International Conference on Computing Science, Communication and Security (COMS2)
Ganpat University, Mehsana, Gujarat, India, February 6-7, 2022

INTERNET OF NO THINGS IN THE ERA OF 6TH GENERATION NETWORKS

Prof. Martin Maier

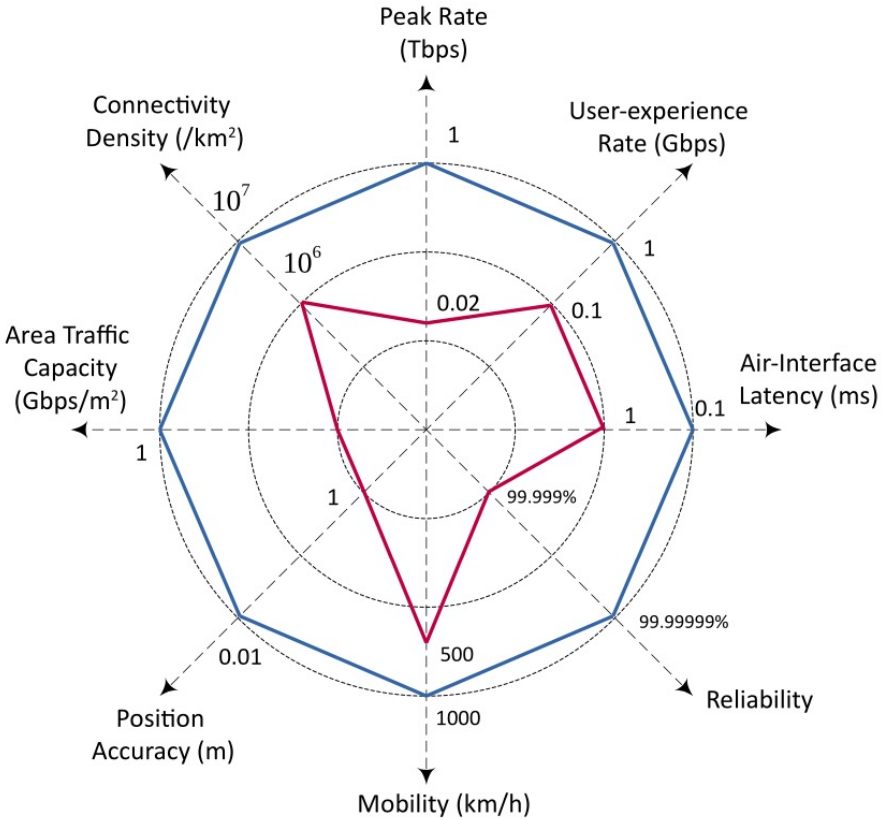
INRS
Institut national de la recherche scientifique

6G Vision | Tactile Internet | Internet of No Things

6G Vision | Tactile Internet | Internet of No Things

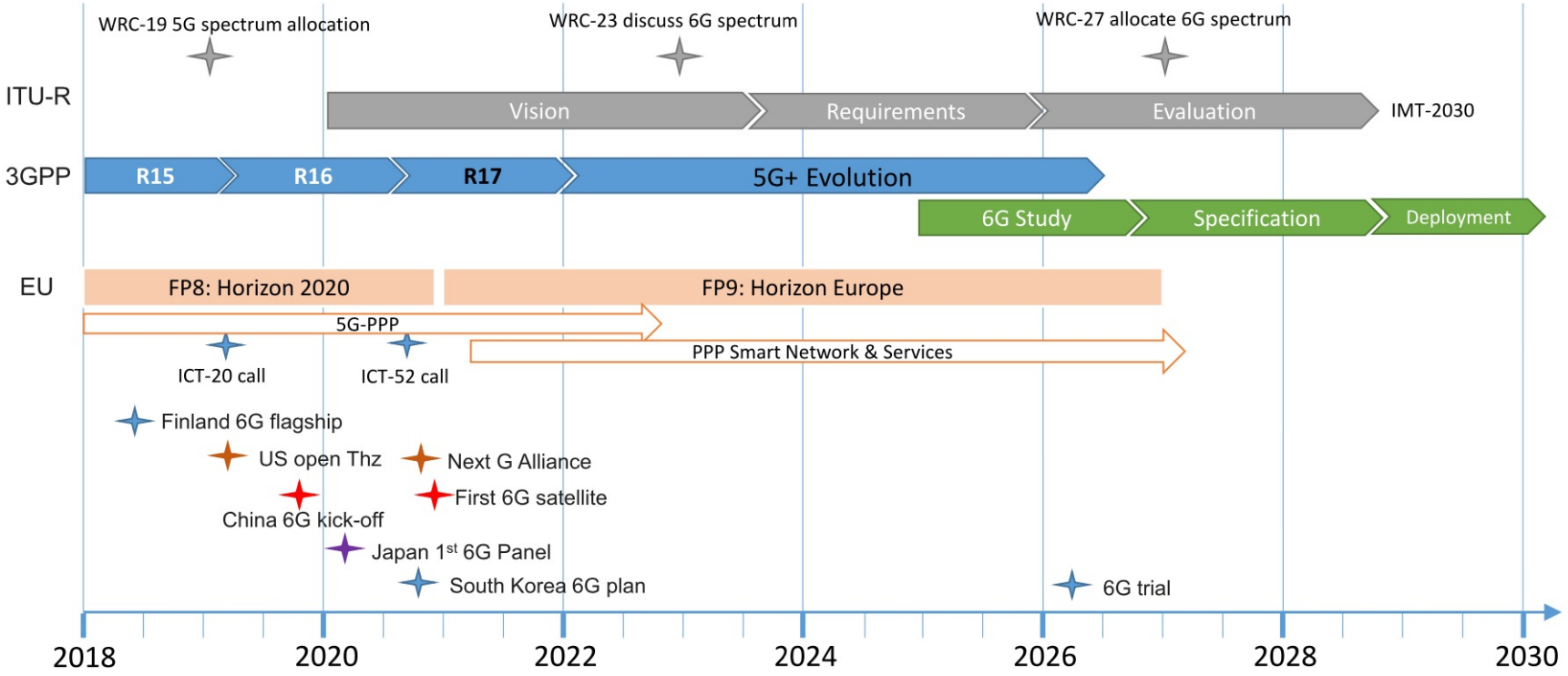
6G vs 5G: Same KPIs

- **Most 5G KPIs still valid for 6G, but scaled by 10, 100, or even higher**
  - Peak data rate: 1 Tbps
  - User-experience rate: 1 Gbps
  - Area traffic capacity: 1 Gbps/m^2
  - Connectivity density: 10^7/km^2
  - Air-interface latency: 0.1 ms
  - Reliability: 99.99999%
  - Mobility: 1000 km/h
  - Position accuracy: 0.01 m



W. Jiang et al., “The Road Towards 6G: A Comprehensive Survey,” IEEE Open Journal of the Communications Society, Feb. 2021.

6G Standardization: Roadmap



W. Jiang et al., “The Road Towards 6G: A Comprehensive Survey,” IEEE Open Journal of the Communications Society, Feb. 2021.

6G Standardization: SDO Efforts

- European Telecommunications Standards Institute (ETSI)
- Next Generation Mobile Networks (NGMN) Alliance
- Alliance for Telecommunications Industry Solutions (ATIS)
- Next G Alliance (US/CAN operators & manufacturers & Apple/Google/FB/MS)
- Association of Radio Industries and Businesses (ARIB)
- 3rd Generation Partnership Project (3GPP)
- IEEE Future Networks (FN) Initiative
- **ITU-T Focus Group on Technologies for Network 2030 (FG-NET-2030)**

W. Jiang et al., “The Road Towards 6G: A Comprehensive Survey,” IEEE Open Journal of the Communications Society, Feb. 2021.

ITU-T FG-NET-2030

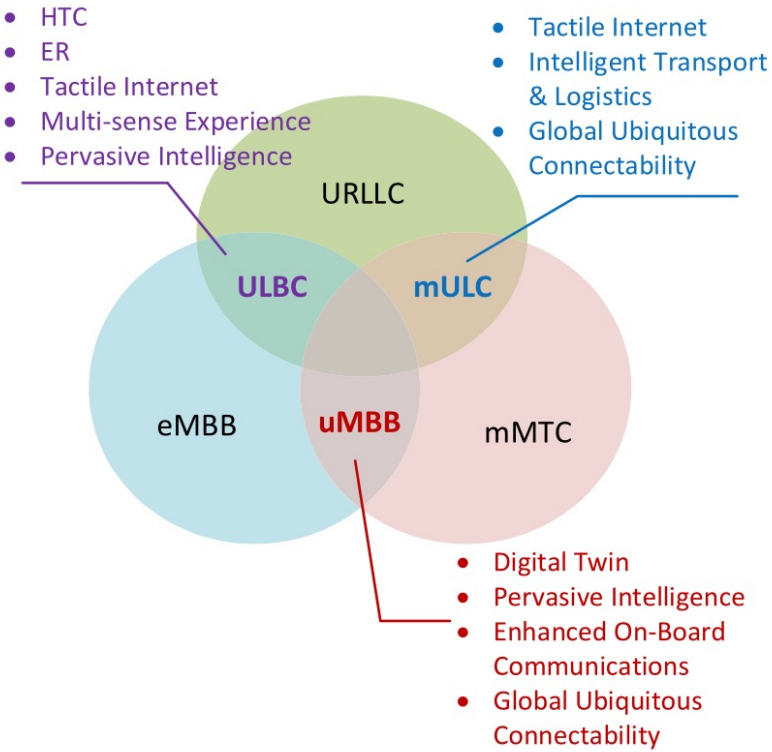
- Focus on **fixed (wireline) networks** and related technologies
- Driving themes for Network 2030
  - **Fusion of digital and real worlds** across all dimensions used by human beings, or by physical, digital, or virtual objects
  - **Multi-sense networks** including haptic communication services
  - **Time-engineered communication services**

White Paper “Network 2030 – A Blueprint of Technology, Applications and Market Drivers Towards the Year 2030 and Beyond,” 2019.

6G: Enhanced Services & Disruptive Applications

- **6G Enhanced Services**
  - Ubiquitous MBB (uMBB)
  - Massive URLLC (mULC)
  - Ultra-reliable low-latency broadband communication (ULBC)

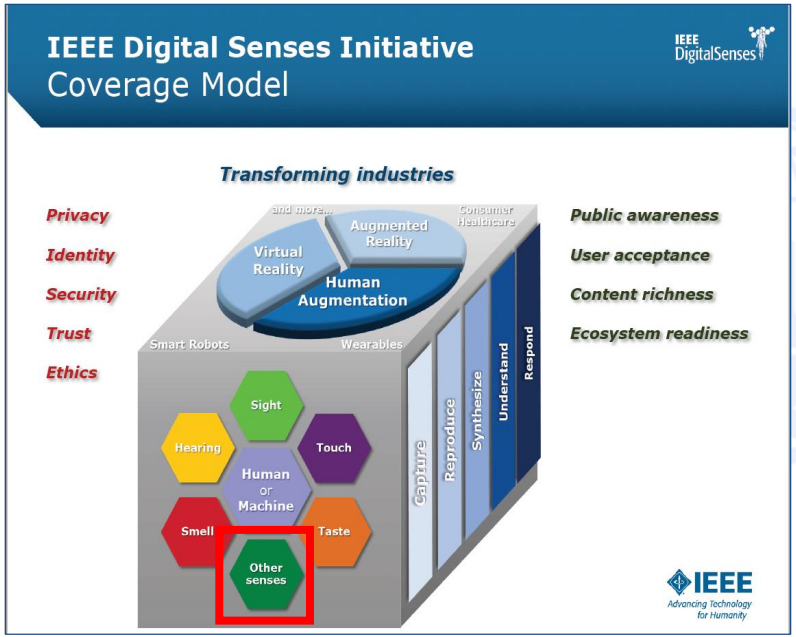
- **6G Disruptive Applications**
  - Tactile Internet
  - Multi-sense Experience
  - Extended Reality
  - Pervasive Intelligence
  - Digital Twin

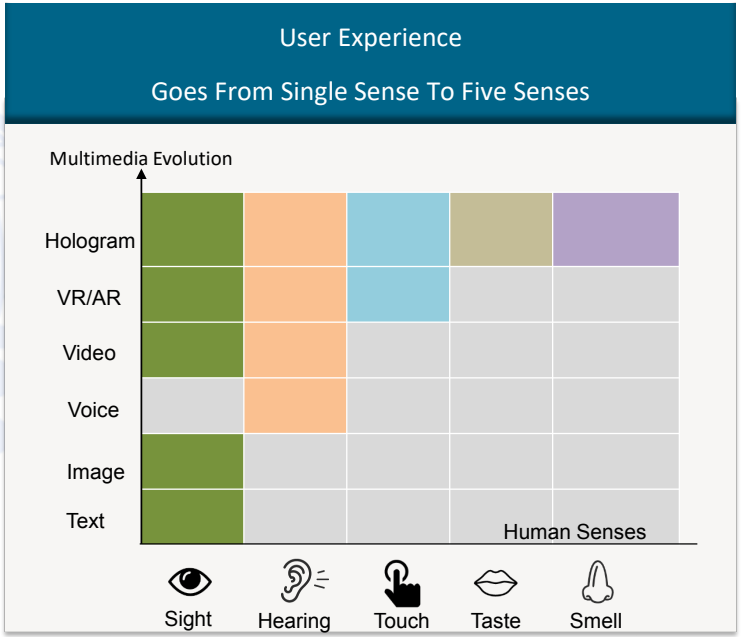


W. Jiang et al., "The Road Towards 6G: A Comprehensive Survey," IEEE Open Journal of the Communications Society, Feb. 2021.

6G Vision | Tactile Internet | Internet of No Things

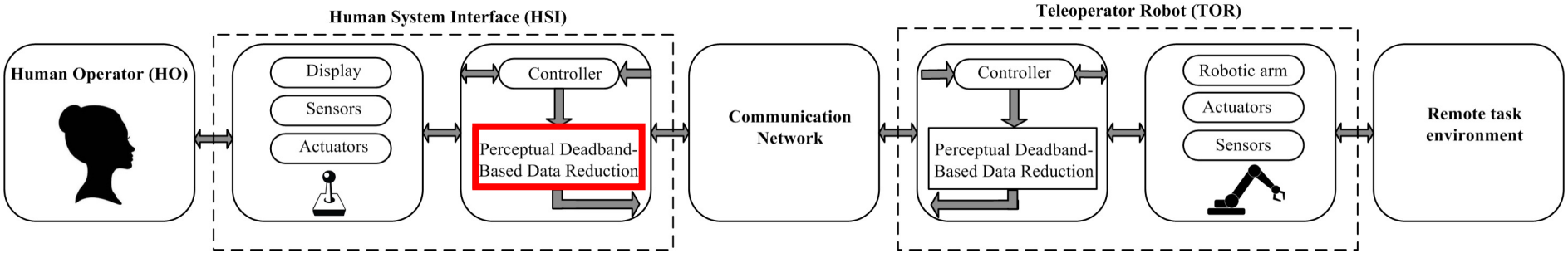
Digital Senses and Digital Reality

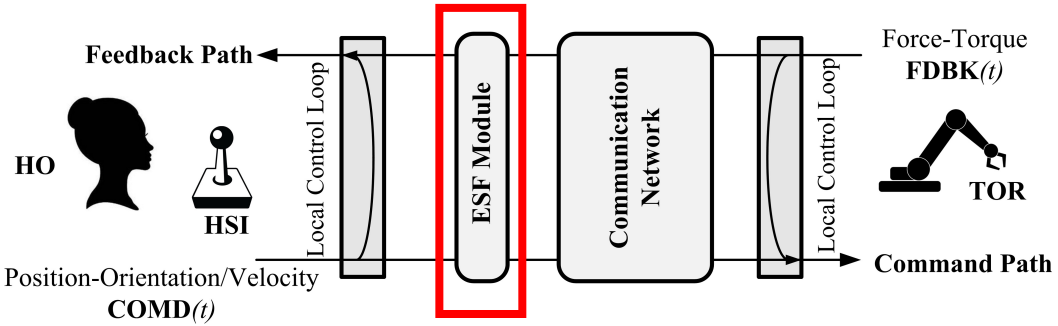




- Well explored: sight, hearing
- Emerging: touch, taste, smell

Haptic Communications & Teleoperation





Edge Sample Forecast (ESF) via AI Enhanced MEC

ESF: Multi-Layer Perceptron (MLP)

Algorithm 1 Edge Sample Forecast

Input: $\mathcal{T}, \mathcal{S}, t_0, \Xi$
Output: θ^*

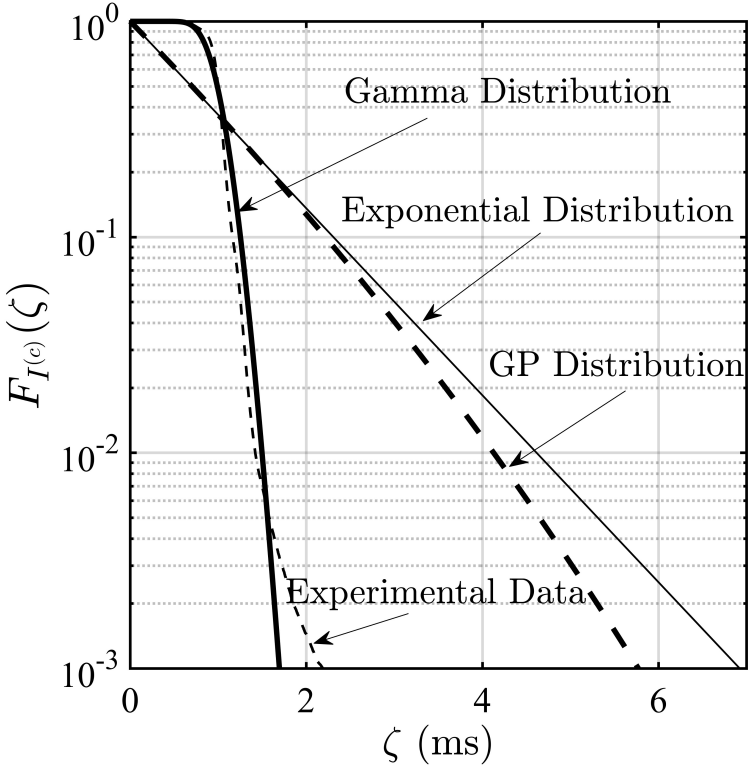
$\delta = 1/F_s$
$\mathcal{T}^\delta, \mathcal{S}^\delta = \text{SAMPLE\_ALIGNER}(\mathcal{T}, \mathcal{S}, \delta)$
$\Delta \leftarrow \left\lceil \frac{t_0 - \mathcal{T}^\delta(L)}{\delta} \right\rceil$
$\mathcal{A}_0 \leftarrow \left(s_1^\delta, ..., s_L^\delta\right) \in \mathbb{R}^L$
for $i = 1$ to Δ **do**
  $t_i^* \leftarrow t_L^\delta + i \times \delta$
  $\theta_i = \Psi\left(\mathcal{A}_{i-1}, \Xi\right)$
  $\mathcal{A}_i = \left(\mathcal{A}_{i-1}(2), \mathcal{A}_{i-1}(3), ..., \mathcal{A}_{i-1}(L), \theta_i\right)$
end for
$\theta^* \leftarrow \frac{\theta_\Delta - \theta_{\Delta-1}}{t_\Delta^* - t_{\Delta-1}^*}\left(t_0 - t_{\Delta-1}^*\right) + \theta_{\Delta-1}$
return θ^*

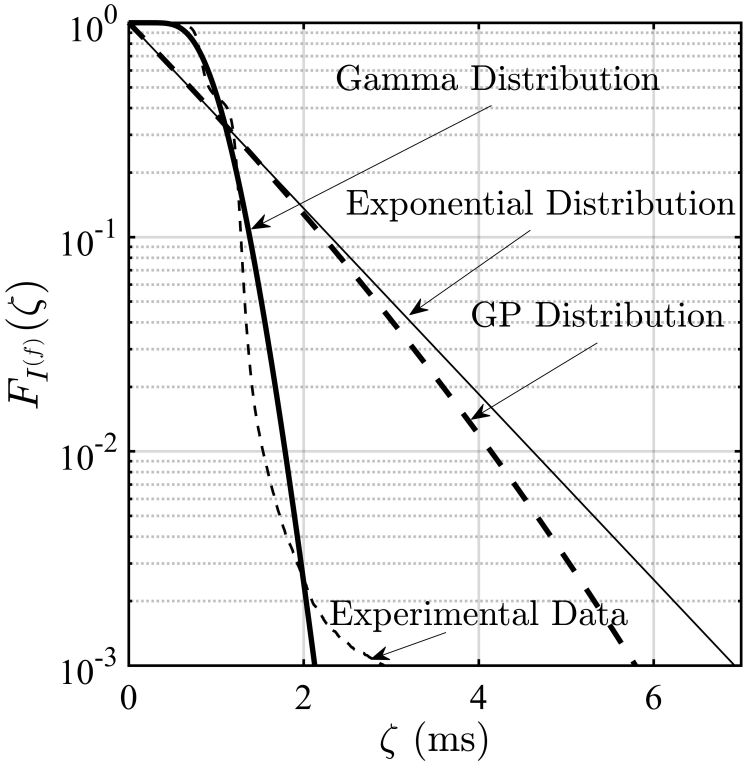
Algorithm 2 SAMPLE_ALIGNER()

Input: $\mathcal{T}, \mathcal{S}, \delta$
Output: $\mathcal{T}^\delta, \mathcal{S}^\delta$

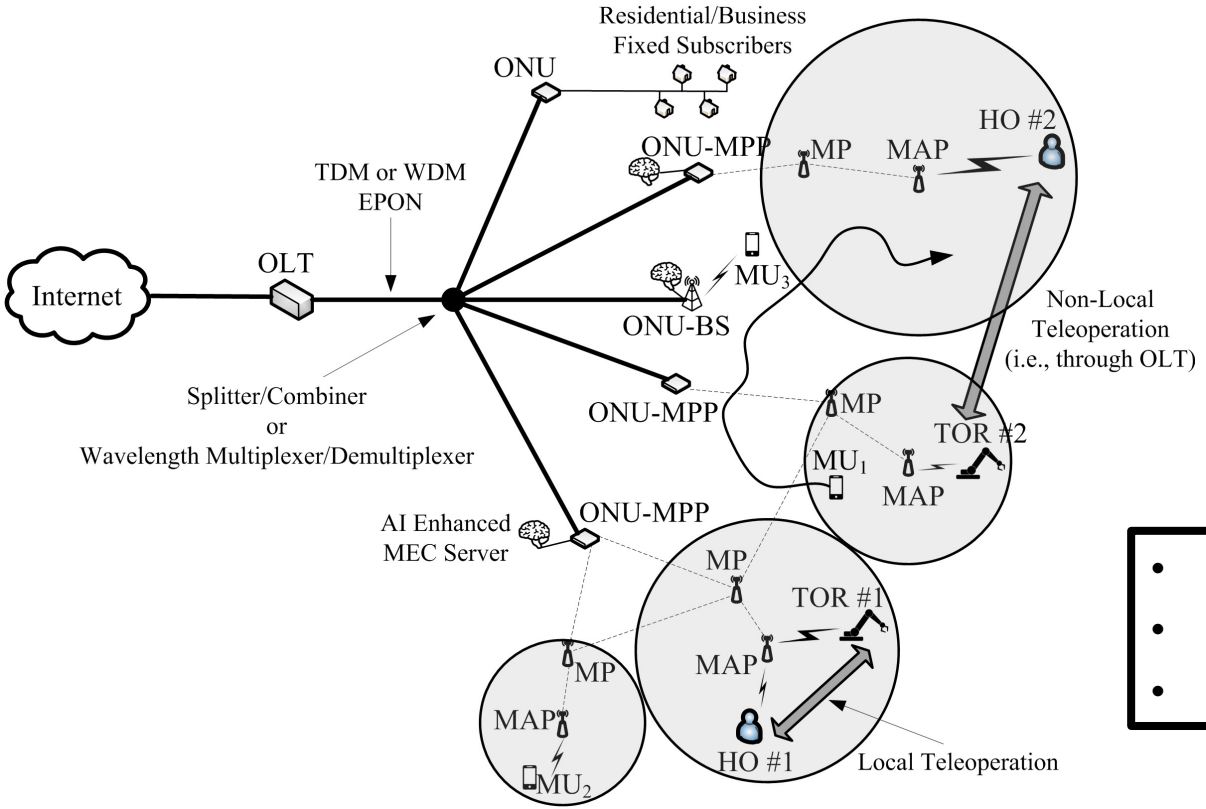
$L \leftarrow \left\lceil \frac{t_K - t_1}{\delta} \right\rceil$
for $i = 1$ to L **do**
  $t_i^\delta \leftarrow t_1 + (i-1)\delta$
end for
$s_1^\delta \leftarrow s_1$
for $i = 2$ to L **do**
  $s_i^\delta \leftarrow \frac{s_j - s_{j-1}}{t_j - t_{j-1}}\left(t_i^\delta - t_{j-1}\right) + s_{j-1}, \forall j : t_{j-1} < t_i^\delta < t_j$
end for
return $\mathcal{T}^\delta, \mathcal{S}^\delta$

Haptic Traffic Traces: Packet Interarrival Times



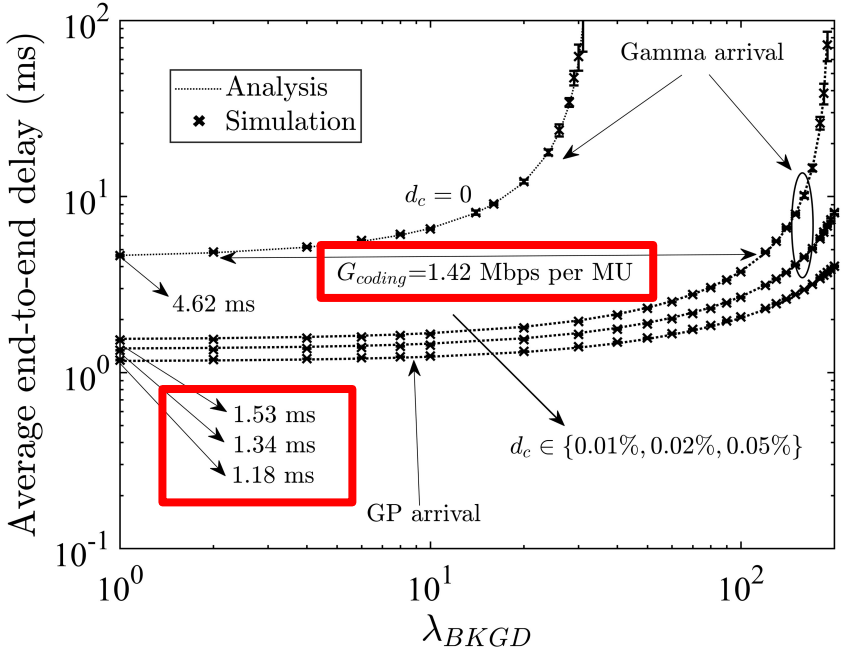


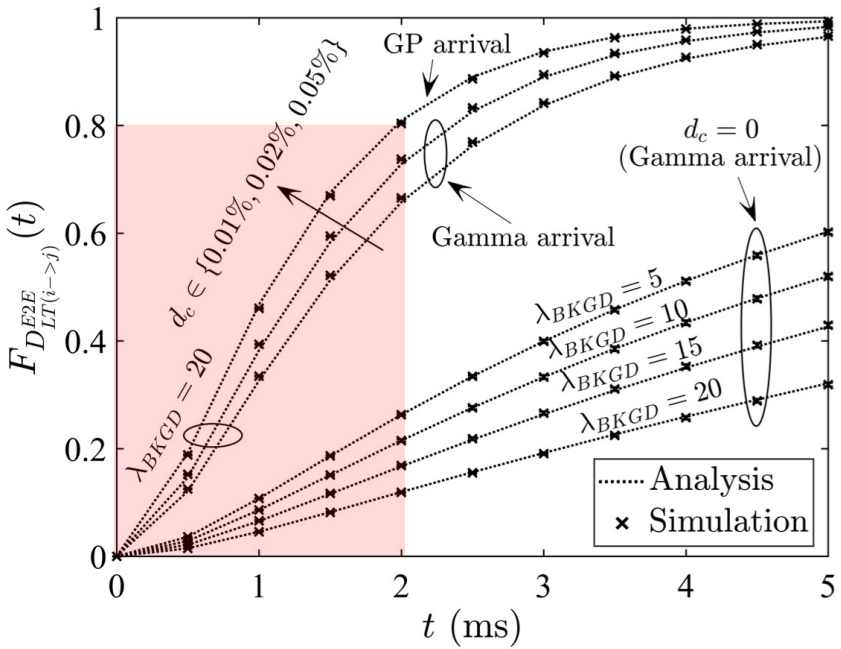
Tactile Internet: FiWi Enhanced LTE-A HetNets



- MU: Mobile User
- HO: Human Operator
- TOR: Teleoperator Robot

Tactile Internet: Time-Engineered Communications

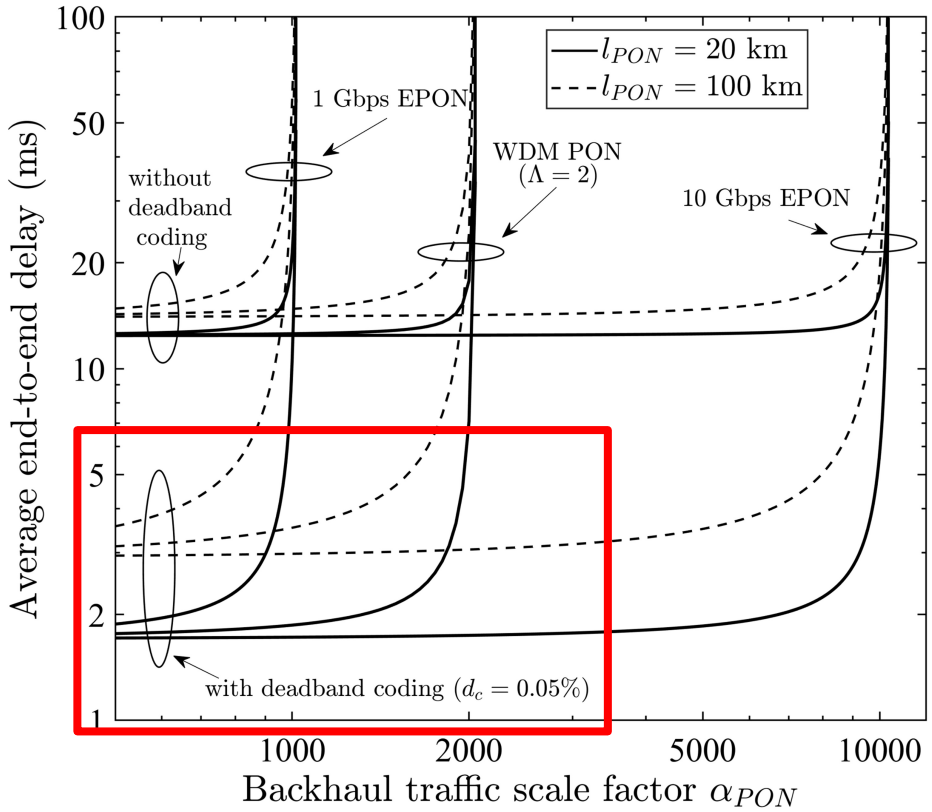




Deadband coding gain of 1.42 Mbps per MU for upper E2E delay limit of 4.8 ms

E2E delay below 2 ms with probability as high as 0.8

Tactile Internet: NG-PON Backhaul

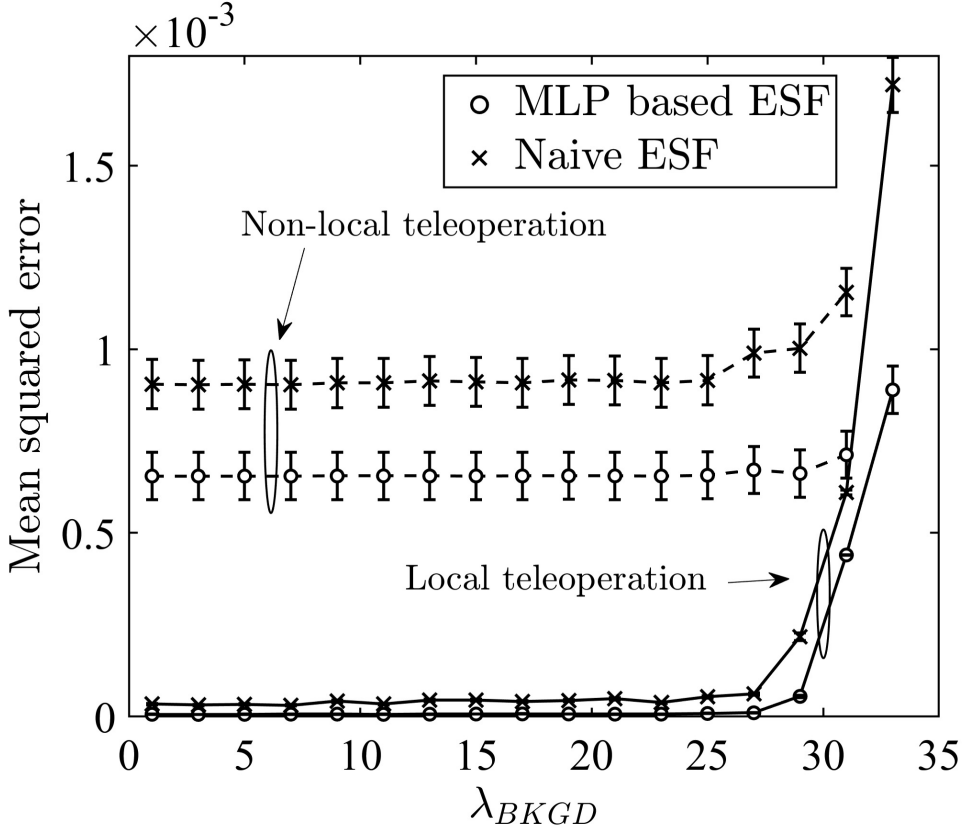


Deadband Coding & PON Backhaul:

- 1/10 Gbps EPON
- WDM PON

Sufficient to achieve average E2E delay of 1-10 ms

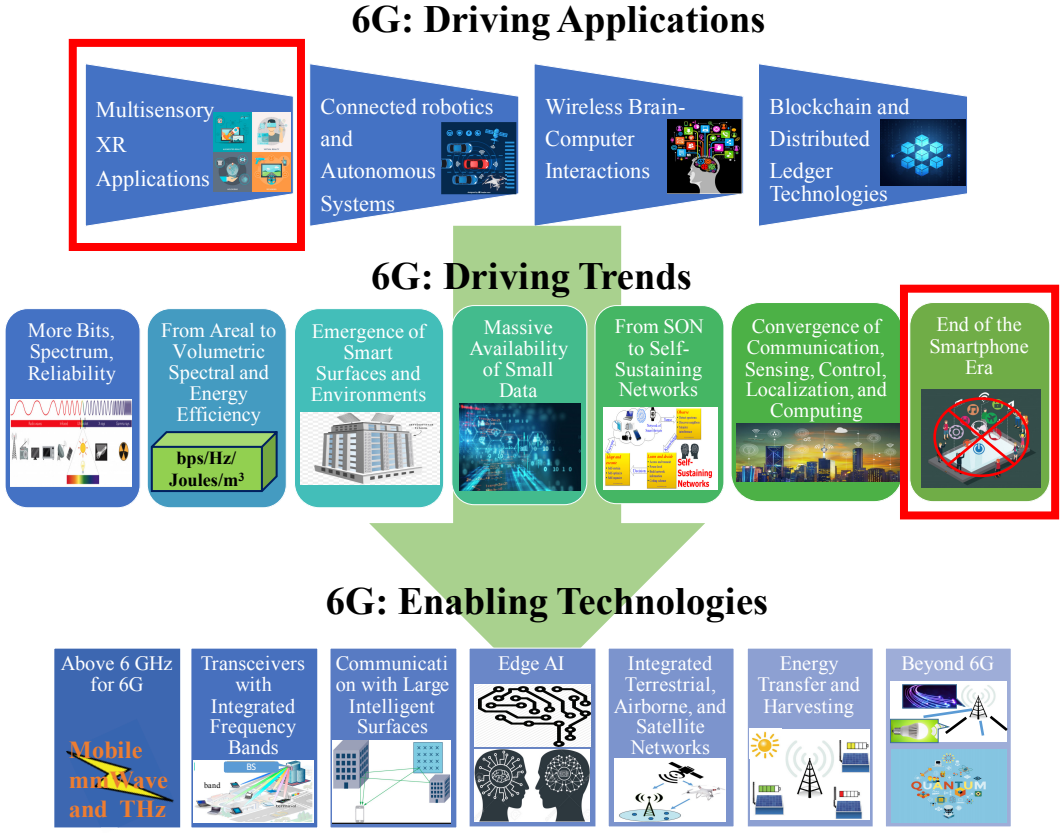
Tactile Internet: ESF Forecasting Accuracy



Haptic traffic traces used to train MLP based ESF to **perceive remote task environment in real-time at 1-ms granularity**

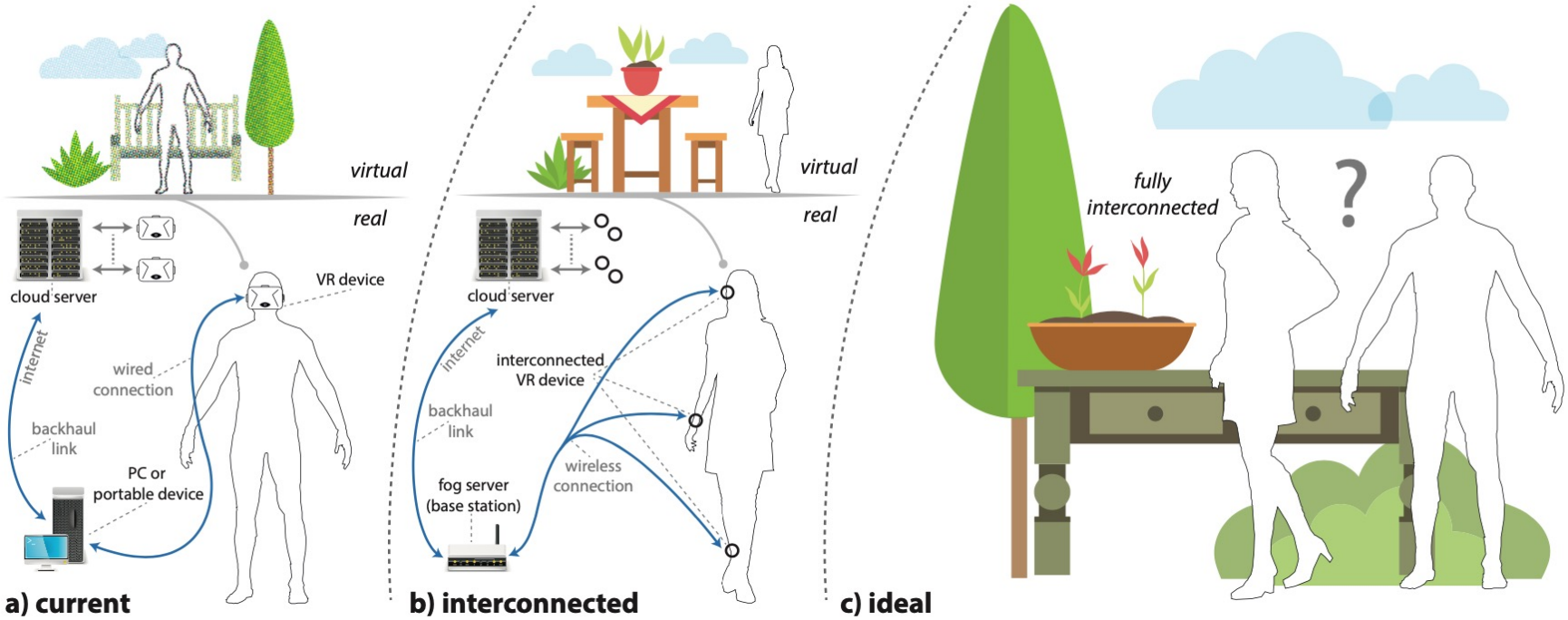
6G Vision | Tactile Internet | Internet of No Things

6G: Convergence of Technologies



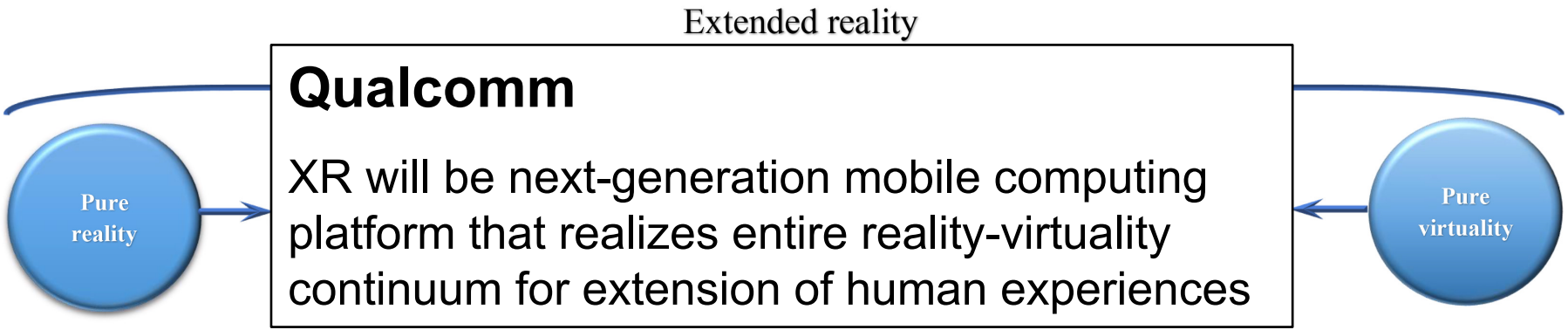
W. Saad, M. Bennis, and M. Chen, "A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems," IEEE Network, vol. 34, no. 3, pp. 134-142, May/June 2020.

The 3 Evolutionary Stages of VR Systems



E. Bastrug et al., “Toward Interconnected Virtual Reality: Opportunities, Challenges, and Enablers,” IEEE Communications Magazine, June 2017.

XR: Extended Reality



6G Post-Smartphone Era

The user lives “naked” without gadgets.

Services materialize when the user needs them ...

... and disappear when not needed.

J. Aikio et al., “On The Road to Digital Paradise: The Naked Approach,” The Naked Approach Project, Finland, 2016.

Eric Schmidt: “The Internet Will Disappear”

Davos 2015

Ubiquitous Computing

Mark Weiser, CTO Xerox PARC

(Scientific American, September 1991):

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

The Computer for the 21st Century

Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence

by Mark Weiser

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Consider writing, perhaps the first information technology. The ability to represent spoken language symbolically for long-term storage freed information from the limits of individual memory. Today this technology is ubiquitous in industrialized countries. Not only do books, magazines and newspapers convey written information, but so do street signs, billboards, shop signs and even graffiti. Candy wrappers are covered in writing. The constant background presence of these products of "literacy technology" does not require active attention, but the information to be transmitted is ready for use at a glance. It is difficult to imagine modern life otherwise.

Silicon-based information technology, in contrast, is far from having become part of the environment. More than 50 million personal computers have been sold, and the computer nonetheless remains largely in a world of its own. It is approachable only through complex jargon that has nothing to do with the tasks for which people use computers. The state of the art is perhaps analogous to the period when scribes had to know as much about making ink or baking clay as they did about writing.

The arcane aura that surrounds personal computers is not just a "user interface" problem. My colleagues and I at the Xerox Palo Alto Research Center think that the idea of a "personal" computer itself is misplaced and that the vision of laptop machines, dynabooks and "knowledge navigators" is only a transitional step toward achieving the real potential of information technology. Such machines cannot truly make computing an integral, invisible part of people's lives. We are therefore trying to conceive a new way of thinking about computers, one that takes into account the human world and allows the computers themselves to vanish into the background.

Such a disappearance is a fundamental consequence not of technology but of human psychology. Whenever people learn something sufficiently well, they cease to be aware of it. When you look at a street sign, for example, you absorb its information without consciously performing the act of reading. Computer scientist, economist and Nobelist Herbert A. Simon calls this phenomenon "compiling"; philosopher Michael Polanyi calls it the "tacit dimension"; psychologist J. J. Gibson calls it "visual invariants"; philosophers Hans Georg Gadamer and Martin Heidegger call it the "horizon" and the "ready-to-hand"; John Seely Brown of PARC calls it the "periphery." All say, in essence, that only when things disappear in this way are we freed to use them without thinking and so to focus beyond them on new goals.

The idea of integrating computers seamlessly into the world at large runs counter to a number of present-day trends. "Ubiquitous computing" in this context does not mean just computers that can be carried to the beach, jungle or airport. Even the most powerful notebook computer, with access to a worldwide information network, still focuses attention on a single box. By analogy with writing, carrying a superlaptop is like owning just one very important book. Customizing this book, even writing millions of other books, does not begin to capture the real power of literacy.

Furthermore, although ubiquitous computers may use sound and video in addition to text and graphics, that does not make them "multimedia computers." Today's multimedia machine makes the computer screen into a demanding focus of attention rather than allowing it to fade into the background.

Perhaps most diametrically opposed to our vision is the notion of virtual reality, which attempts to make a world inside the computer. Users don special goggles that project an artificial scene onto their eyes; they wear gloves or even bodysuits that sense their motions and gestures so that they can move about and manipulate virtual objects. Although it may have its purpose in allowing people to explore realms otherwise inaccessible—the insides of cells, the surfaces of distant planets, the information web of data bases—virtual reality is only a map, not a territory. It excludes desks, offices, other people not wearing goggles and bodysuits, weather, trees, walks, chance encounters and, in general, the infinite richness of the universe. Virtual reality focuses an enormous apparatus on simulating the world rather than on invisibly enhancing the world that already exists.

Indeed, the opposition between the

MARK WEISER is head of the Computer Science Laboratory at the Xerox Palo Alto Research Center. He is working on the next revolution of computing after workstations, variously known as ubiquitous computing or embodied virtuality. Before working at PARC, he was a professor of computer science at the University of Maryland; he received his Ph.D. from the University of Michigan in 1979. Weiser also helped found an electronic publishing company and a video arts company and claims to enjoy computer programming "for the fun of it." His most recent technical work involved the implementation of new theories of automatic computer memory reclamation, known in the field as garbage collection.

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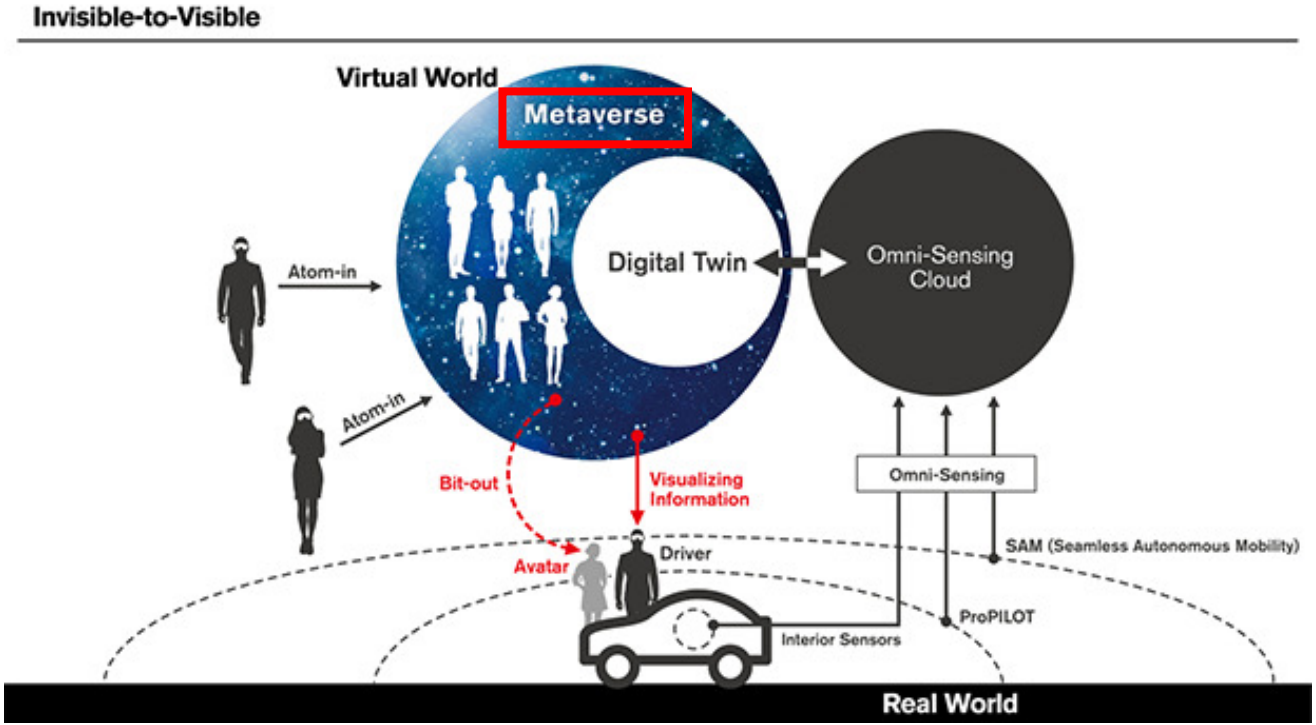
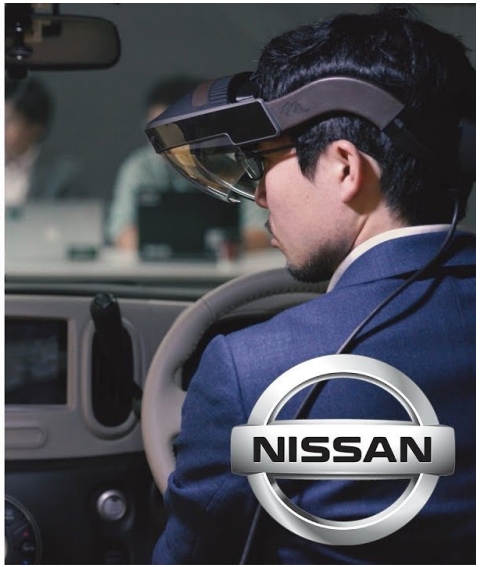
Nissan's I2V Concept to `See the Invisible'



Nissan Newsroom, "Nissan unveils Invisible-to-Visible technology concept at CES: Future connected-car technology merges real and virtual worlds to help drivers `see the invisible'," Jan. 2019.

Nissan’s I2V Concept to `See the Invisible’



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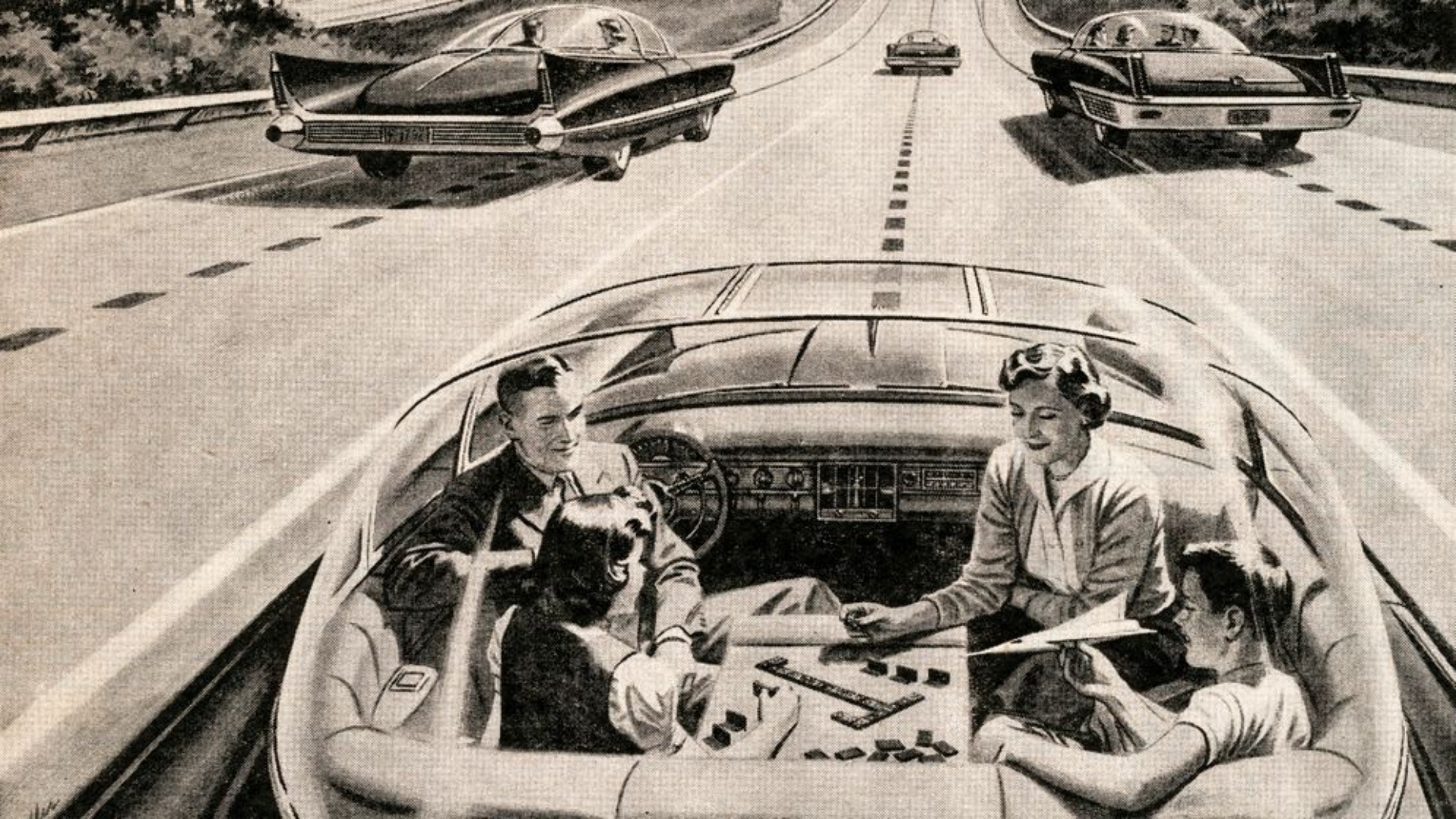
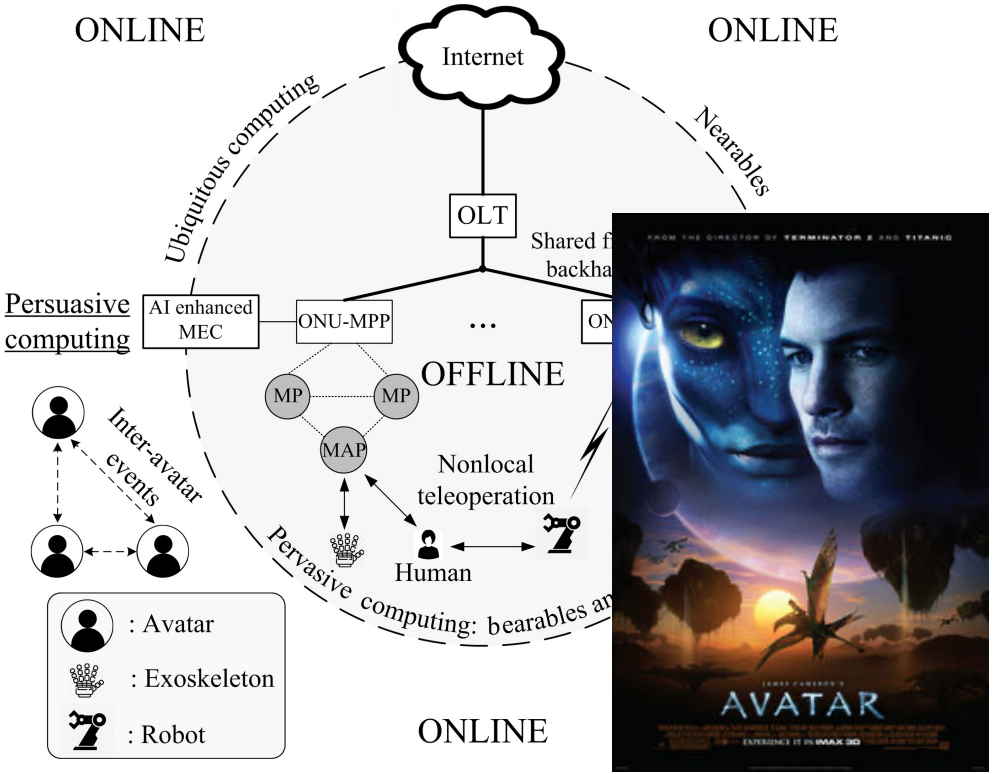


Internet of No Things*

Bearables (e.g., smartphones)

Wearables (e.g., Oculus Quest, Microsoft HoloLens)

Nearables (e.g., AI enhanced MEC)



* The term *Internet of No Things* was first coined by Demos Helsinki founder Roope Mokka in 2015.

Fusion of Digital & Real Worlds

The Multiverse:

An architecture of Extended Reality (XR) experiences

Creation of **cross-reality environments**

PRINCETON UNIVERSITY PRESS

Books Resources Ideas About

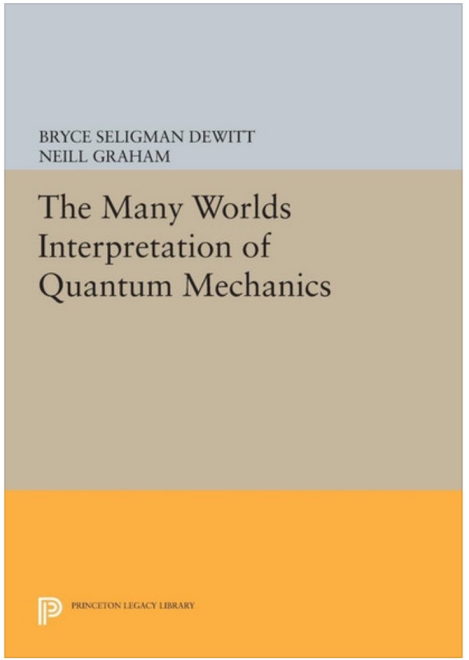
Physics & Astronomy

The Many-Worlds Interpretation of Quantum Mechanics

Edited by Bryce Seligman Dewitt and Neill Graham

Collections:
Princeton Legacy Library

Series:
Princeton Series in Physics



B. J. Pine II and K. C. Korn, “Infinite Possibility: Creating Customer Value on the Digital Frontier,” Berret-Koehler Publishers, Aug. 2011.

Quantum Realm: “Principle of Non-Locality”

- Pysical phenomenon of quantum entanglement transcends spatial and temporal barriers
- Order of time theories: Presentism vs Eternalism
  - Under **Eternalism**, “now” is to time as “where” is to space
  - Past and future are as real as locations north and south
    => **Time travel!**
- Quantum-interconnectedness of all things might be the cause of **extrasensory perception** phenomenon

INRS

Extrasensory perception

From Wikipedia, the free encyclopedia

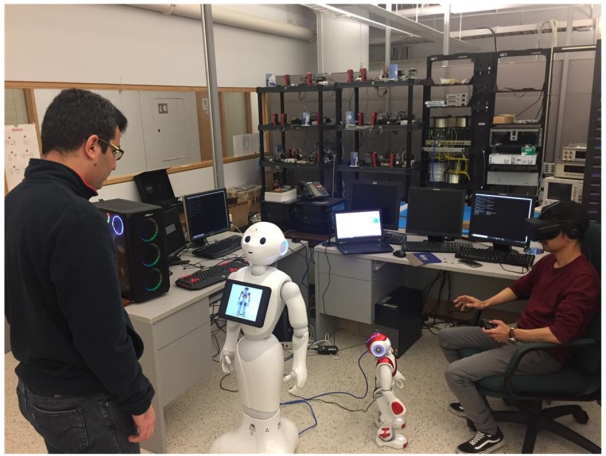
WIKIPEDIA
The Free Encyclopedia

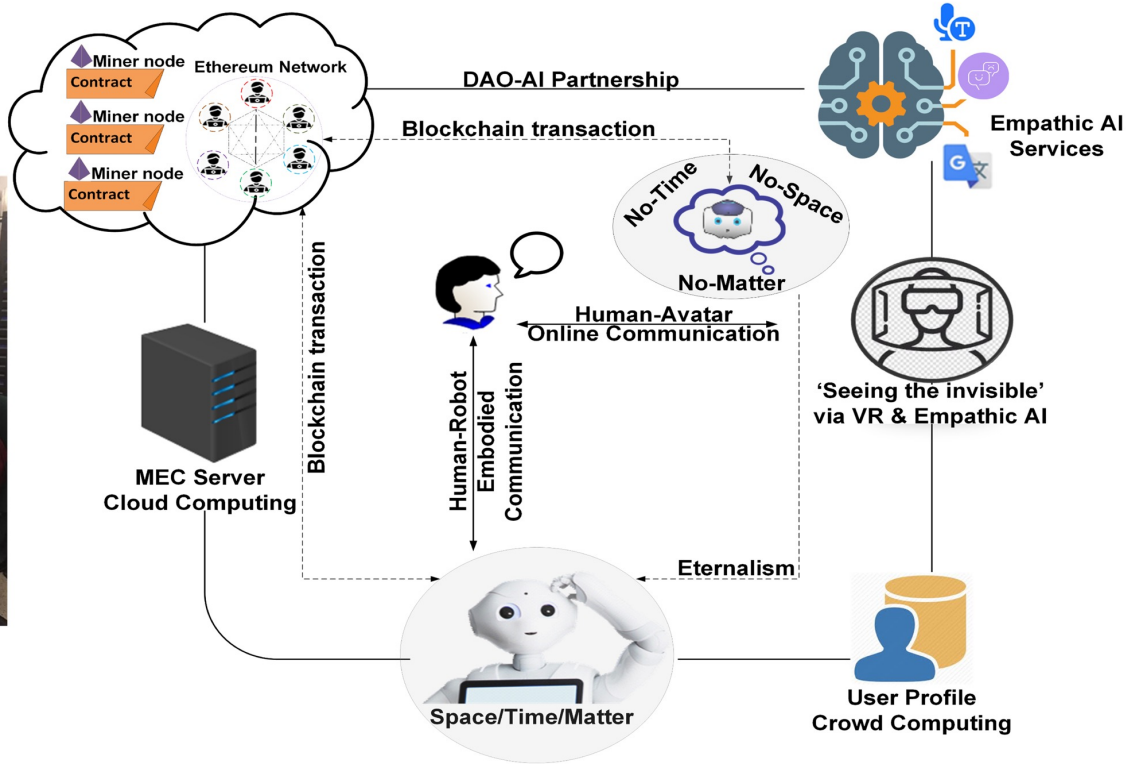
For the book, see Extrasensory Perception (book).
"Second sight" redirects here. For other uses, see Second Sight.

Extrasensory perception or **ESP**, also called **sixth sense**, includes claimed reception of information not gained through the recognized physical senses, but sensed with the mind. The term was adopted by Duke University psychologist J. B. Rhine to denote psychic abilities such as intuition, telepathy, psychometry, clairvoyance and their trans-temporal operation as precognition or retrocognition.[1]

COMPUTER SCIENCE

ESP Network: Mimicking The Quantum Realm

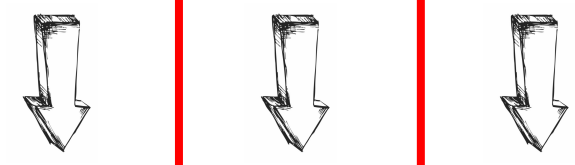




Eternalism: Time Travel

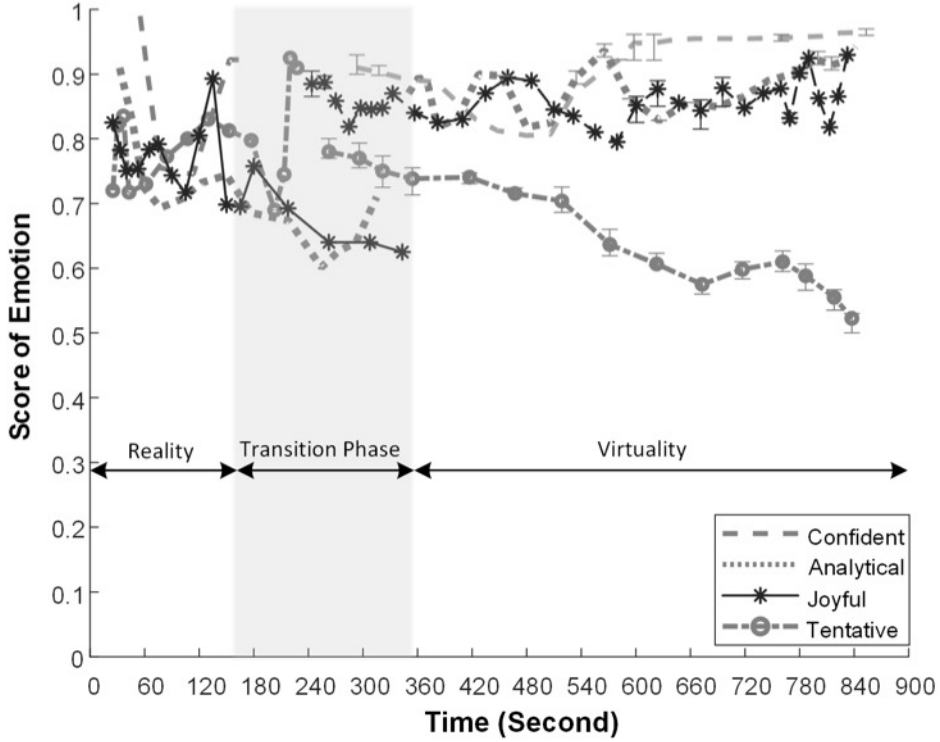
Reality (Robot)

Space | Time | Matter



No-Space | No-Time | No-Matter

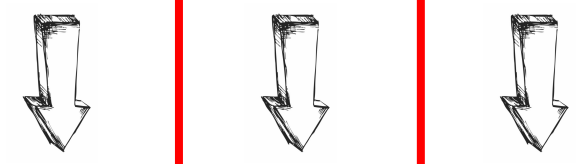
Virtuality (Avatar)



Precognition: Regret of “Trusting AI Blindly”

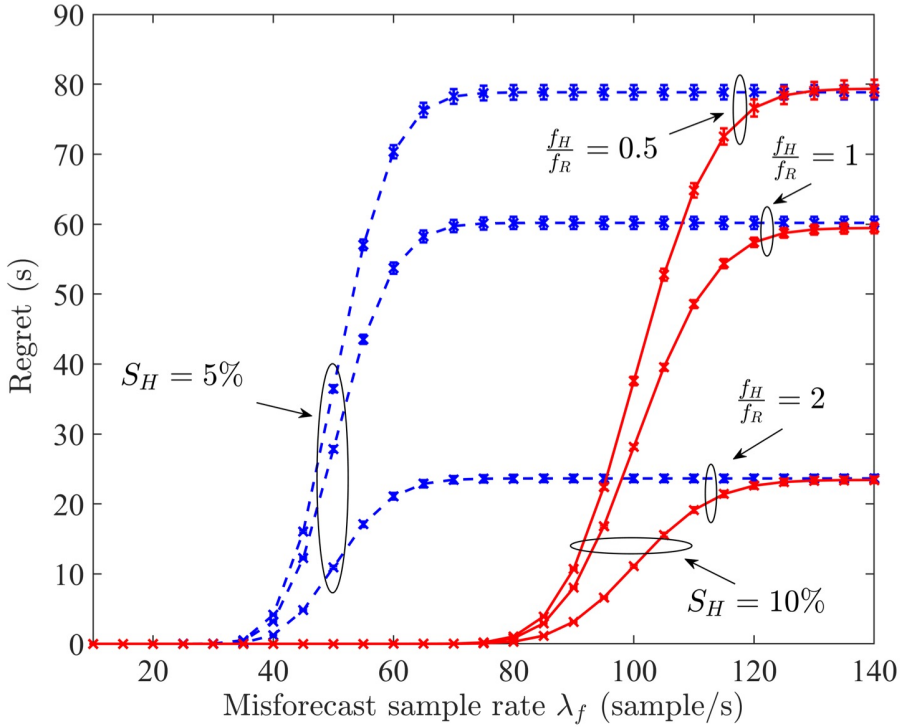
Reality (Robot)

Space | Time | Matter

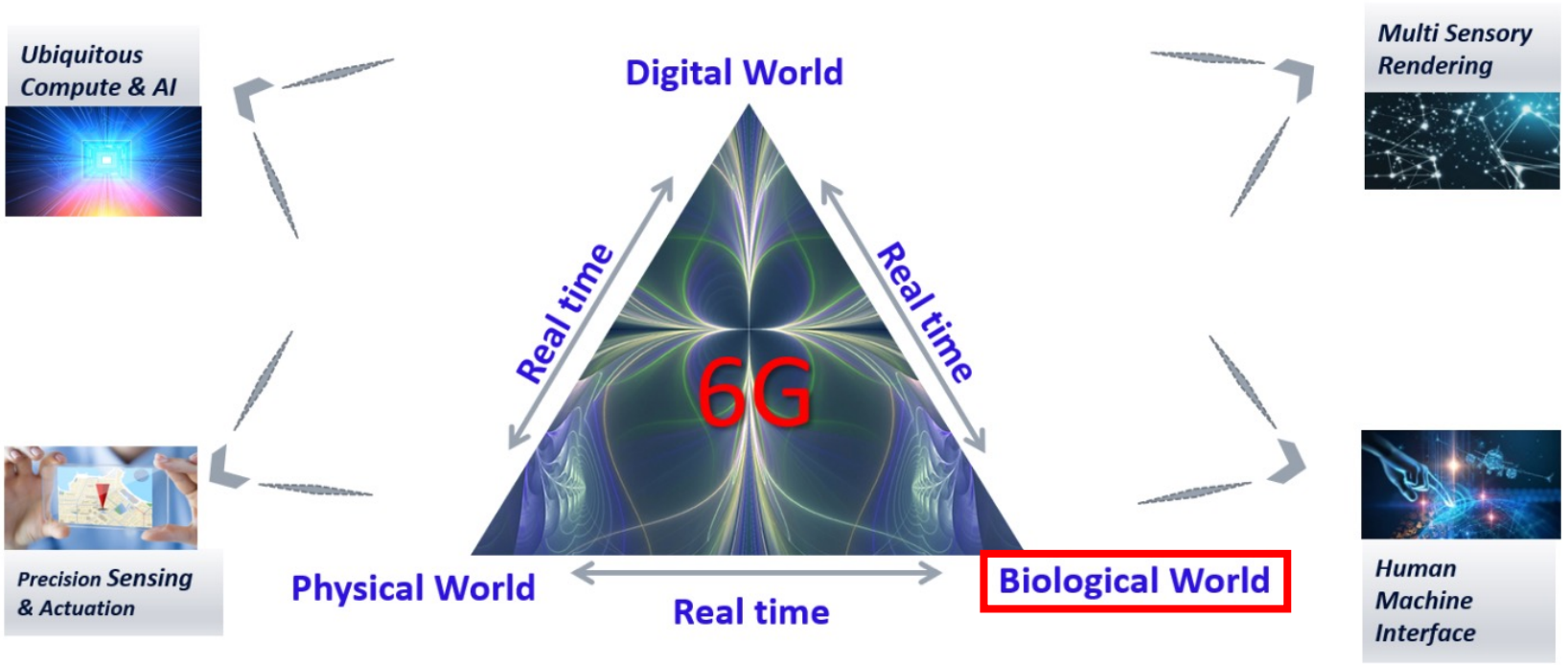


No-Space | Time | No-Matter

Augmented Virtuality (Digital Twin)

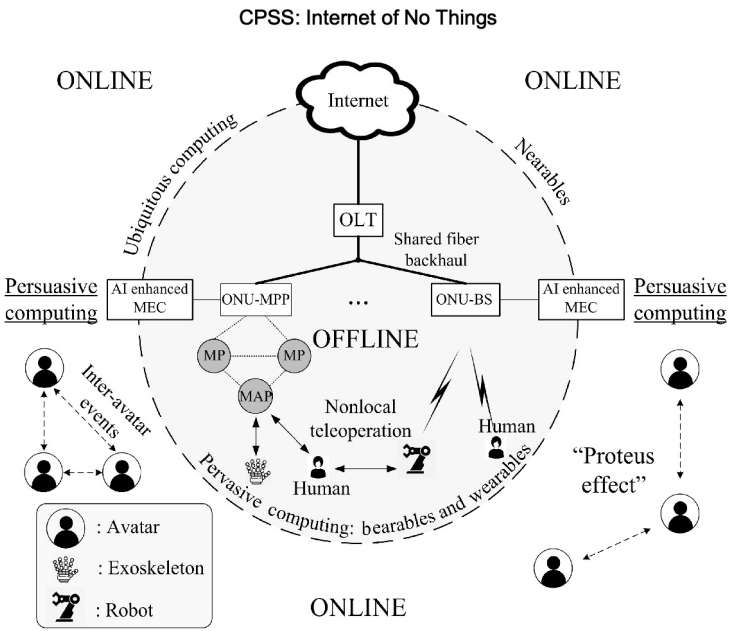


Communications in the 6G Era: Biological World



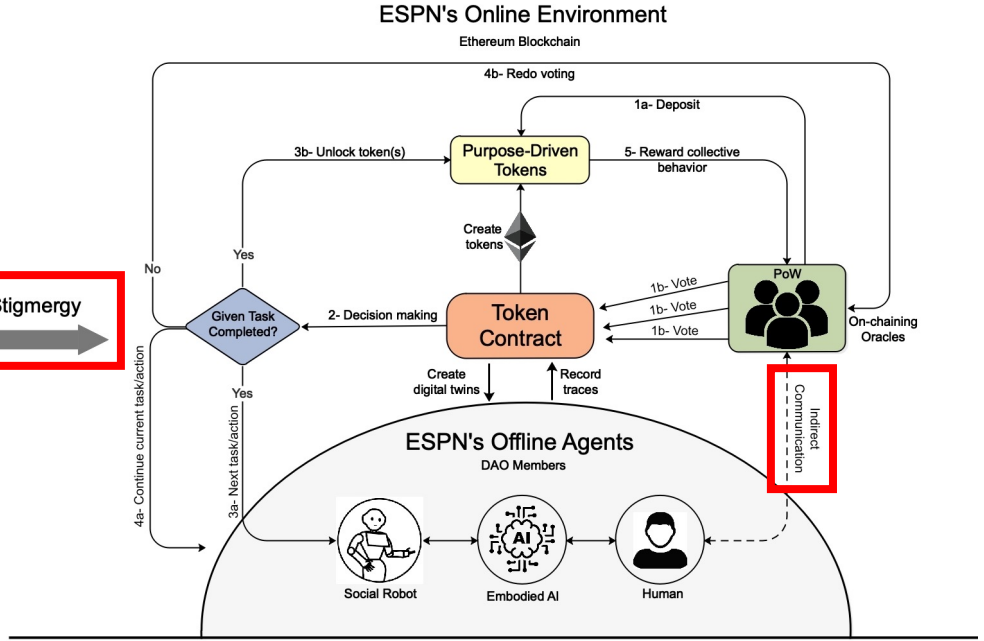
H. Viswanathan and P. E. Mogensen, “Communications in the 6G Era,” IEEE Access, March 2020.

Stigmergy Enhanced Internet of No Things



Extrasensory Perception Network (ESPN) Architecture

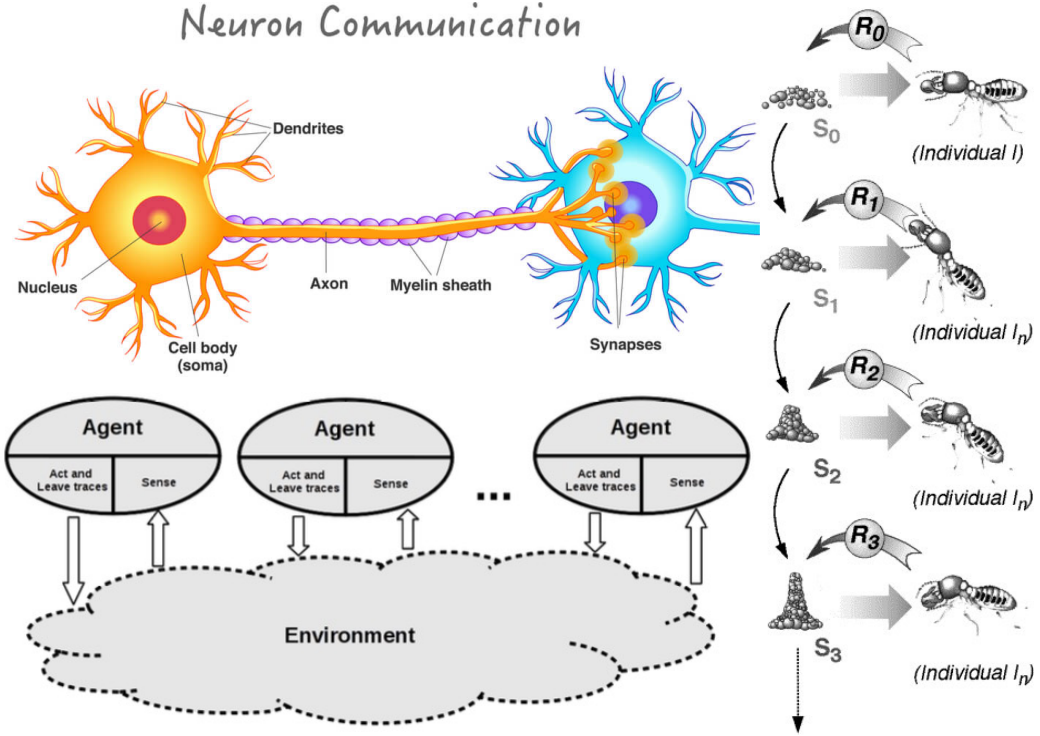
Stigmergy



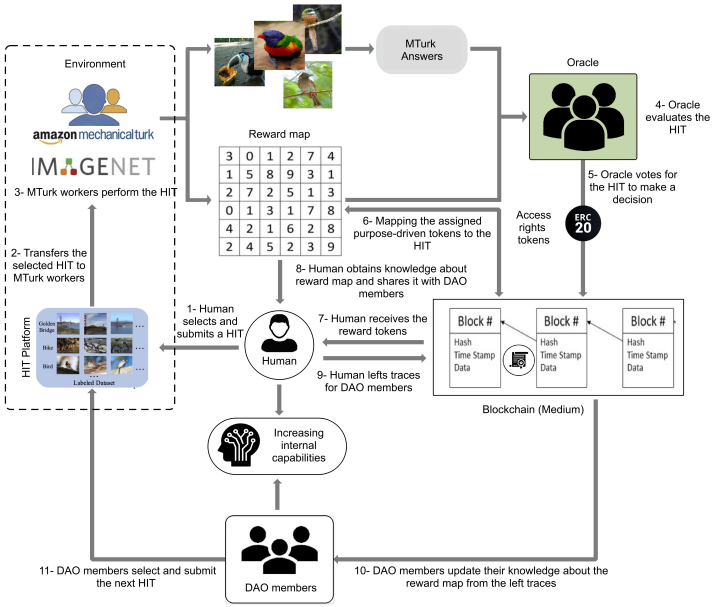
Society 5.0
CI through Tokenized Digital Twins

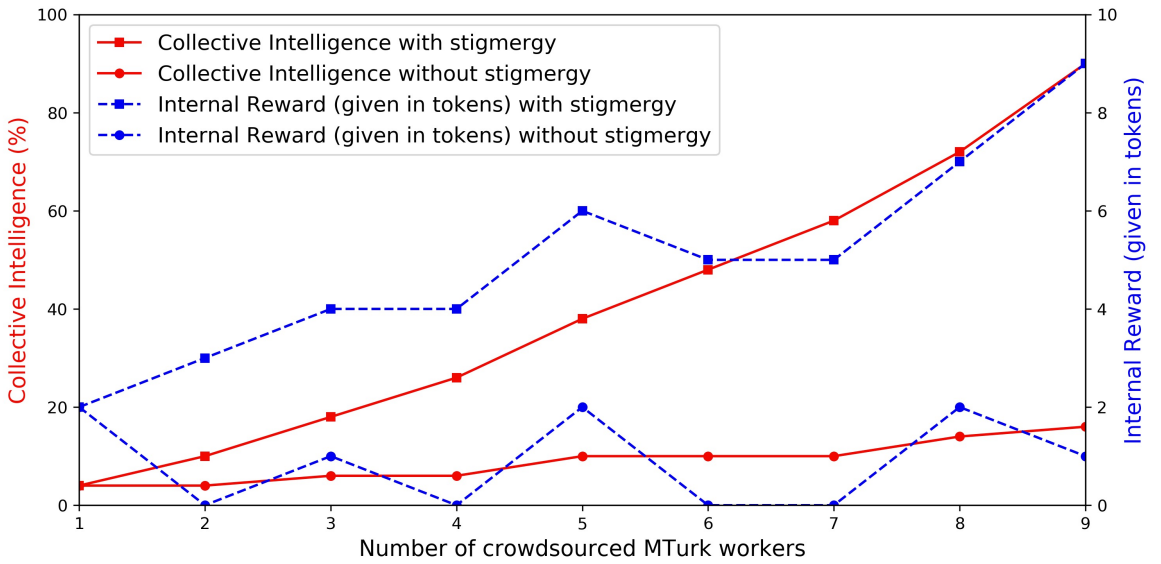
Stigmergy: Nature's Indirect Communication

- **Stigmergy (Greek)**: *Stigma* "sign" and *ergon* "work"
- **Nature's unifying concept** of producing cognition in human brain & natural societies (e.g., ant colonies)
- **Indirect communication** between agents via environment (e.g., ESPN)



Raising Our Collective Intelligence





INDUSTRY 5.0

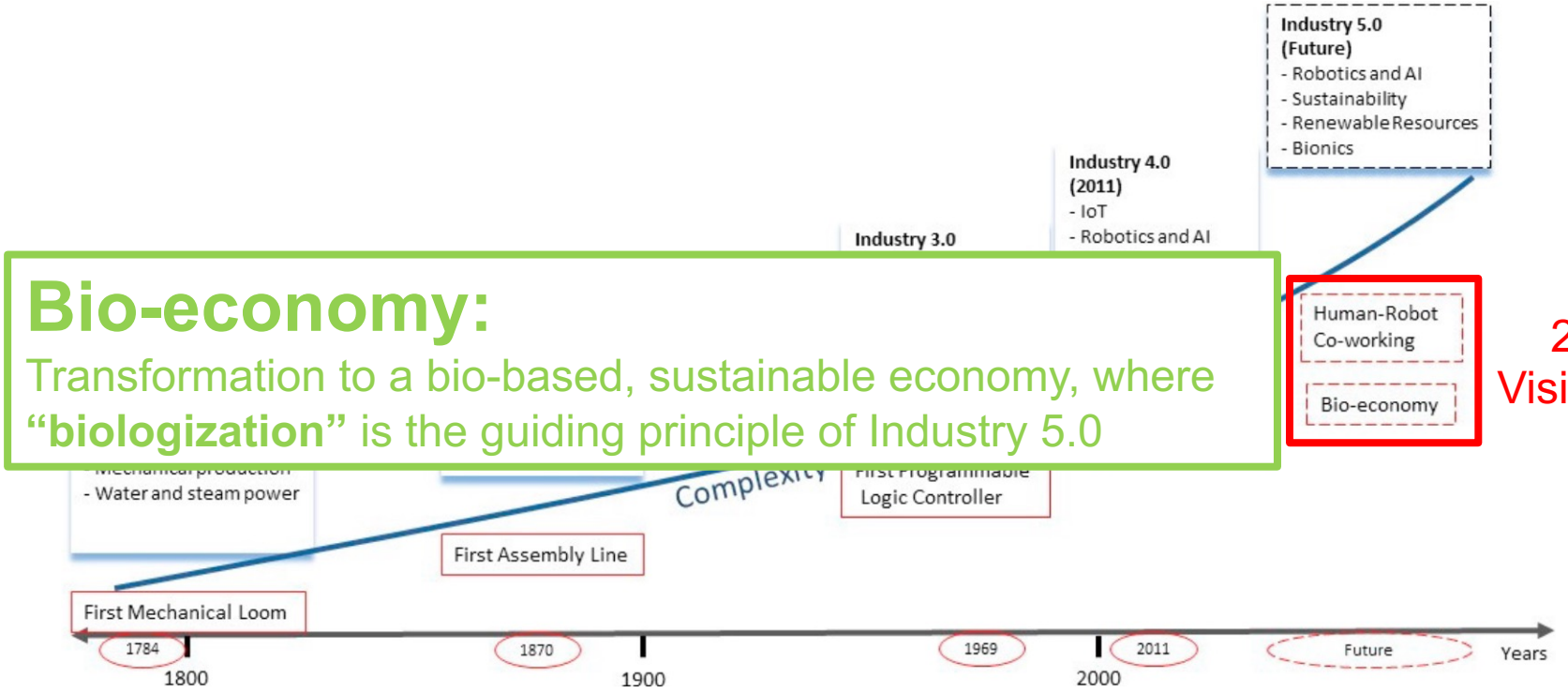
Human-centric

Sustainable

Resilient

EC Concept Paper, Jan. 2021

Industry 5.0



Bio-economy:

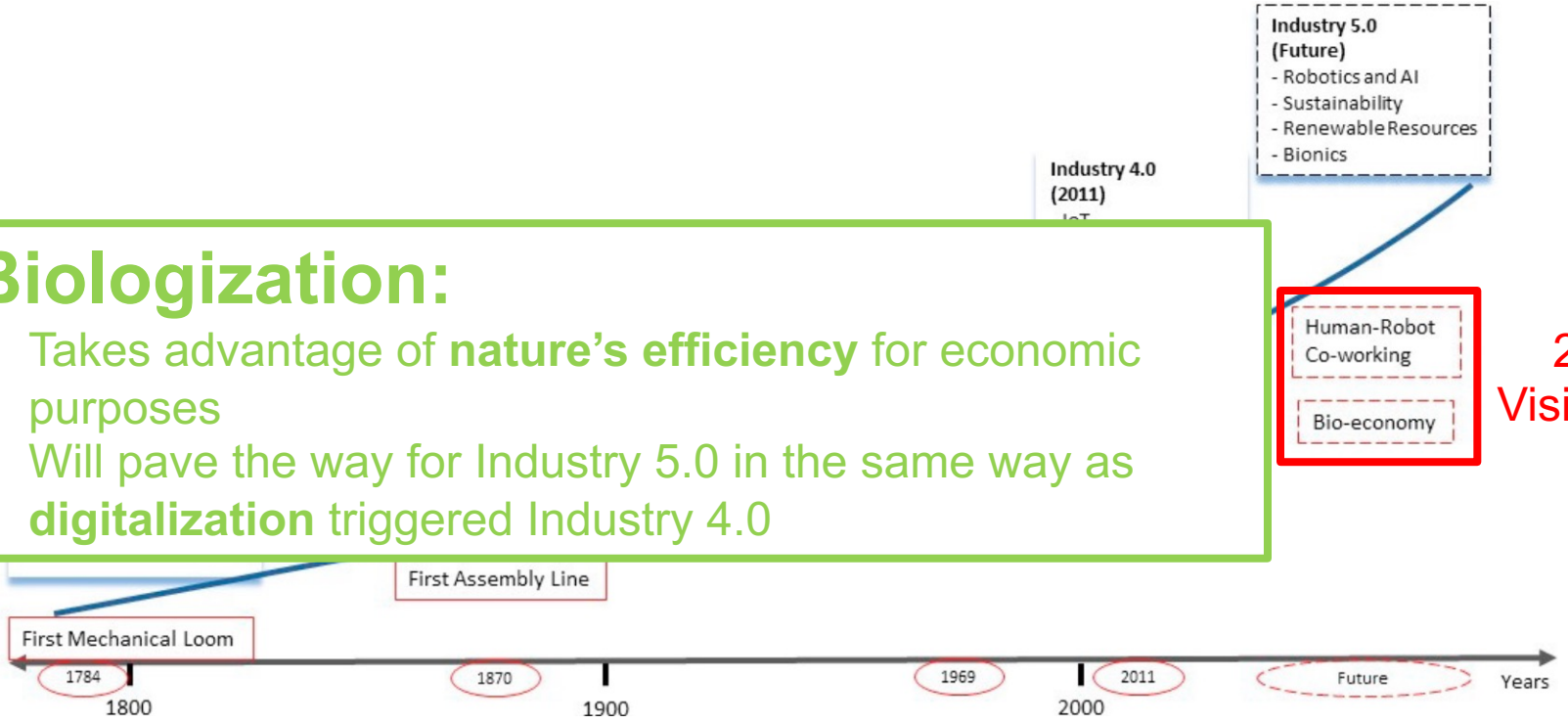
Transformation to a bio-based, sustainable economy, where **"biologization"** is the guiding principle of Industry 5.0

K. A. Demir, B. Döven, and B. Sezen, "Industry 5.0 and Human-Robot Co-working," Procedia Computer Science, 158:688-695, Jan. 2019.

Industry 5.0

Biologization:

- Takes advantage of **nature's efficiency** for economic purposes
- Will pave the way for Industry 5.0 in the same way as **digitalization** triggered Industry 4.0



K. A. Demir, B. Döven, and B. Sezen, "Industry 5.0 and Human-Robot Co-working," Procedia Computer Science, 158:688-695, Jan. 2019.

6G vs 5G: Internet of No Things vs Everything

"6G will be transformative"

5G

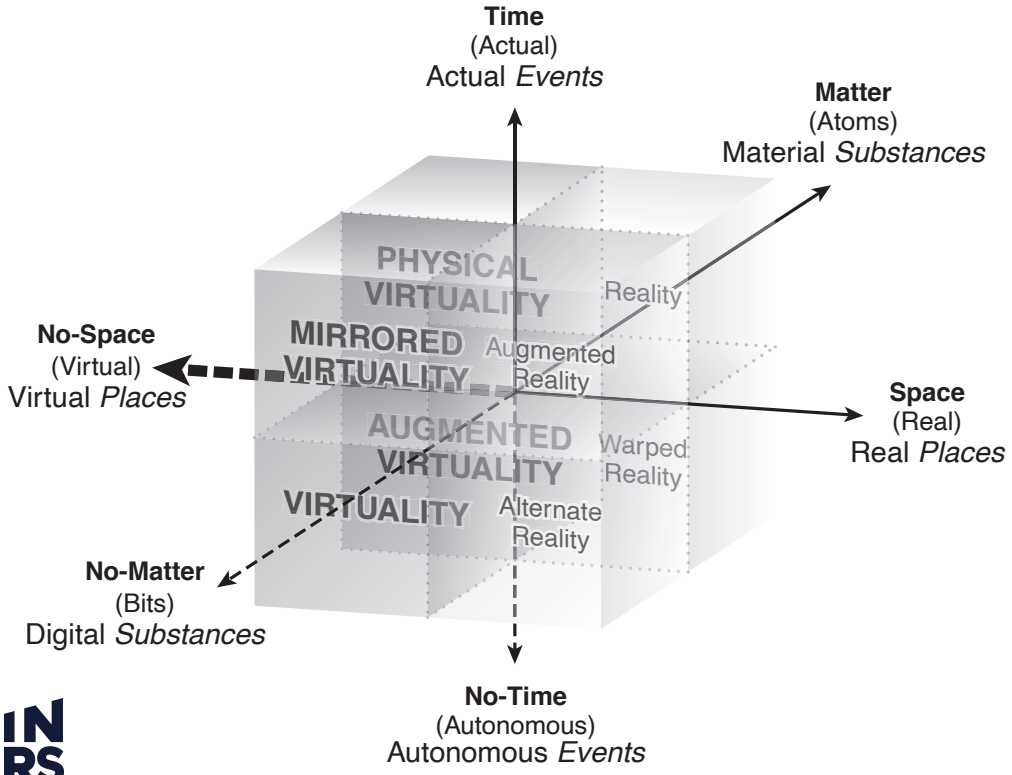
Supposed to be **Internet of Everything (IoE)**

6G

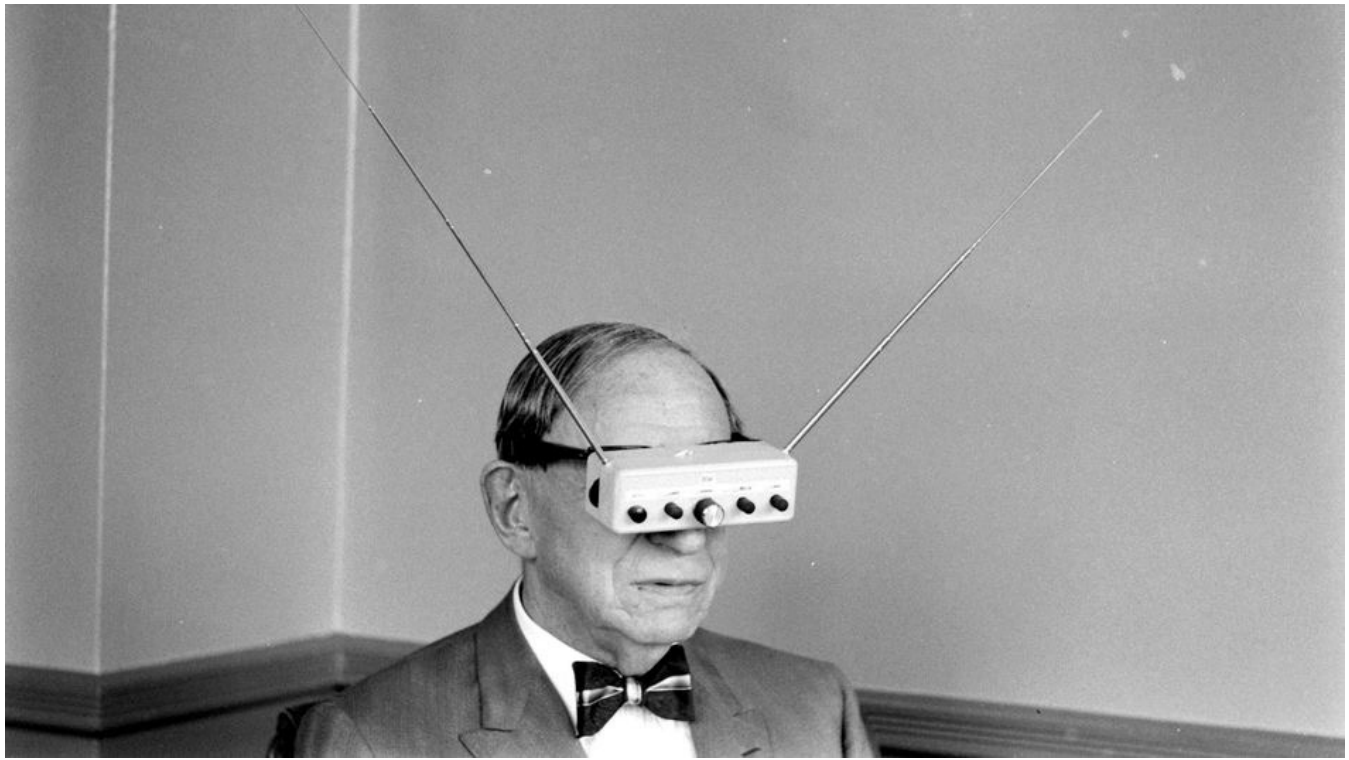
What's the opposite of Everything?

No-thing ☺

Next G: Multiverse vs Metaverse



Elon Musk: “Sure, you can put a TV on your nose”



Teleyeglasses

Hugo Gernsback
1936


FACEBOOK
Meta


Inspired by
Iceland


INRS