

5G: The Plaform for the Digital Society

Merouane DEBBAH

November 20th 2019

Algiers, Alger

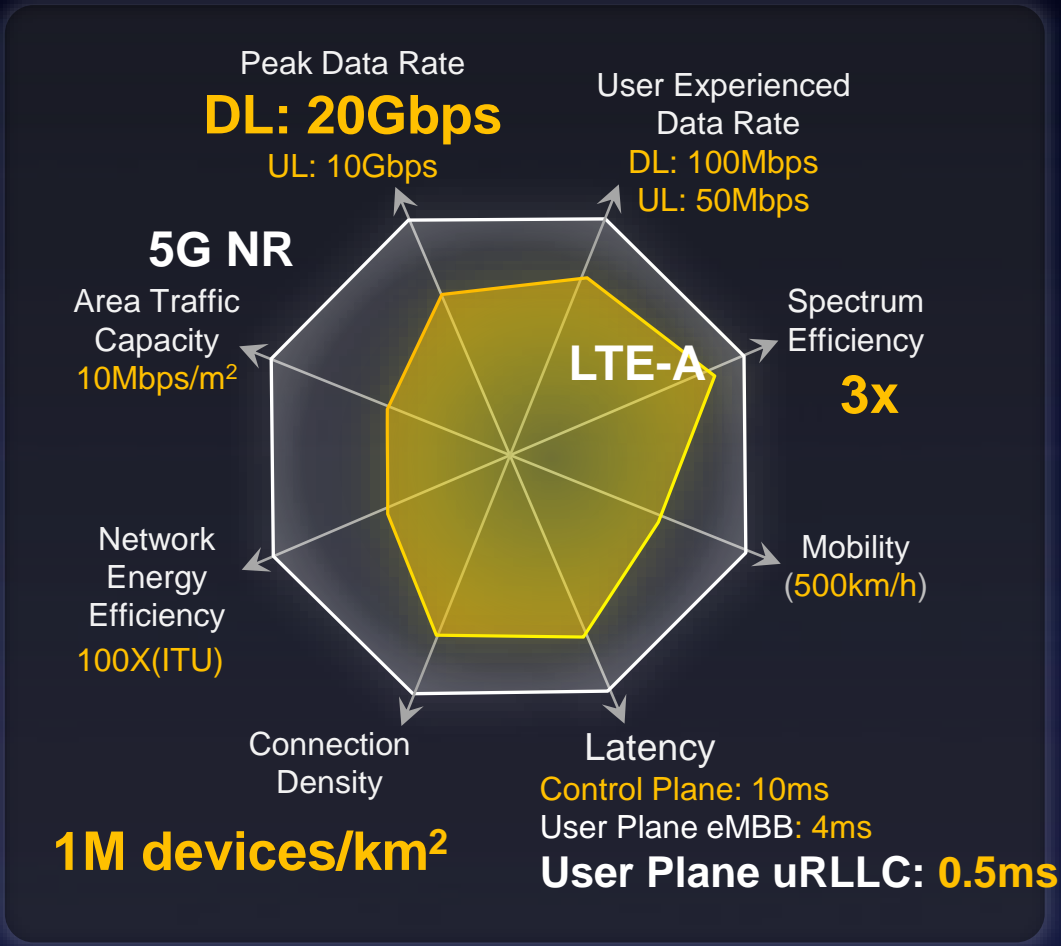
3 Waves of Dividends



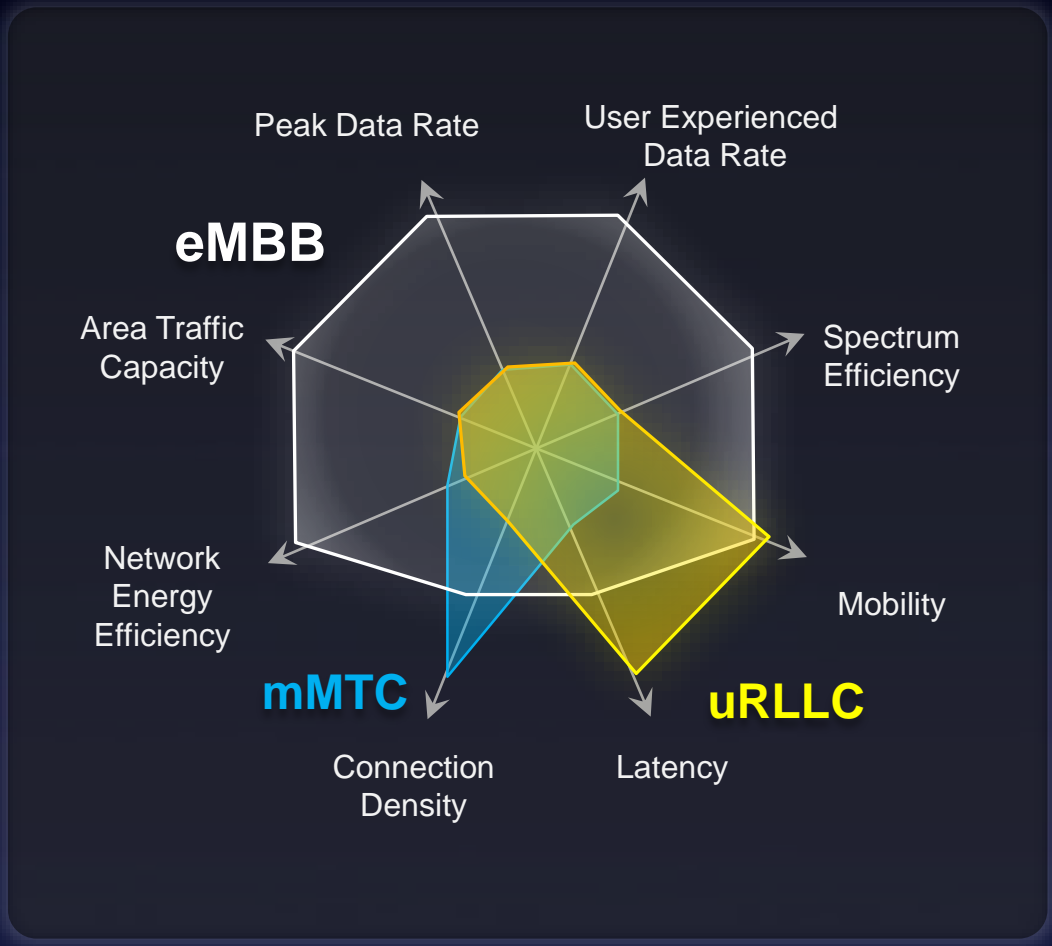
Source: Huawei MI

5G Capability Requirements Defined by 3GPP

3GPP Standardization Targets for 5G NR



Requirements of Different Services



Source: 3GPP TR 38.913

R15 Enables Ultimate User Experience on eMBB

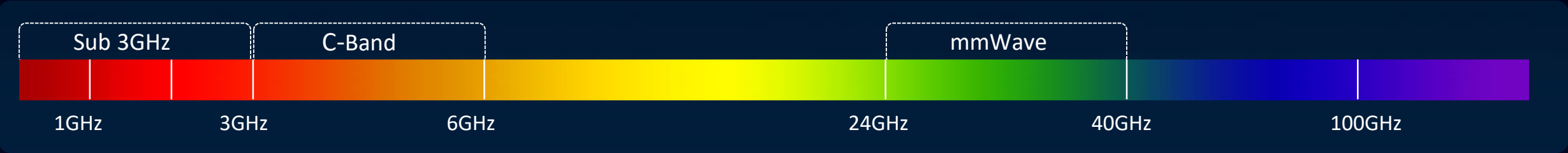
R15 Builds the Foundation of Commercial 5G Networks



Key 5G Features of Release 15



5G Spectrum Release is Speeding Up

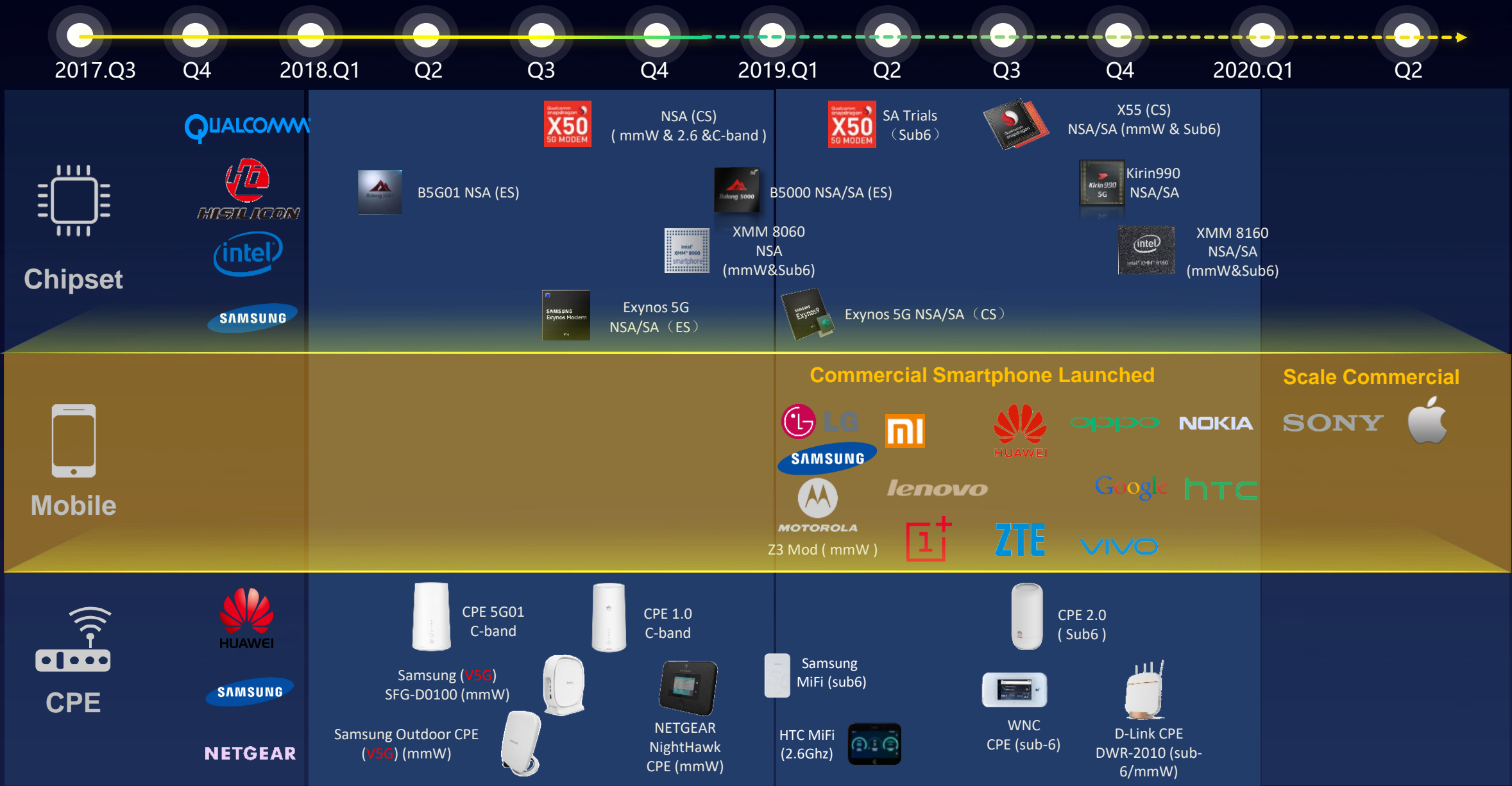


Global 5G Spectrum Auction Plan



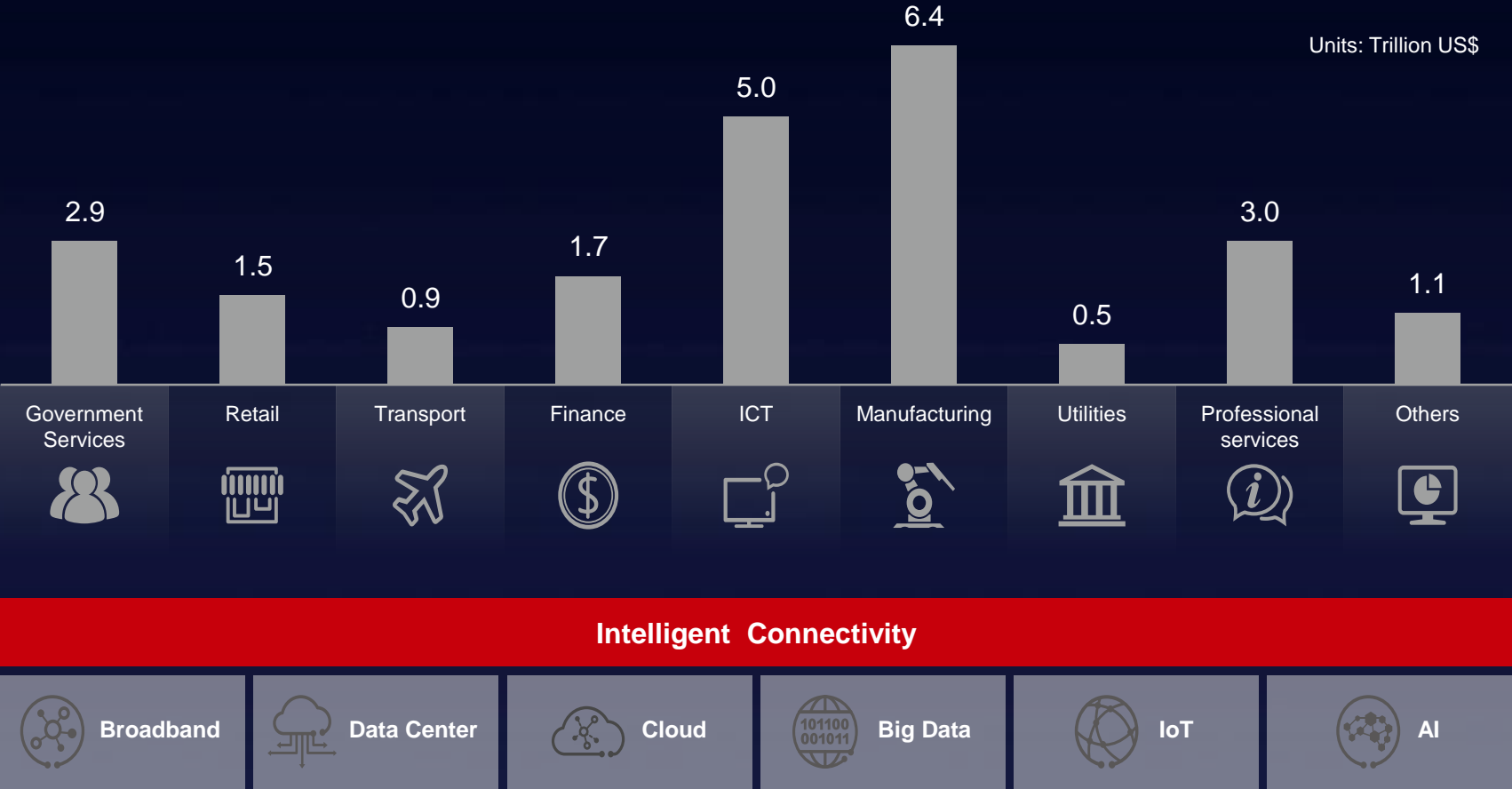
C-Band Becomes Globally Harmonized 5G Spectrum

Ecosystem Drive 1st Wave 5G Commercial launch in 2019



2025: Tapping into the Opportunities of Digital Economy

Valued at US\$23 Trillion



We Are Entering a Hyper-connected Intelligent World



All Things Sensed

Sensing the physical world,
mapping it to digital

signals

Temperature, space, and touch
Sense of smell, hearing, and
vision



All Things Connected

Data goes online to power
machine intelligence

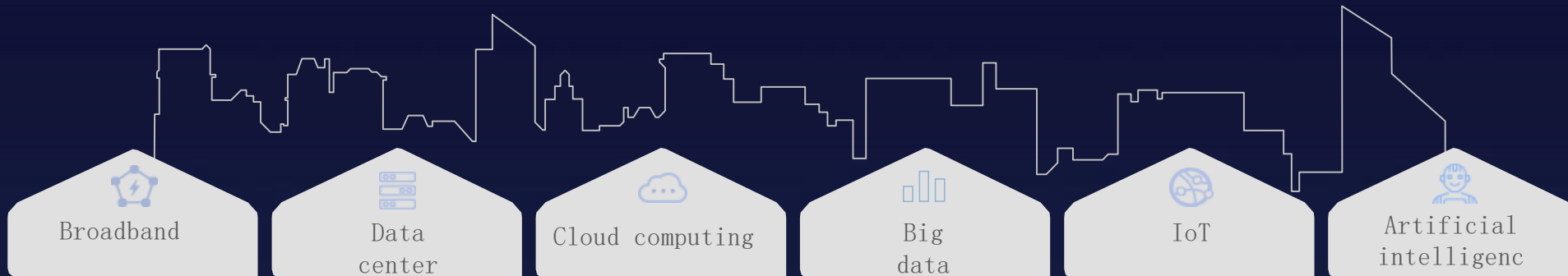
Ubiquitous connections, wide
connections, multiple connections, and
deep connections



All Things Computed

Network integrated AI to
power new applications

Digital twins
Digital survival



We Are Entering a Hyper-connected Intelligent World

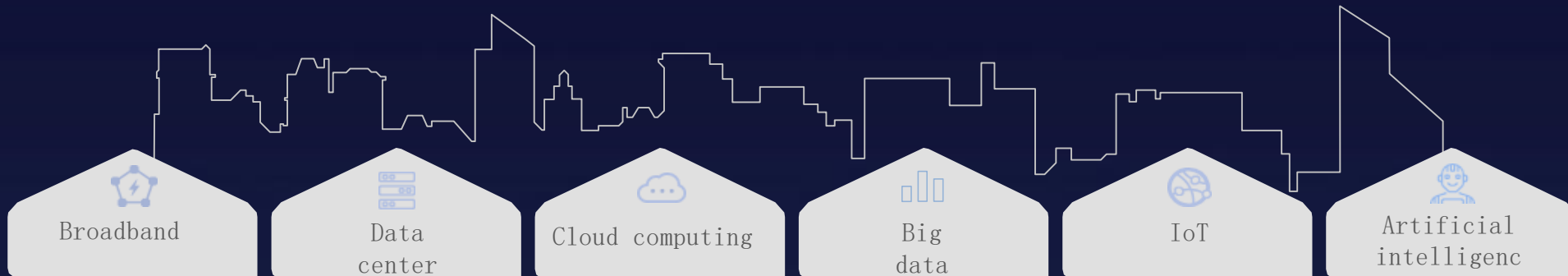


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Better Perception



Naked Eyes



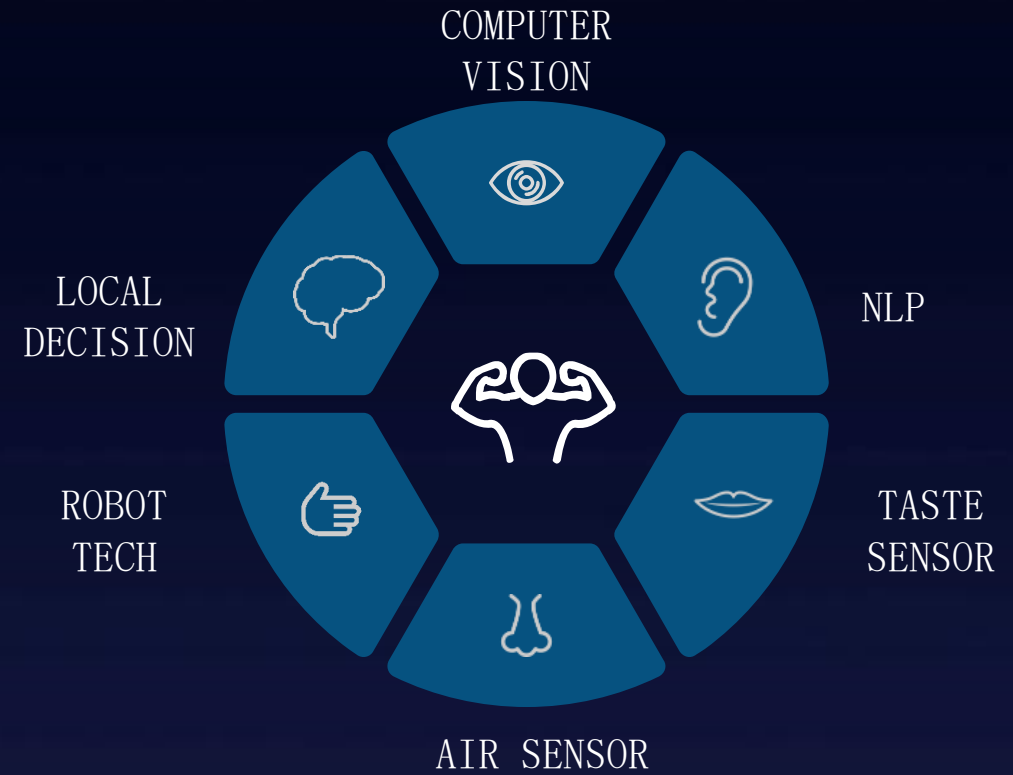
P30 Pro



Air Quality



Blood Pressure



More Information, Better Service & Experience

Convergence of Wireless Transmissions and Sensing

Spatial Dimension

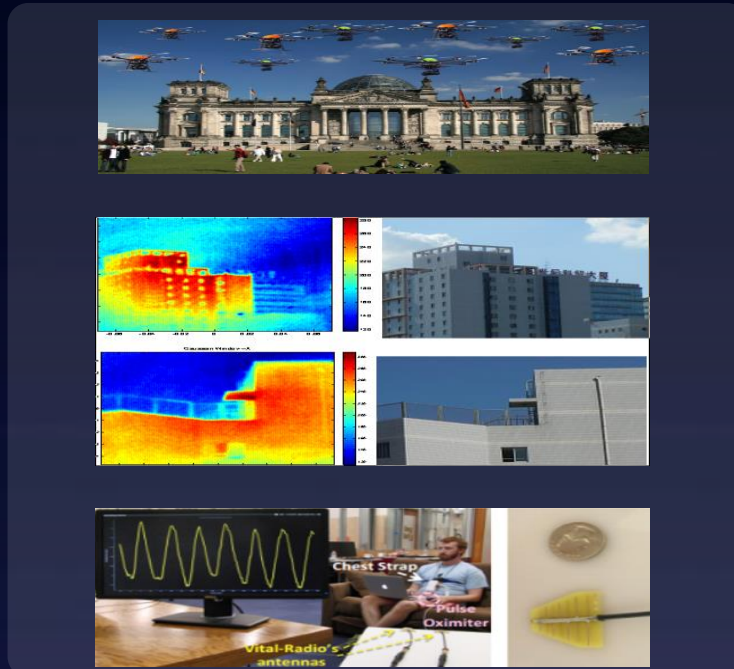
Chemistry

Biology

Medical



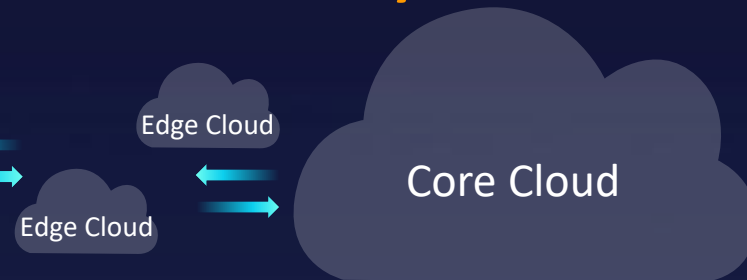
Terminal Sensing



Infrastructure Sensing



Analytics

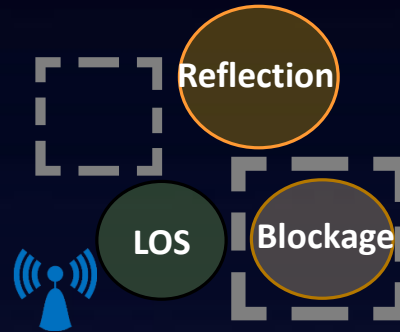


Sensing Assisted Transmission

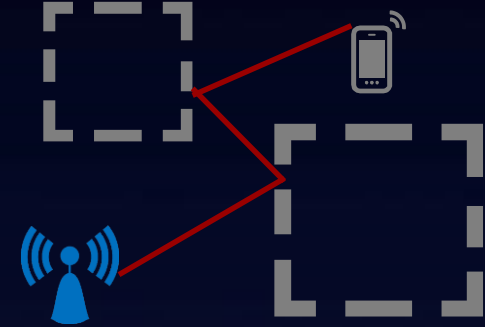
Sensing Assisted PHY



1. Air Interface
Relative sensing



2. Reality mapping and Judging



3. Beam Forming tracking

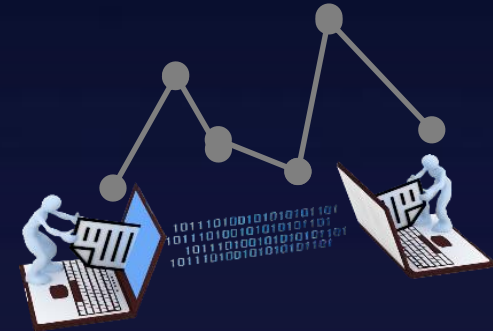
Sensing Assisted Network



1. Environment sensing



2. Infrastructure and
traffic reconstruction

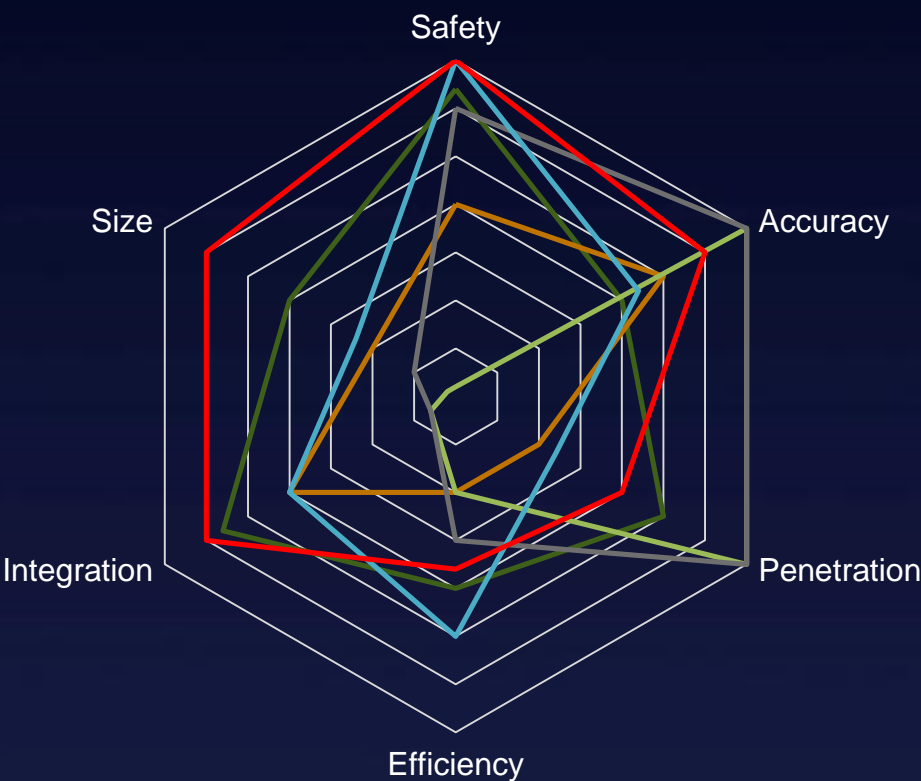


3. Network planning
and traffic steering

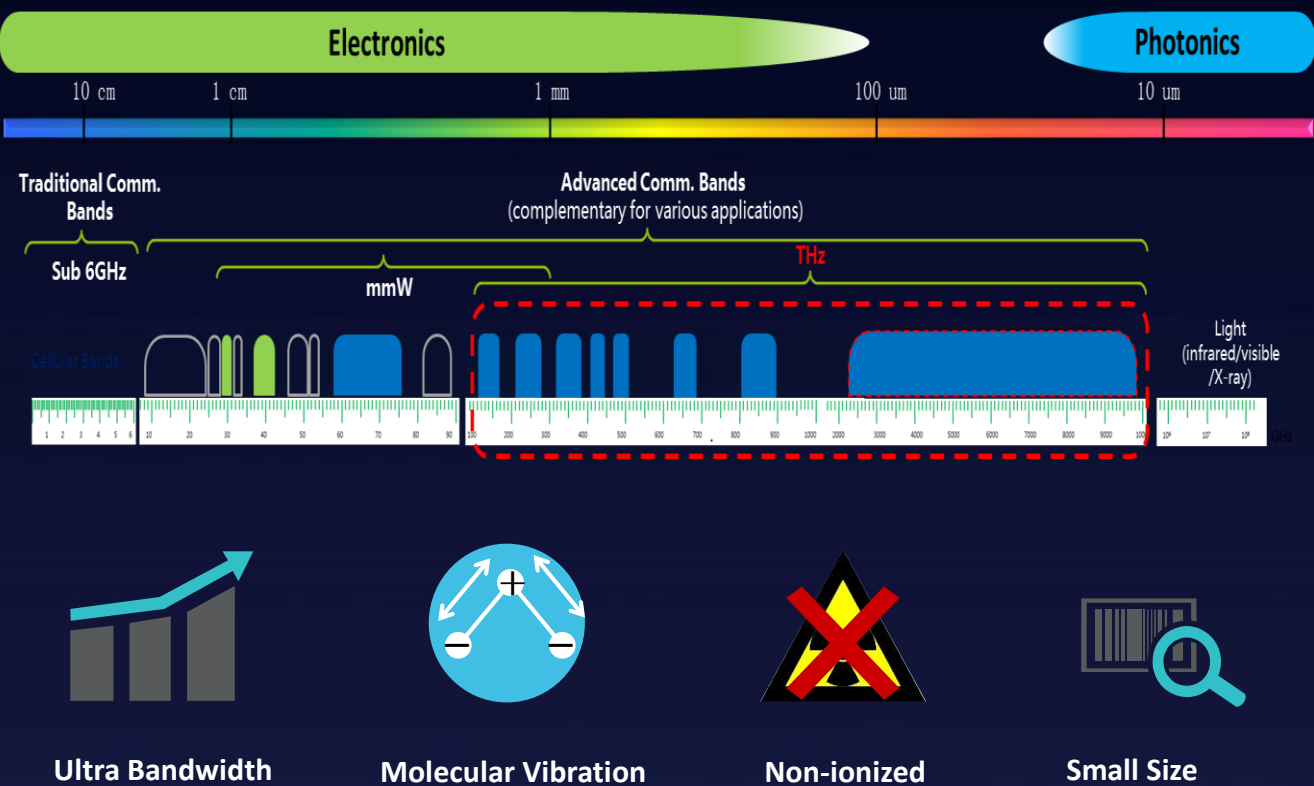
Sensing and Spectrum

TECHNOLOGY

■ MM-wave radar ■ Lidar ■ CT ■ MRI ■ Thermal imager ■ THz



Tera-THz Extend the Scope of Sensing



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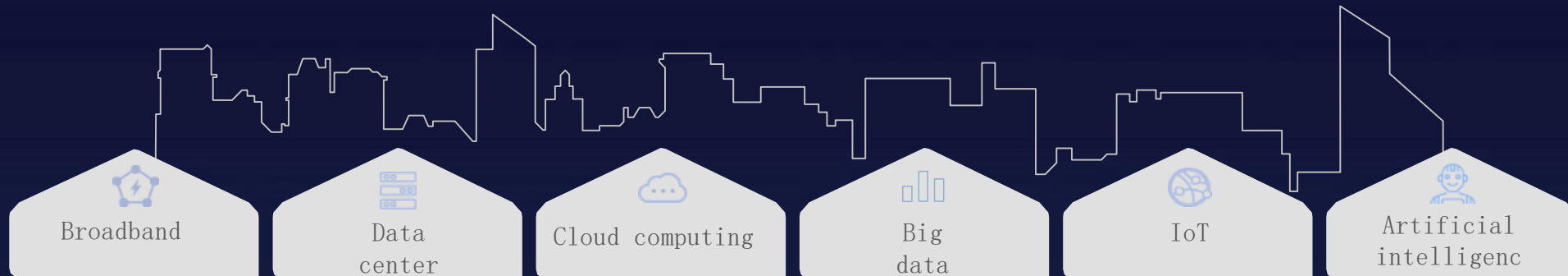
Temperature, space, and touch
Sense of smell, hearing, and
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Network integrated AI to
power new applications

Digital twins
Digital survival

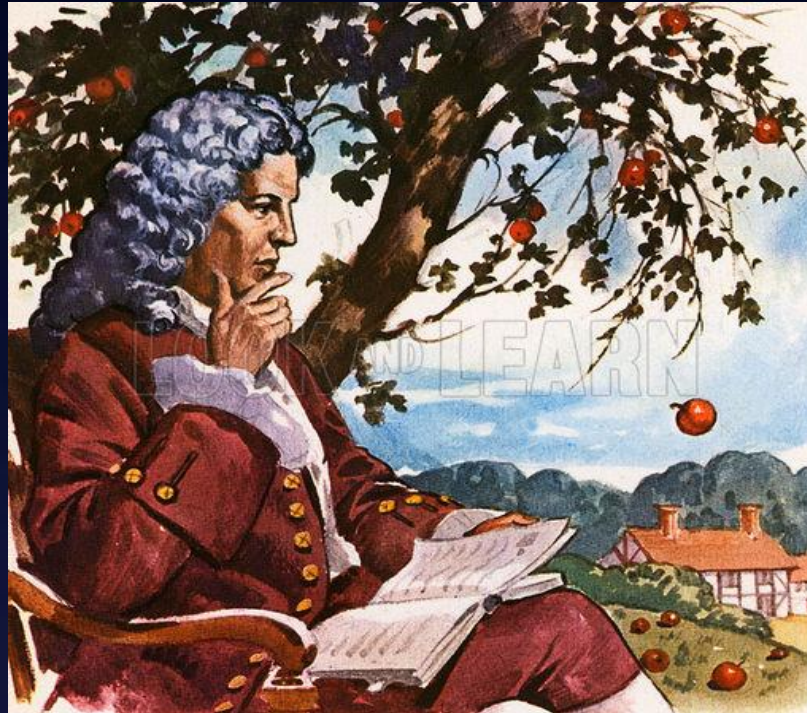
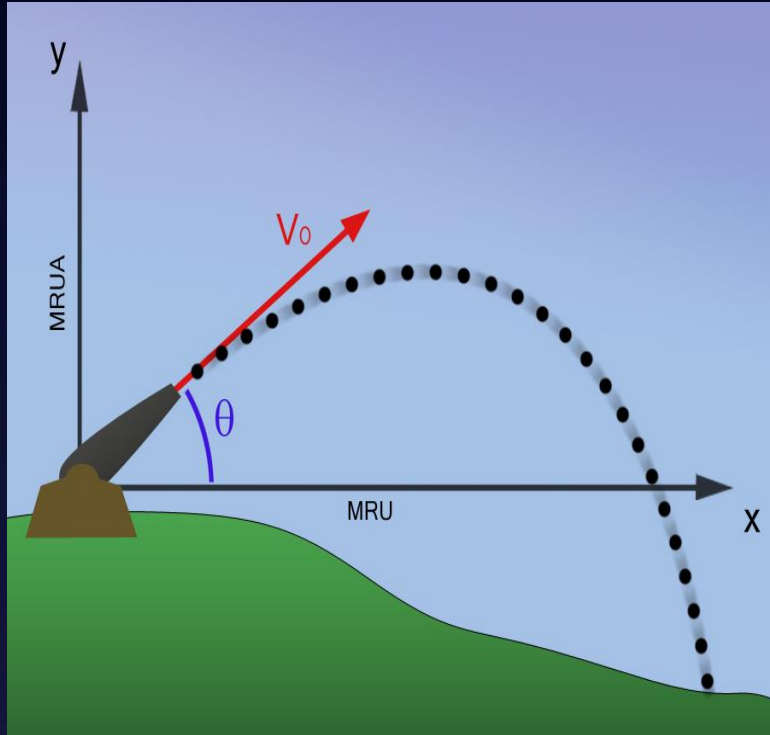


The Rise of AI: 1989-2019

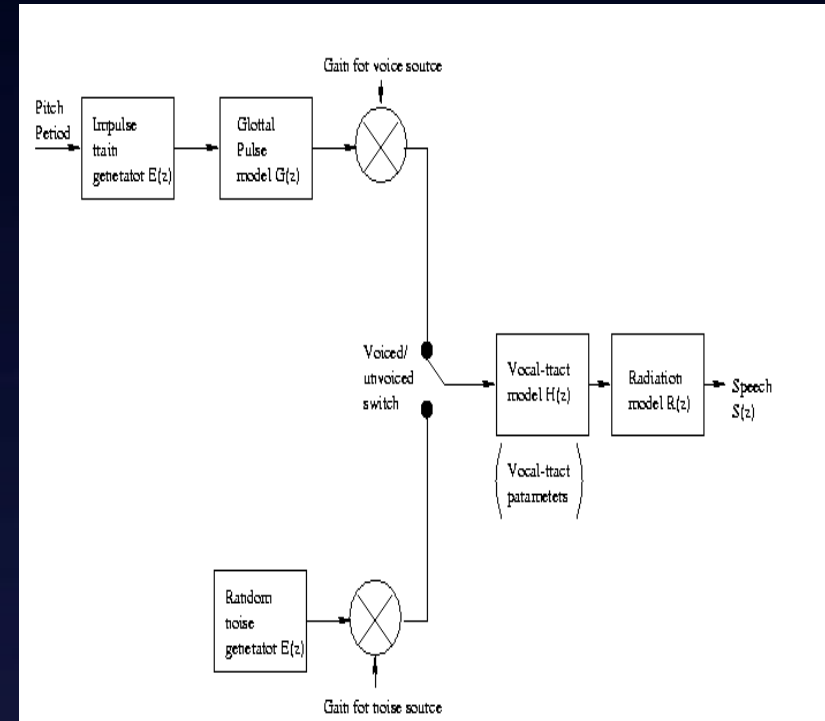
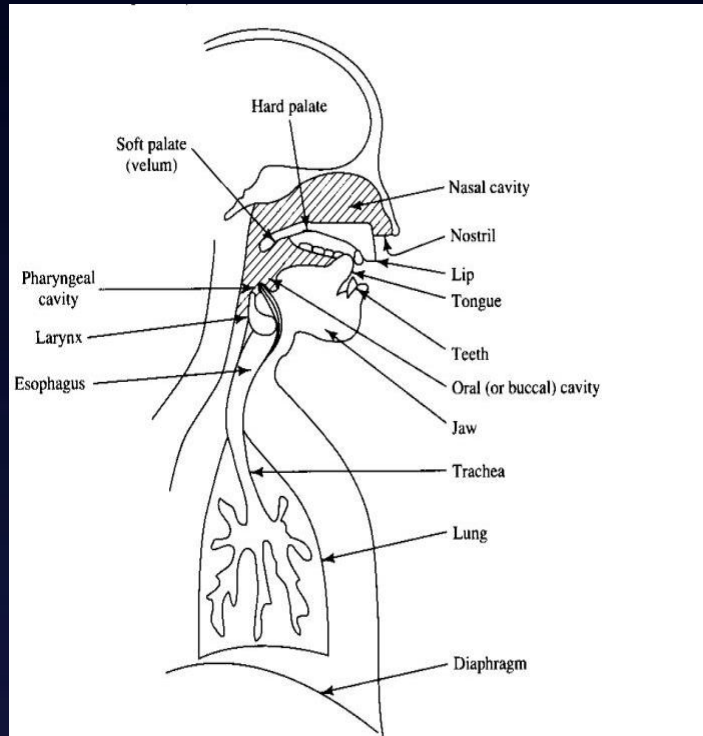


2019 Turing Award

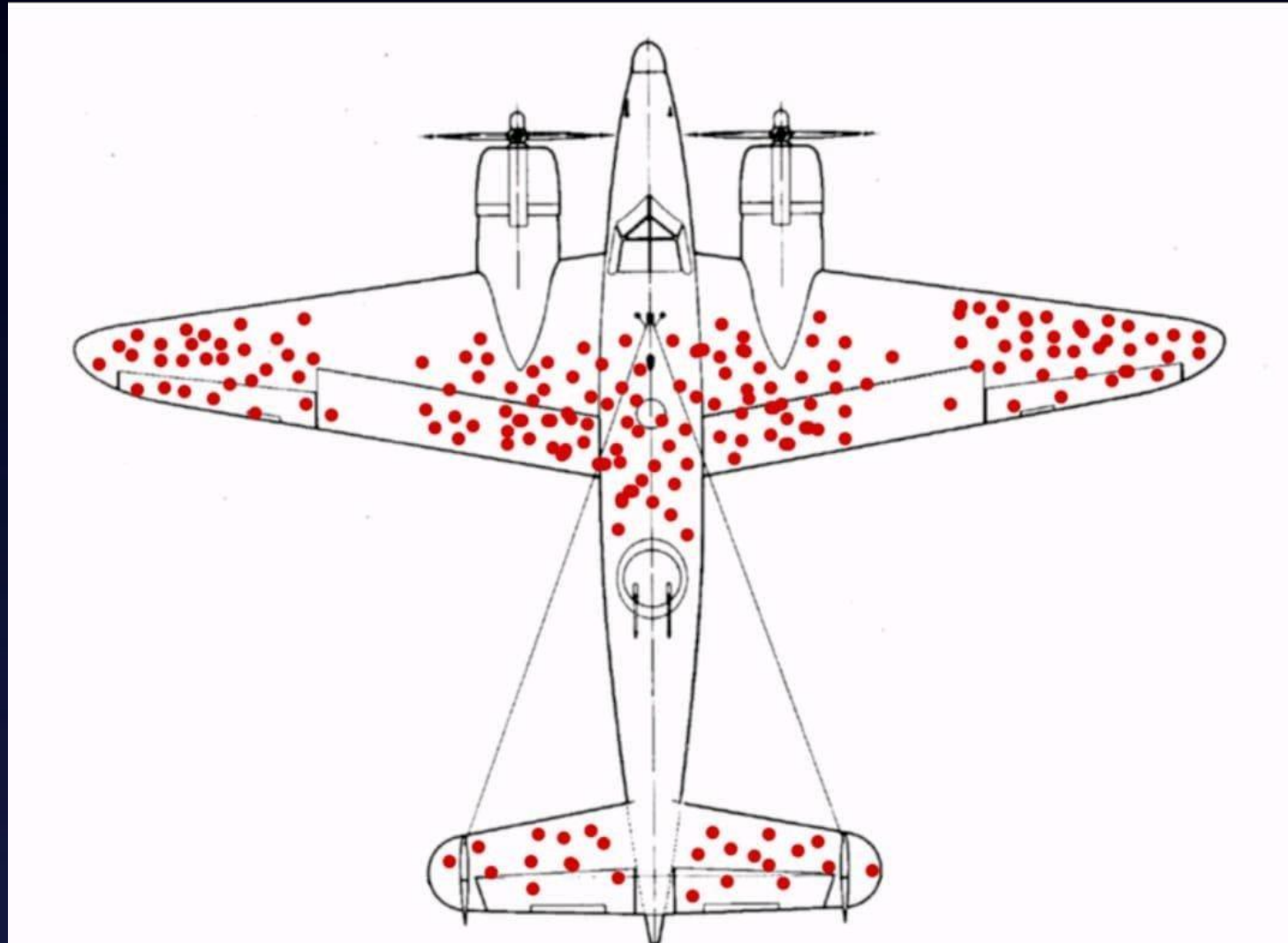
The Cost of Understanding



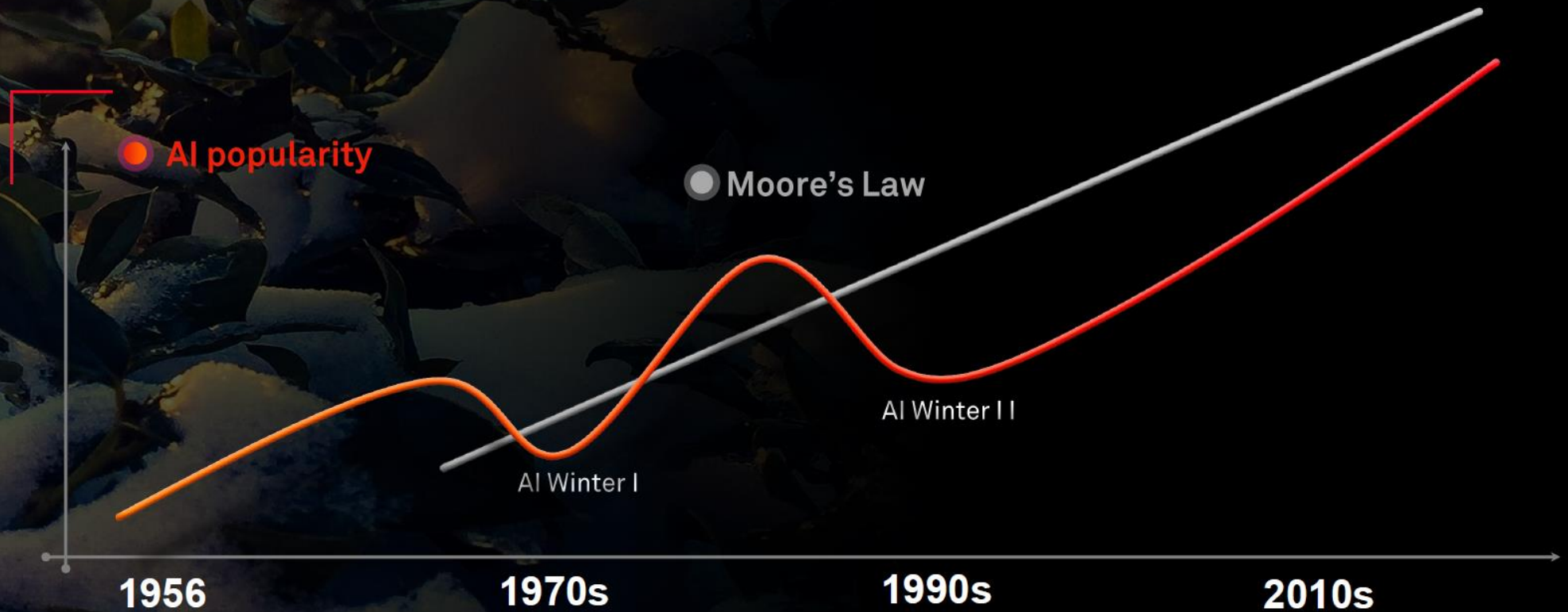
The Limits of Modelling



New Paradigms for Data



AI: Overall outcome of 60 years of development in ICT



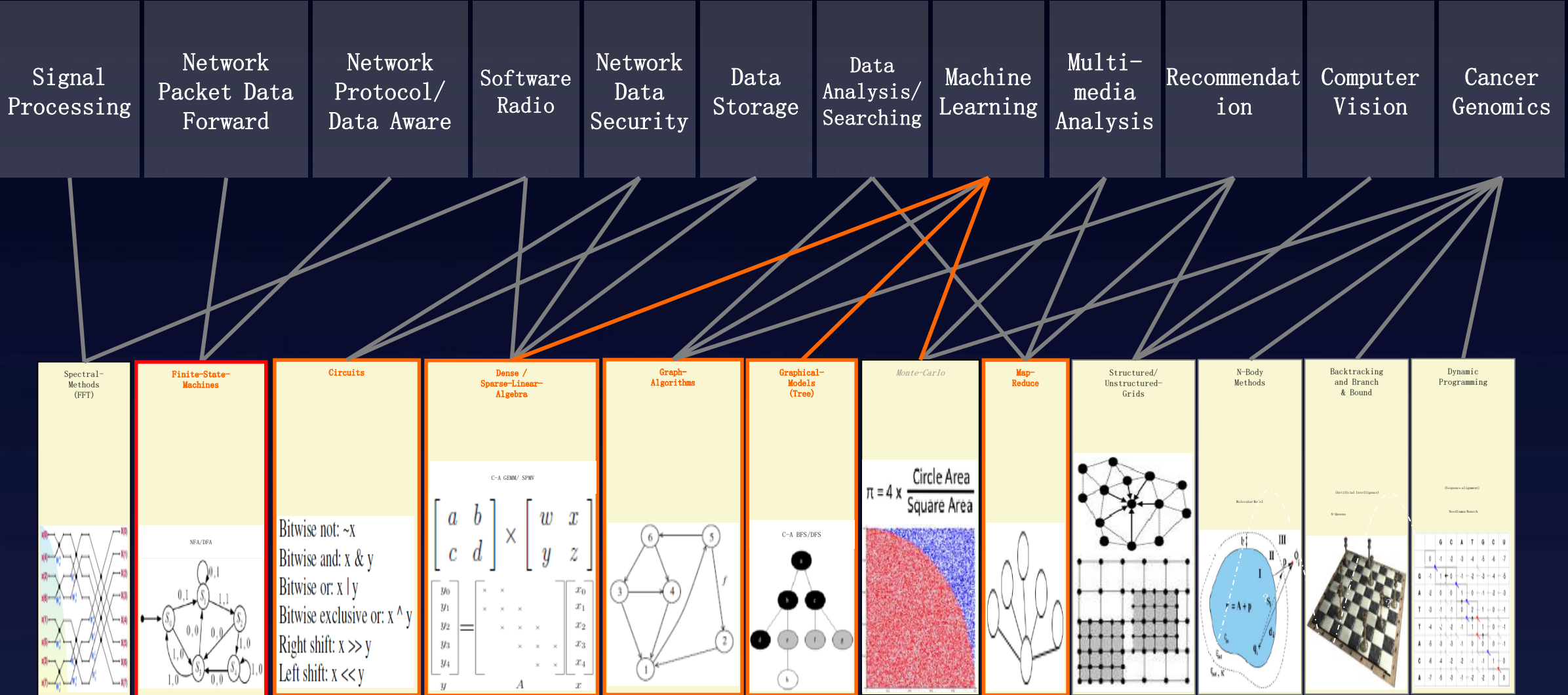
Why now?

Massive amounts of data that can be used to train Machine Learning models are being generated, for example through daily creation of billions of images, online click streams, voice and video, mobile locations, and sensors embedded in the Internet of Things devices.

Computing capacity has become available to train larger and more complex models much faster. Graphics processing units (GPUs), originally designed to render the computer graphics in video games, have been repurposed to execute the data and algorithm crunching required for machine learning at speeds many times faster than traditional processor chips. Key Trend Emerging: Specially design chips and Hardware for Machine Learning workloads (Tensor Units).

Machine-learning algorithms have progressed in recent years, especially through the development of deep learning and reinforcement-learning techniques based on neural networks.

New Paradigms for Algorithms



New Paradigms for Computing

	Device				Edge		Cloud
	Earphone	Always-on	Smartphone	Laptop	IPC	Edge Server	Data Center
Compute	20 MOPS	100 GOPS	1-10 TOPS	10-20 TOPS	10-20 TOPS	10-100 TOPS	200+ TOPS
Power budget	1 mW	10 mW	1-2 W	3-10 W	3-10 W	10-100 W	200+ W
Model size	10 KB	100 KB	10 MB	10-100 MB	10-100 MB	100+ MB	300+ MB
Latency?	< 10 ms	~10 ms	10-100 ms	10-500 ms	10-500 ms	ms ~ s	ms ~ s
Inference?	Y	Y	Y	Y	Y	Y	Y
Training	N	N	Y	Y	Y	Y	Y
Chip	Ascend-Nano	Ascend-Tiny	Ascend-Lite	Ascend 310	Multi Ascend		Ascend 910

New Paradigms for Networks

Mobile AI: What is the right architecture?

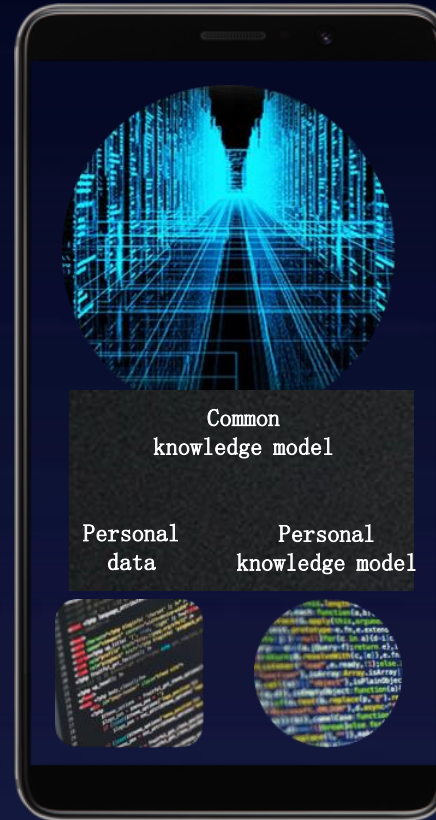


Big Data

Training



Update



Unified training and inference framework

Consistent Development Experience

Cooperative Training/Inference

Device 端
Light 轻量



Cooperative Training/Inference

Edge
Local 本地

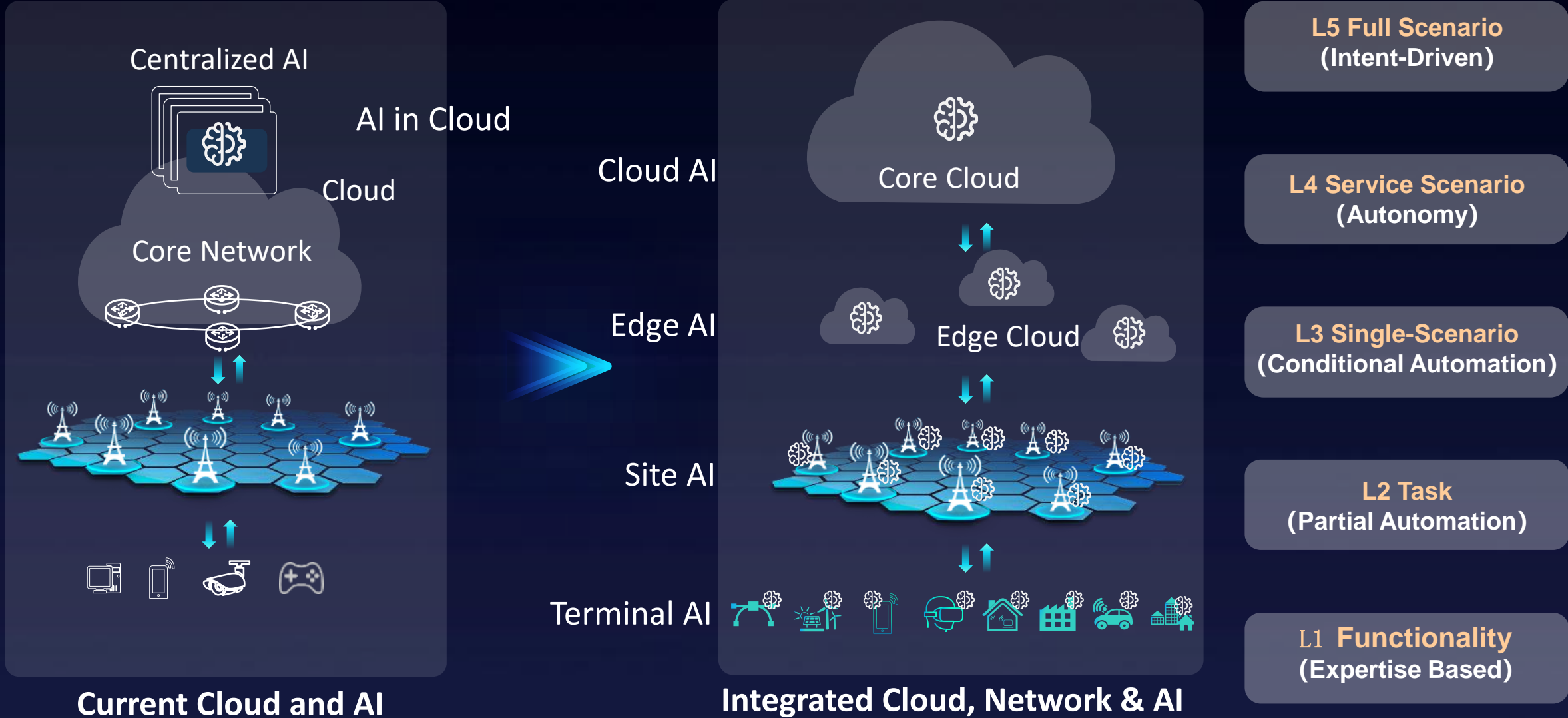


Cooperative Training/Inference

Cloud 云
Large-scale 大规模



New Paradigms for Networks



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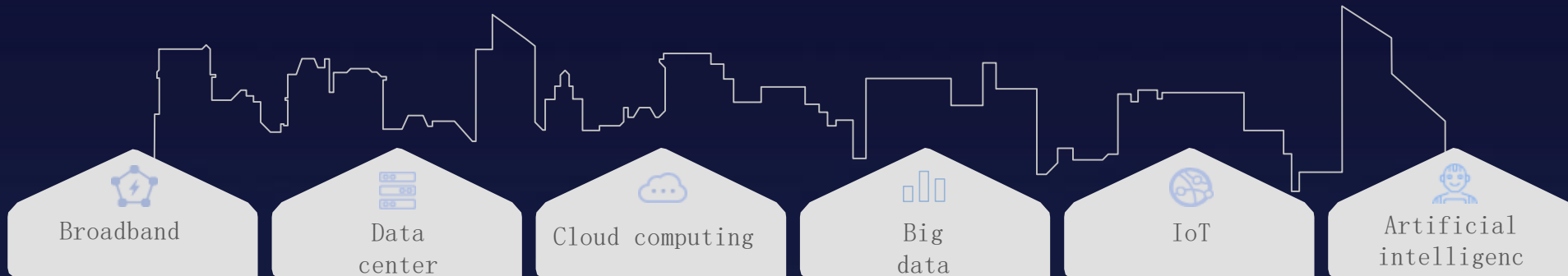
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Better Connection



Information Everywhere

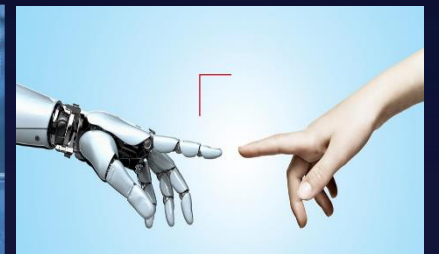
Holoportation &
Edge
Intelligence
(4.62Tbps)



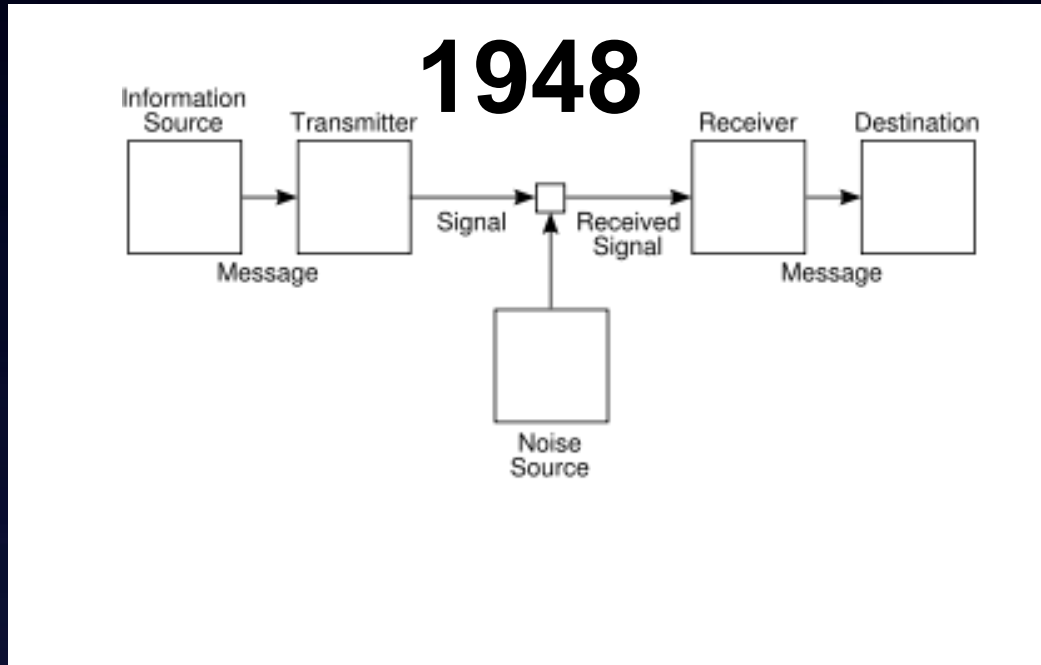
Autonomous /
Flying
Transportation
(4T/day)



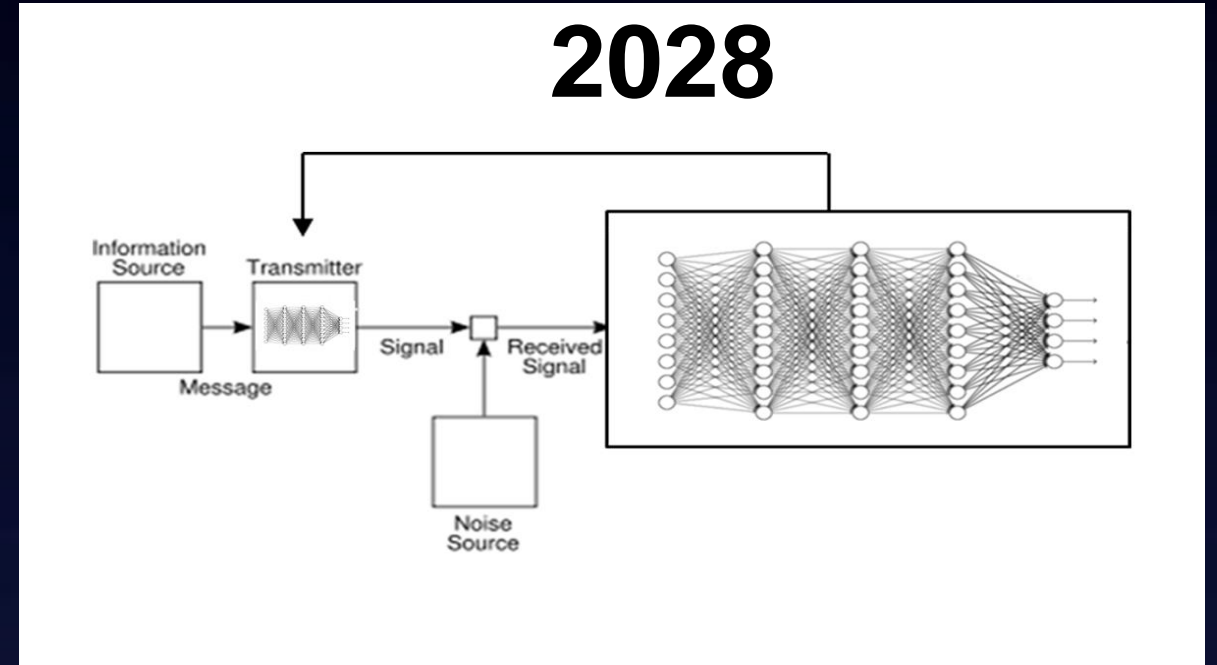
Digital Industry
and Robotics
($\ll 1\text{ms}$)



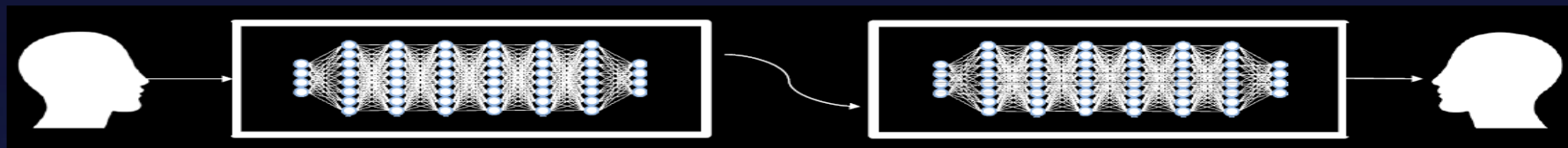
Smart Communications



Shannon 1.0



Shannon 2.0



Smart Channels

Title: Optimal Communication Channels in a Disordered World with Tamed Randomness

Authors: Philipp del Hougne^{1*}, Mathias Fink¹, Geoffroy Lerosey²

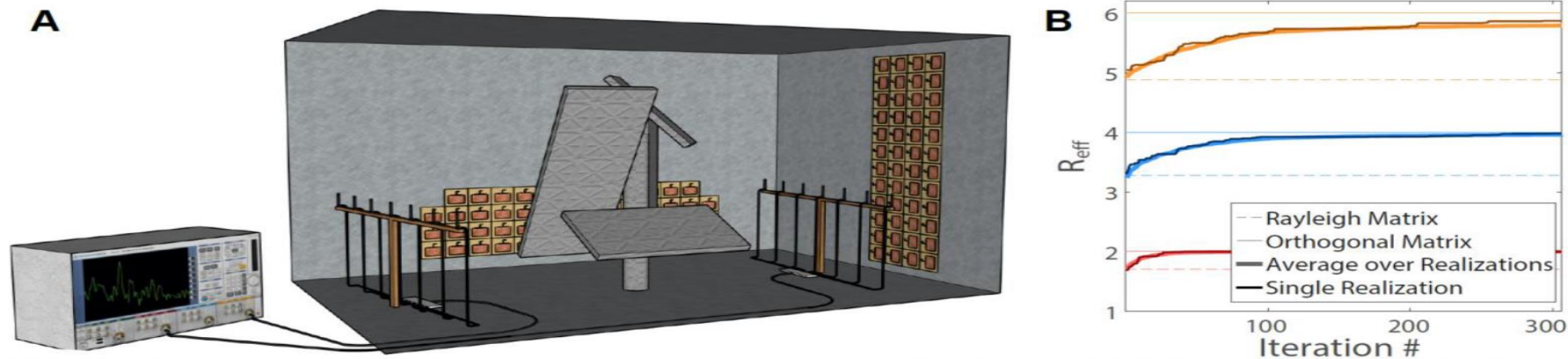
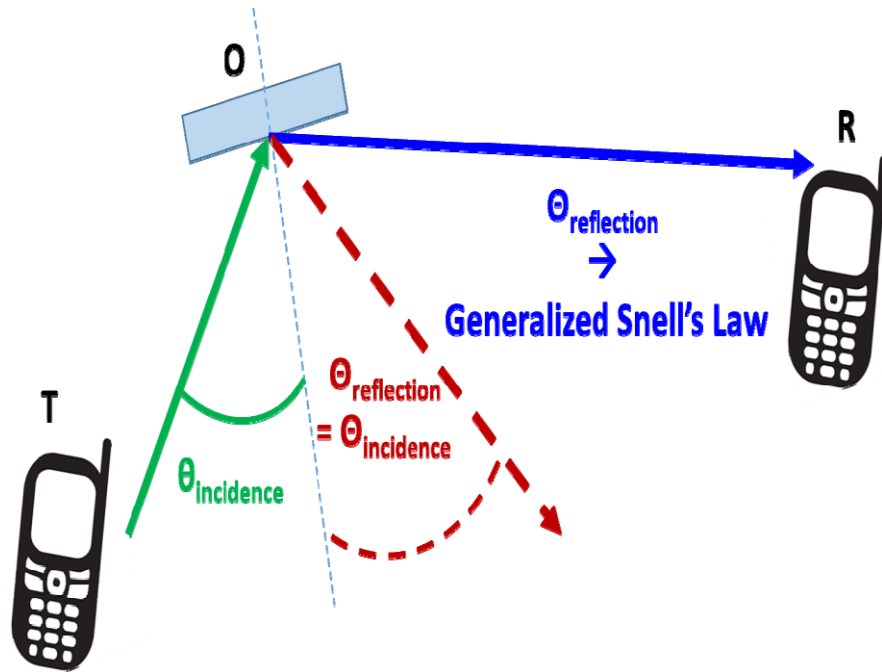


Fig. 1. (A) Experimental setup in a disordered cavity under Rayleigh fading conditions. A phase-binary metasurface reflect-array partially covers the cavity walls; appropriately configured, it physically shapes the channel matrix measured between the two antenna arrays and imposes perfect channel orthogonality. (B) Iterative optimization of channel diversity. The evolution of R_{eff} over the course of the optimization is given for a single realization, as well as averaged over 30 realizations, for $n=2,4,6$ (red, blue, yellow). Benchmarks for Rayleigh fading and perfect orthogonality are indicated, see legend.

Smart Channels

Reconfigurable Metasurfaces

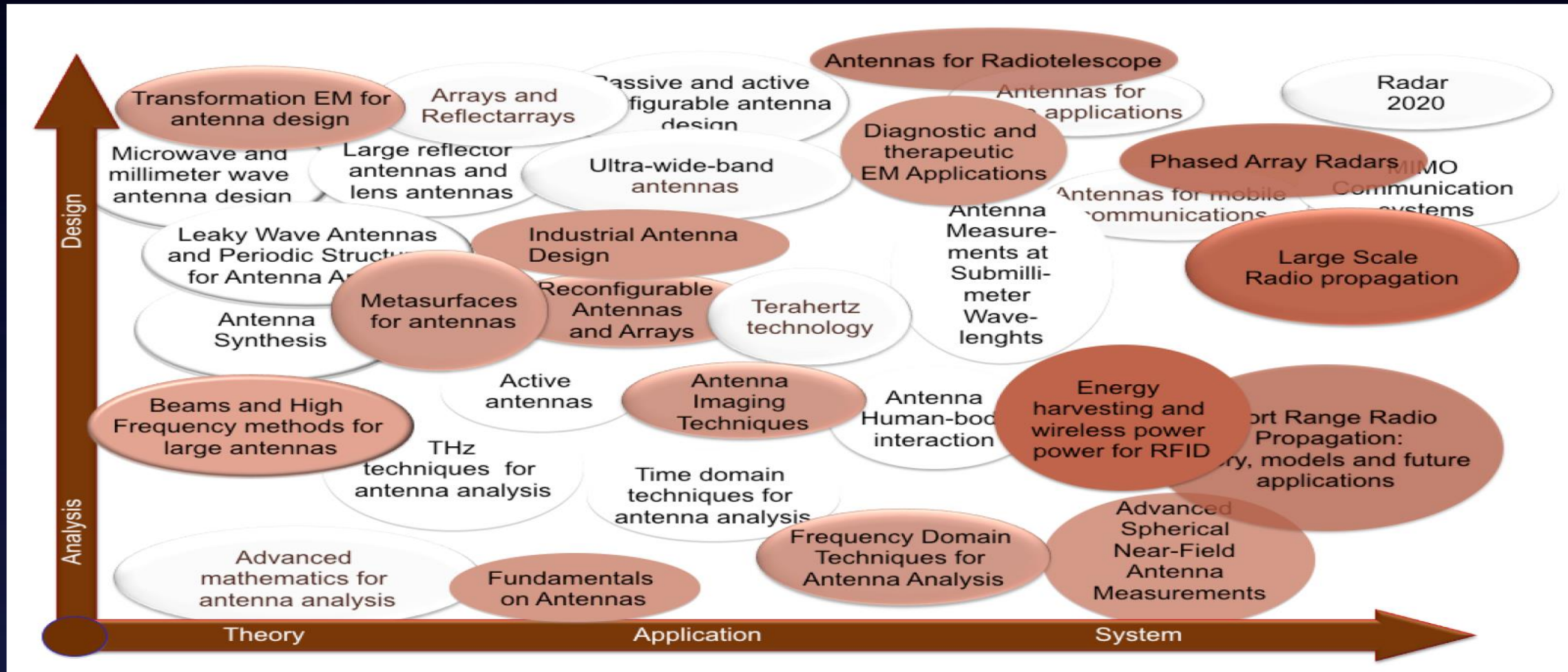


Di Renzo et al.

Smart Radio Environments Empowered by AI Reconfigurable Meta-Surfaces: An Idea Whose Time Has Come

Marco Di Renzo^{1*}, Merouane Debbah², Dinh-Thuy Phan-Huy³, Alessio Zappone⁴, Mohamed-Slim Alouini⁵, Chau Yuen⁶, Vincenzo Sciancalepore⁷, George C. Alexandropoulos⁸, Jakob Hoydis⁹, Haris Gacanin¹⁰, Julien de Rosny¹¹, Ahcene Bounceu¹², Geoffroy Lerosey¹³ and Mathias Fink¹¹

The Central Role of Antennas



Beyond 5G

Standardization Timetable



A GLOBAL INITIATIVE



From Connected Things to Connected Intelligence

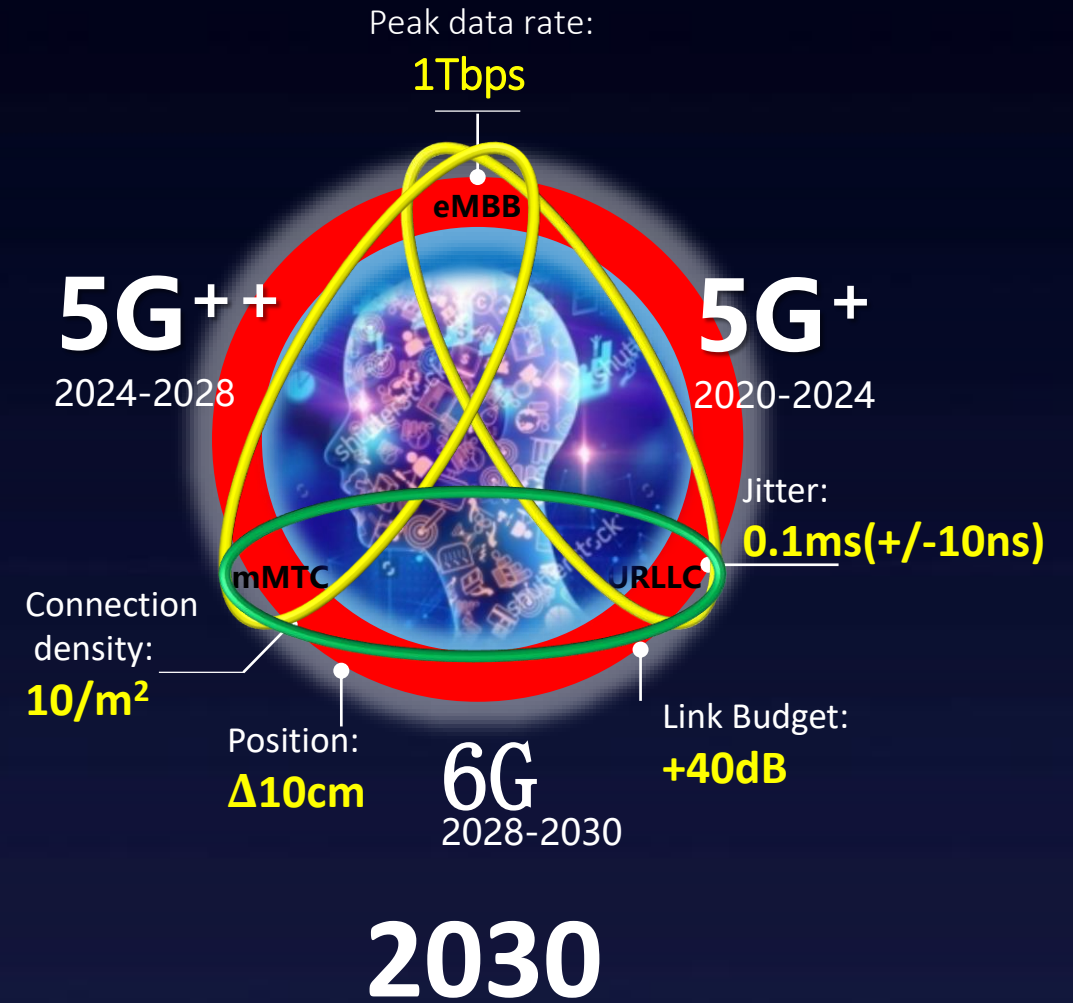
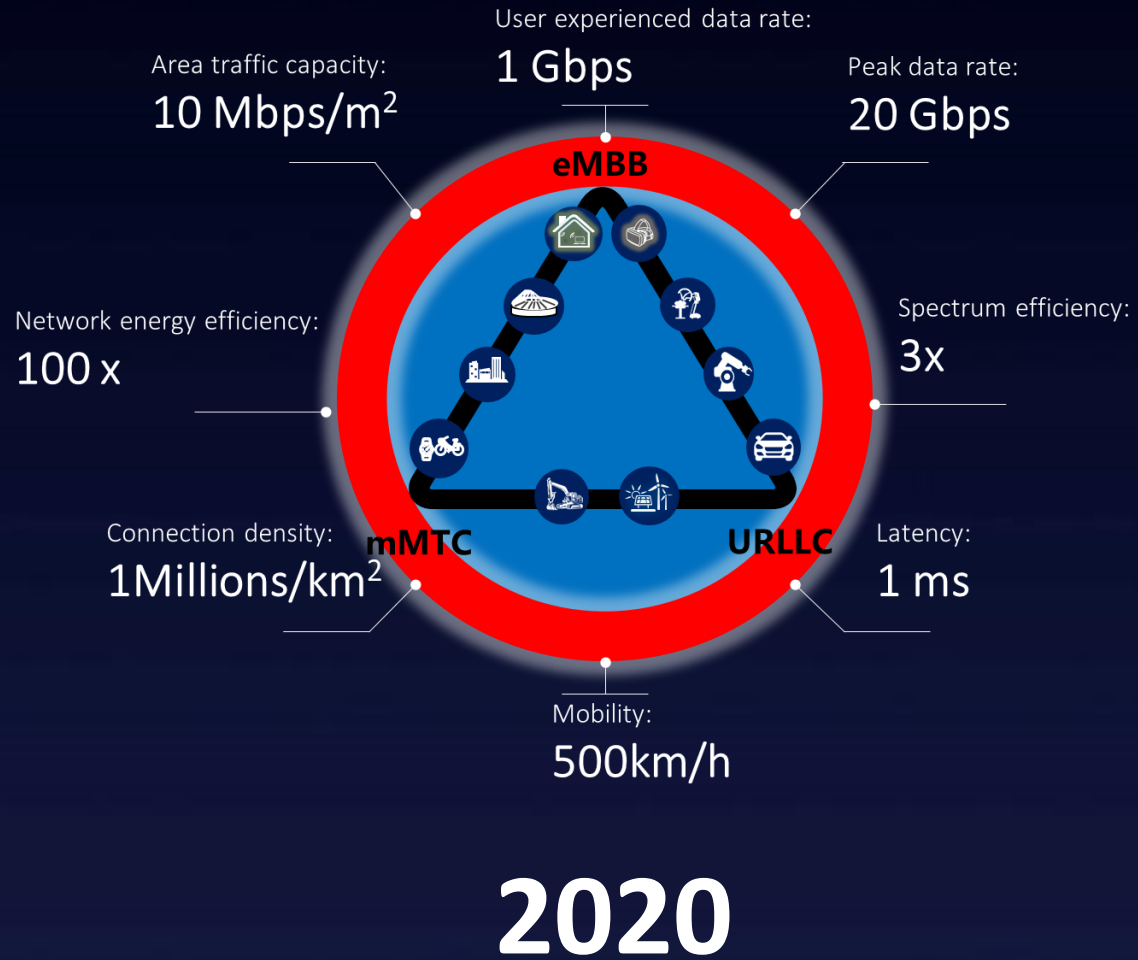


2020



2030

Beyond 5G



Thank you