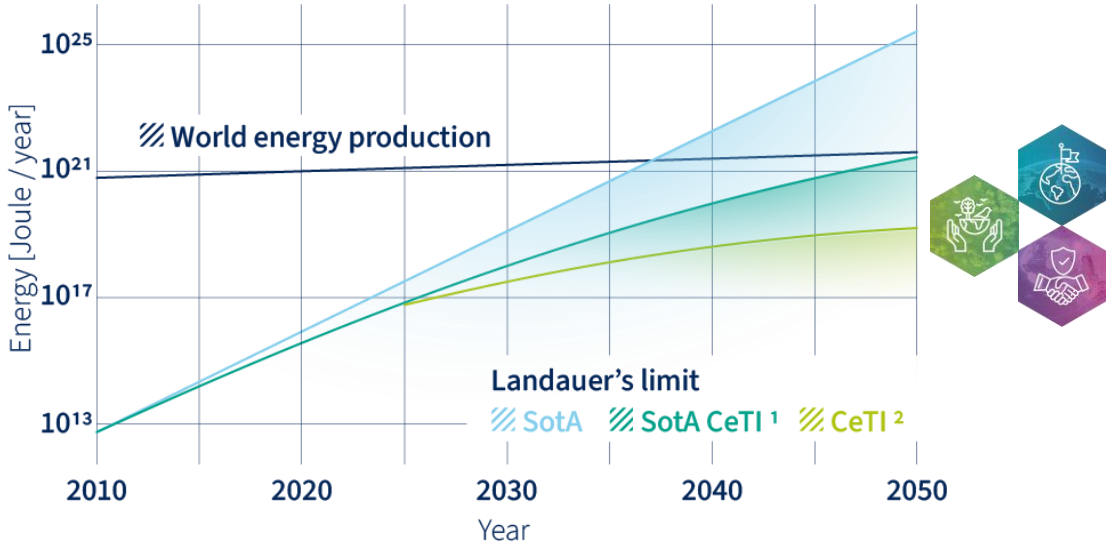

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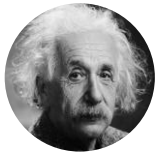

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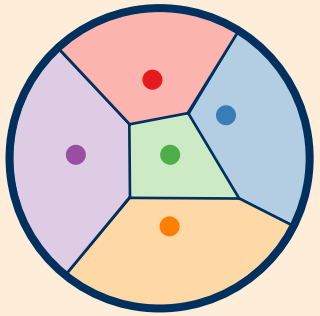
To cope with these limits, we address **fundamental research questions** related to the physical nature of information and computation, as well as the prediction of human behaviour following our designing rules.

Disruption is King!

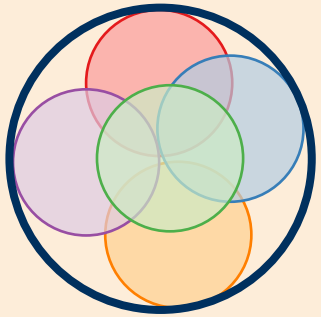
CeTI gAIn Next Generation AI Computing 6G-life

Disruption: Post Shannon Theory

Transmission: $N = 2^{nR}$



ID: $N = 2^{2^{nR}}$



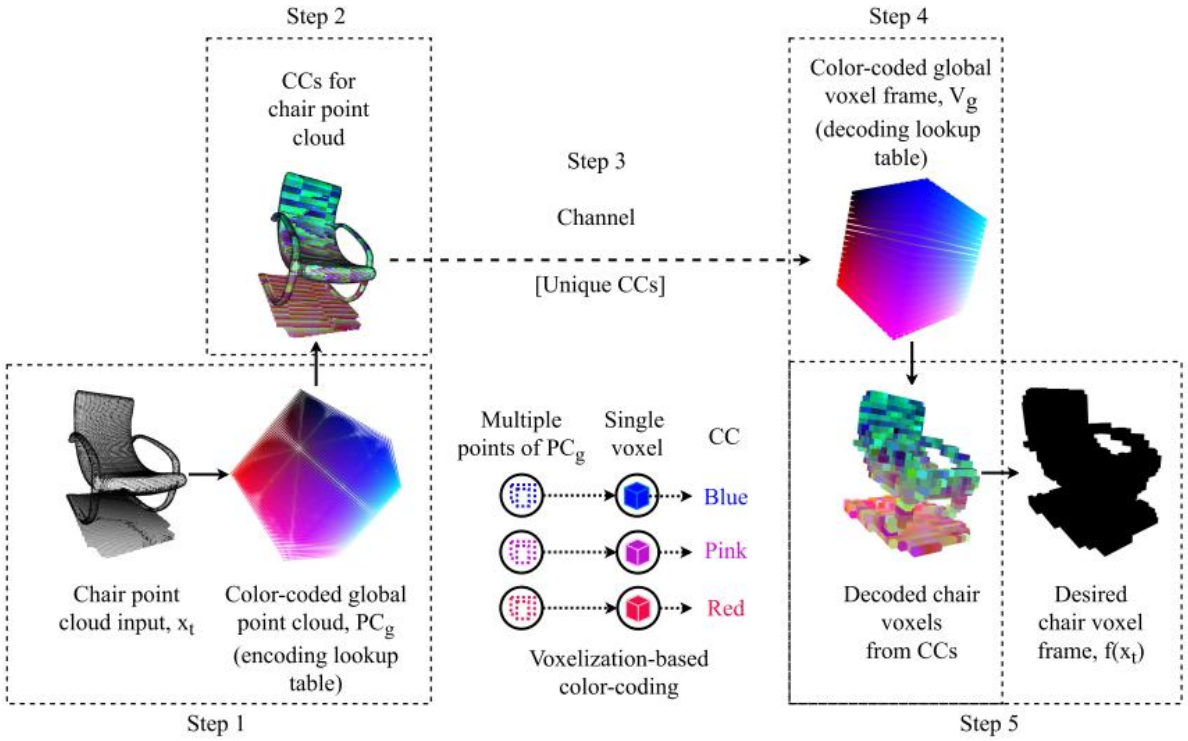
Discrete Memoryless Channel (DMC):

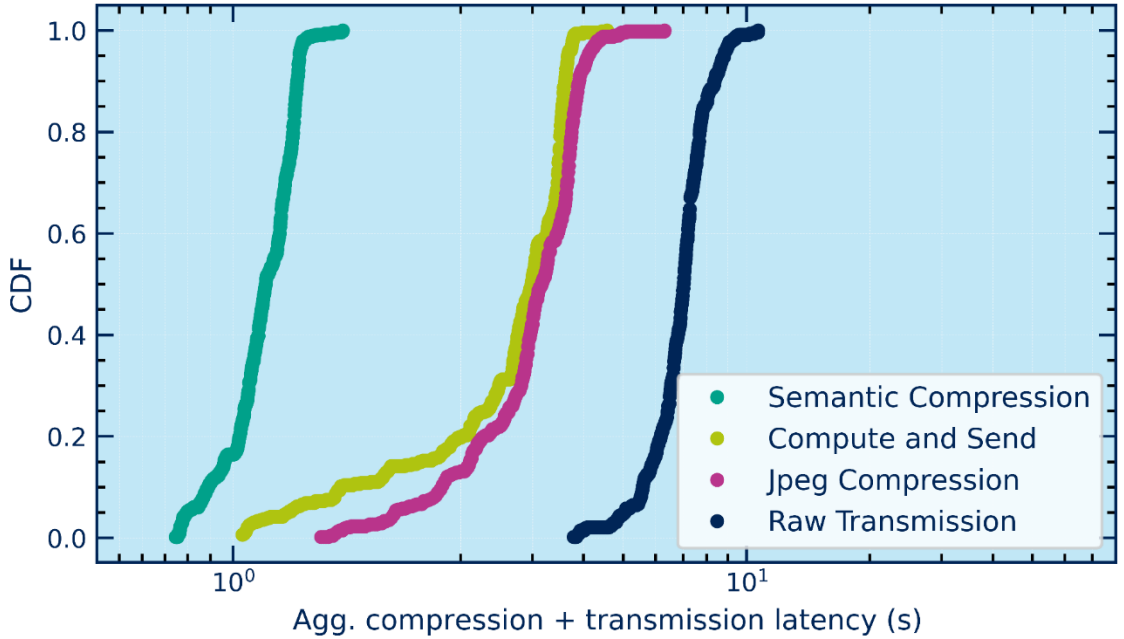
- N number of entities
- n number of bits
- R rate (0.0-1.0)

→ The number of identifiable entities **grows double exponentially** in block size, at the cost of a **new kind of error**

Disruption: Example of Post-Shannon for Control

Voxel-Based Semantic Compression for Networked Immersion

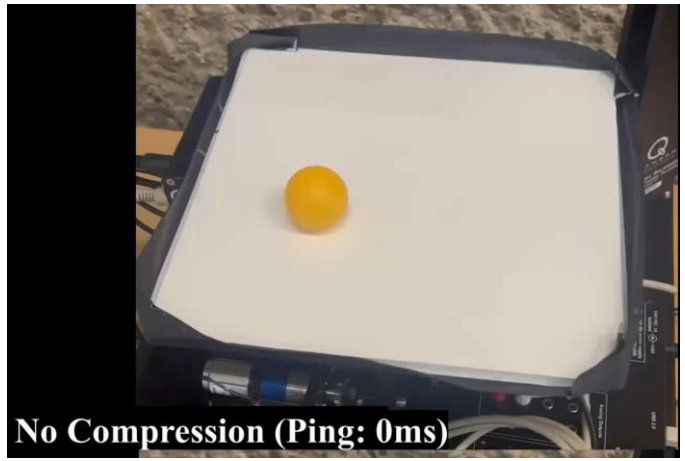


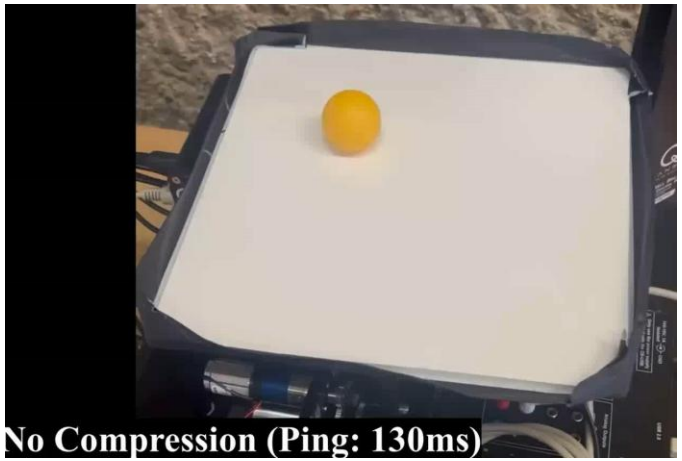


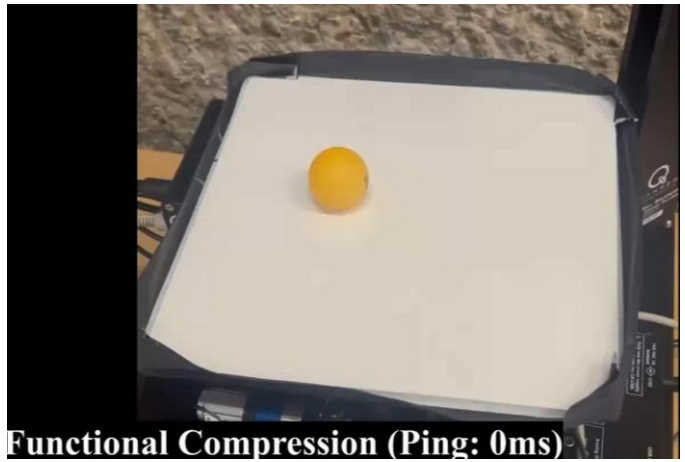
S. Rezwan, H. Wu, J. A. Cabrera, G. T. Nguyen, M. Reisslein and F. H. P. Fitzek, "**cXR+ Voxel-Based Semantic Compression for Networked Immersion**," in *IEEE Access, vol. 11, pp. 52763-52777, 2023*, doi: 10.1109/ACCESS.2023.3279503.

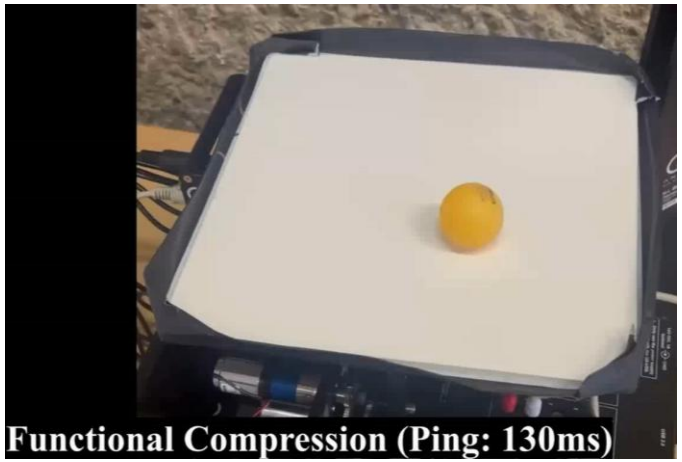
Disruption: Example of Post-Shannon for Control

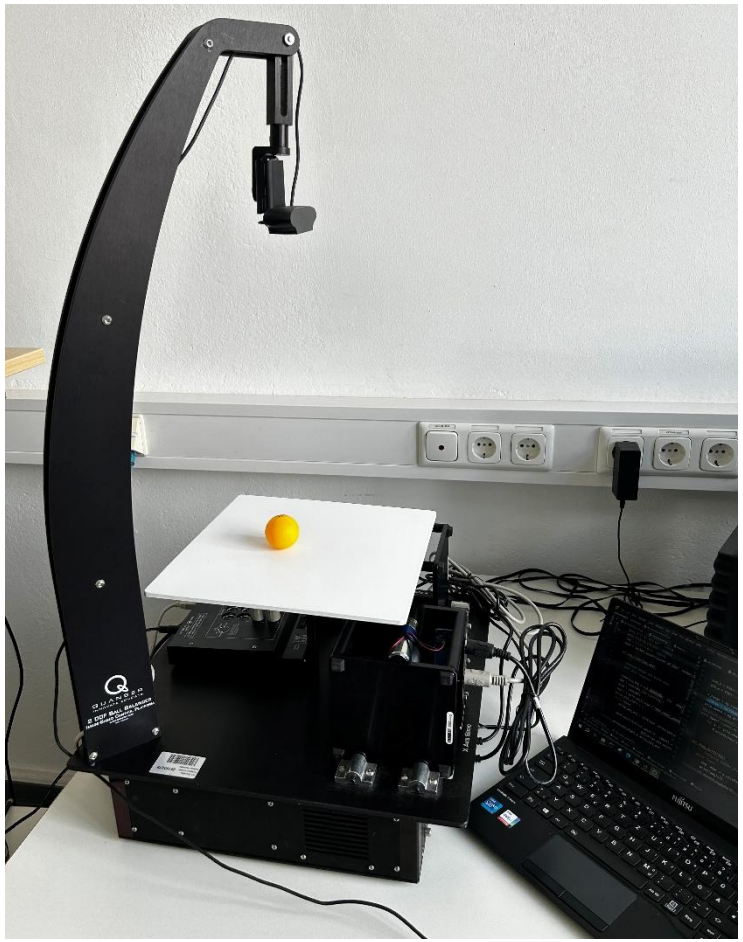
Balancing Beyond-Shannon: Demonstration of Functional Compression Using a Balancing Robot











S. Rezwan, J. A. Cabrera and F. H. P. Fitzek, **"Balancing Beyond-Shannon: Demonstration of Functional Compression Using a Balancing Robot,"** *2024 IEEE 21st Consumer Communications & Networking Conference (CCNC)*, Las Vegas, NV, USA, 2024, pp. 1112-1113, doi: 10.1109/CCNC51664.2024.10454858.

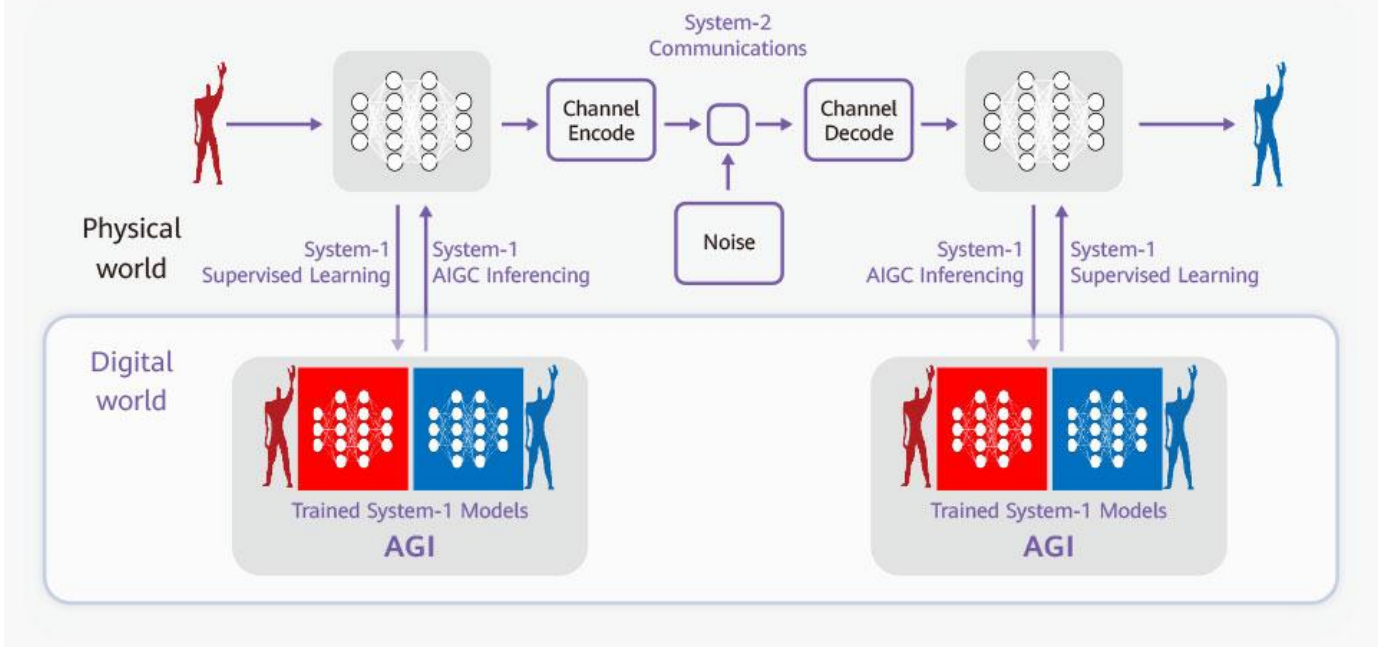
Disruption: Is Post-Shannon part of 6G?

HUAWEI Consumer Products Business Products Support Partners & Developers About Huawei

HuaweiTech

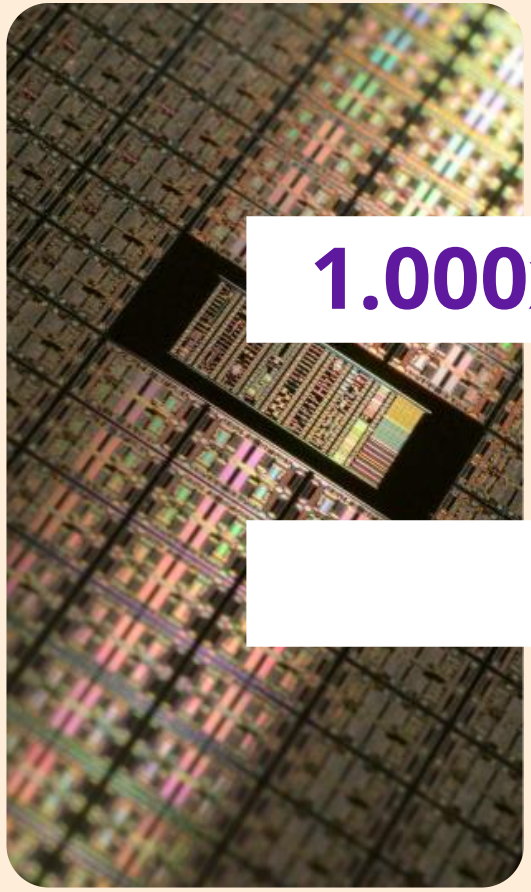
Future Technologies

AI: The Bridge to 6G



- Connected Intelligence = AGI for 6G + 6G for AGI
  - AGI for 6G: Effectiveness communication powered by the post-Shannon-model communication architecture
  - 6G for AGI: An inclusive intelligent neural center that integrates AI learning, training, and inference

Disruption: Computing



1.000x wrt energy

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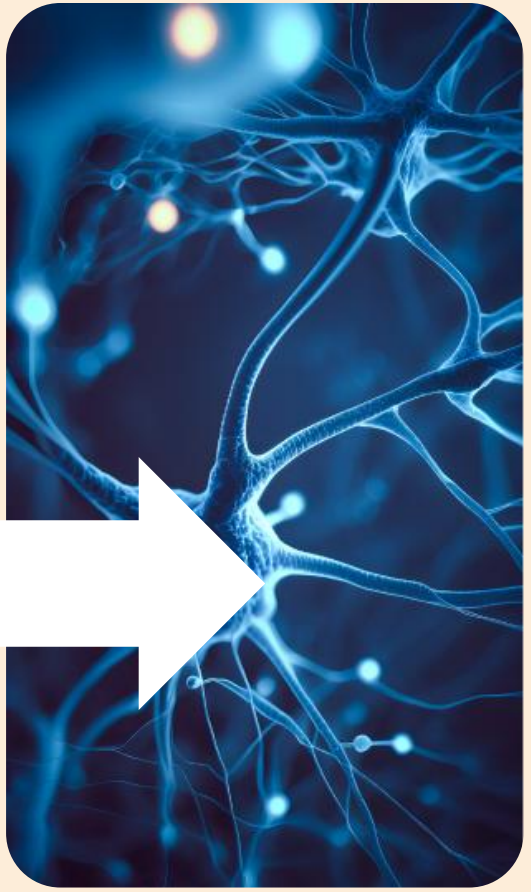
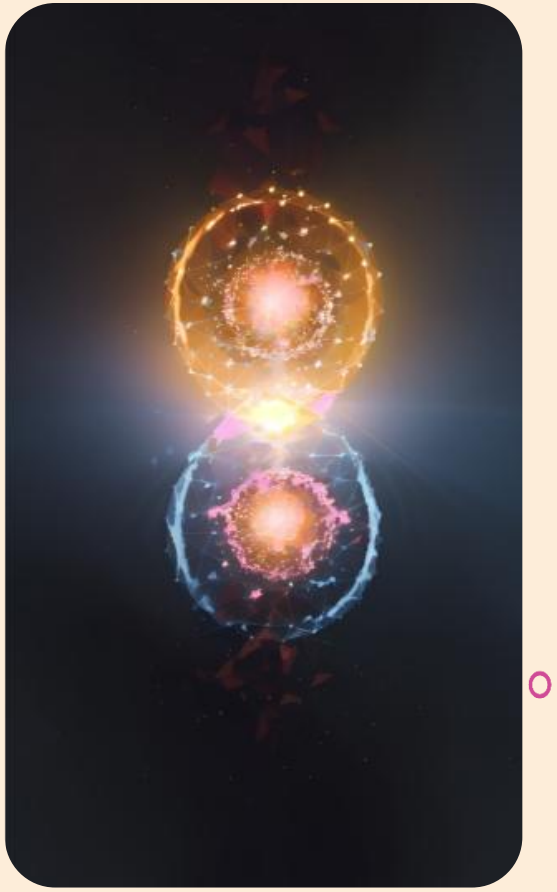




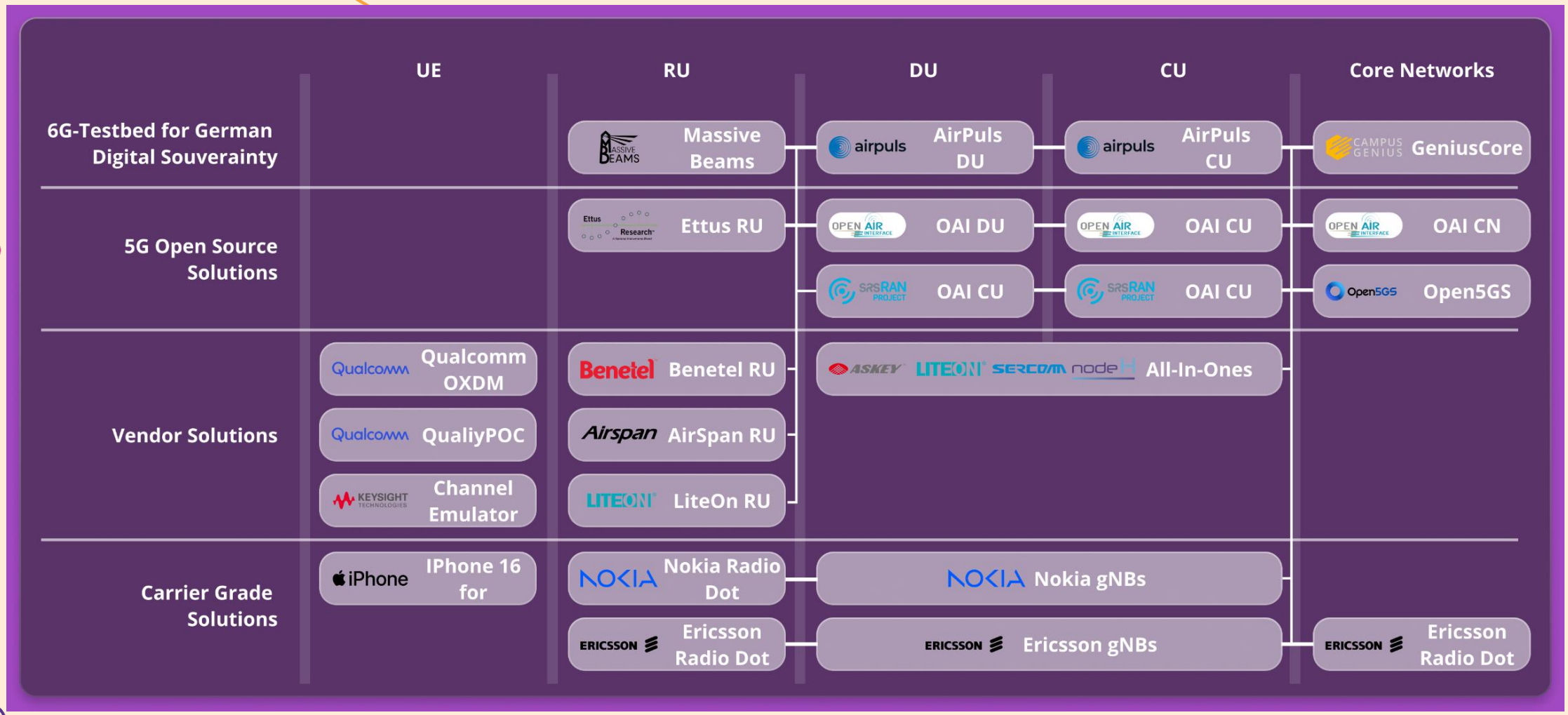
Digital | Analog | Biology | Quantum

CeTI /// gAIn Next Generation AI Computing 6G-life

Disruption: Computer Vision

soron
systems

Disruption: Technical Sovereignty & Testbeds



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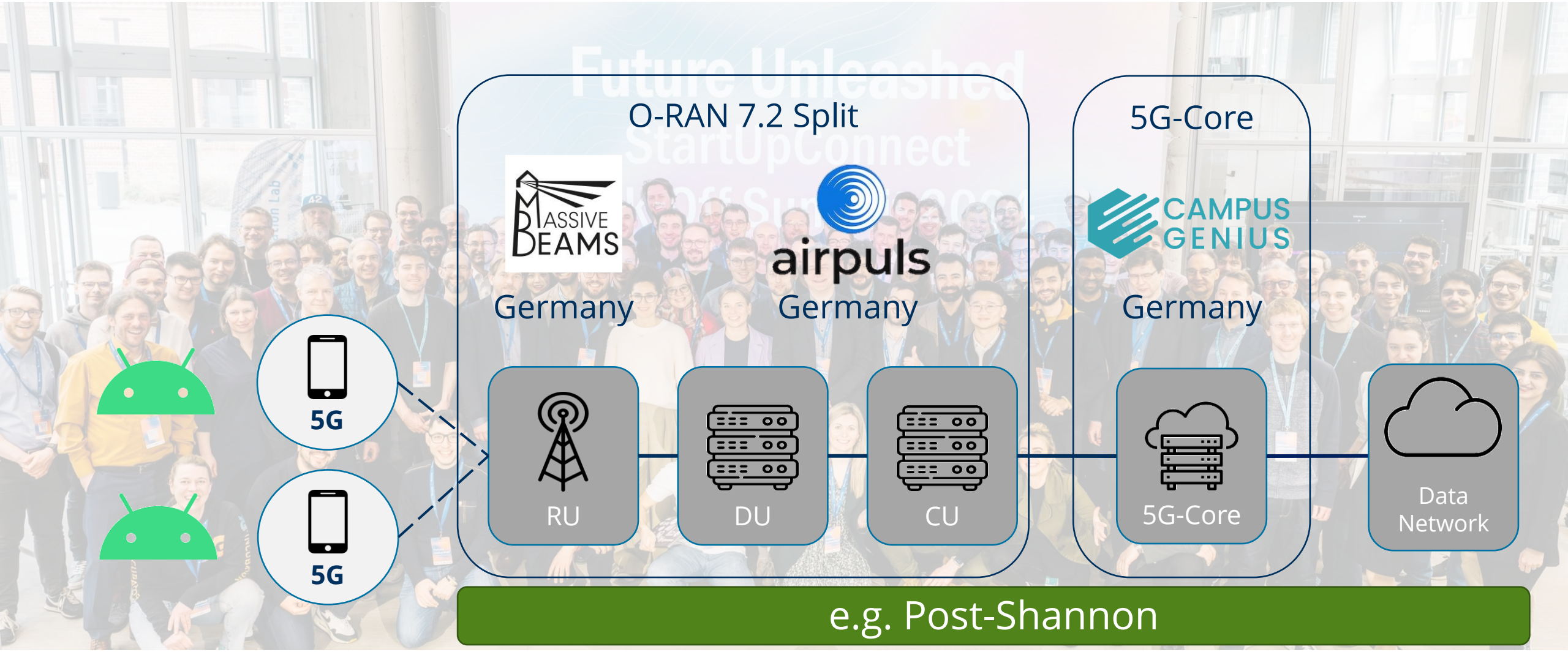
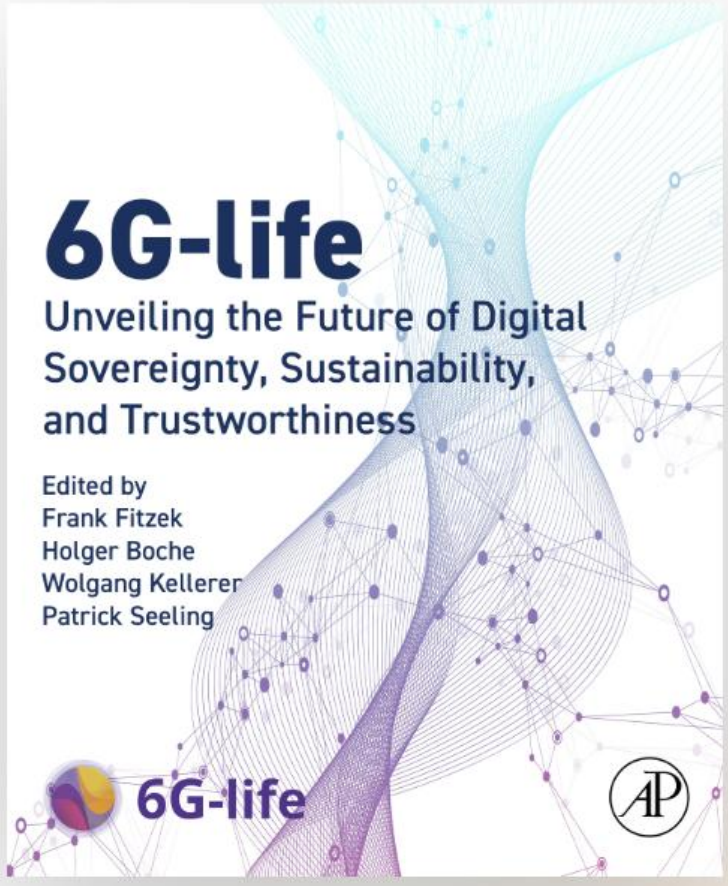


6G-life Book



- Big thanks to the team
- Bigger thanks to Christian Scheunert
- Currently processed by Elsevier

Coming soon!

6G-life: Unveiling the Future of Technological Sovereignty, Sustainability, and Trustworthiness

With both fundamental insights and practical applications, this book is an essential guide for researchers, engineers, and students.

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