



# The Wireless Road Ahead

Merouane Debbah

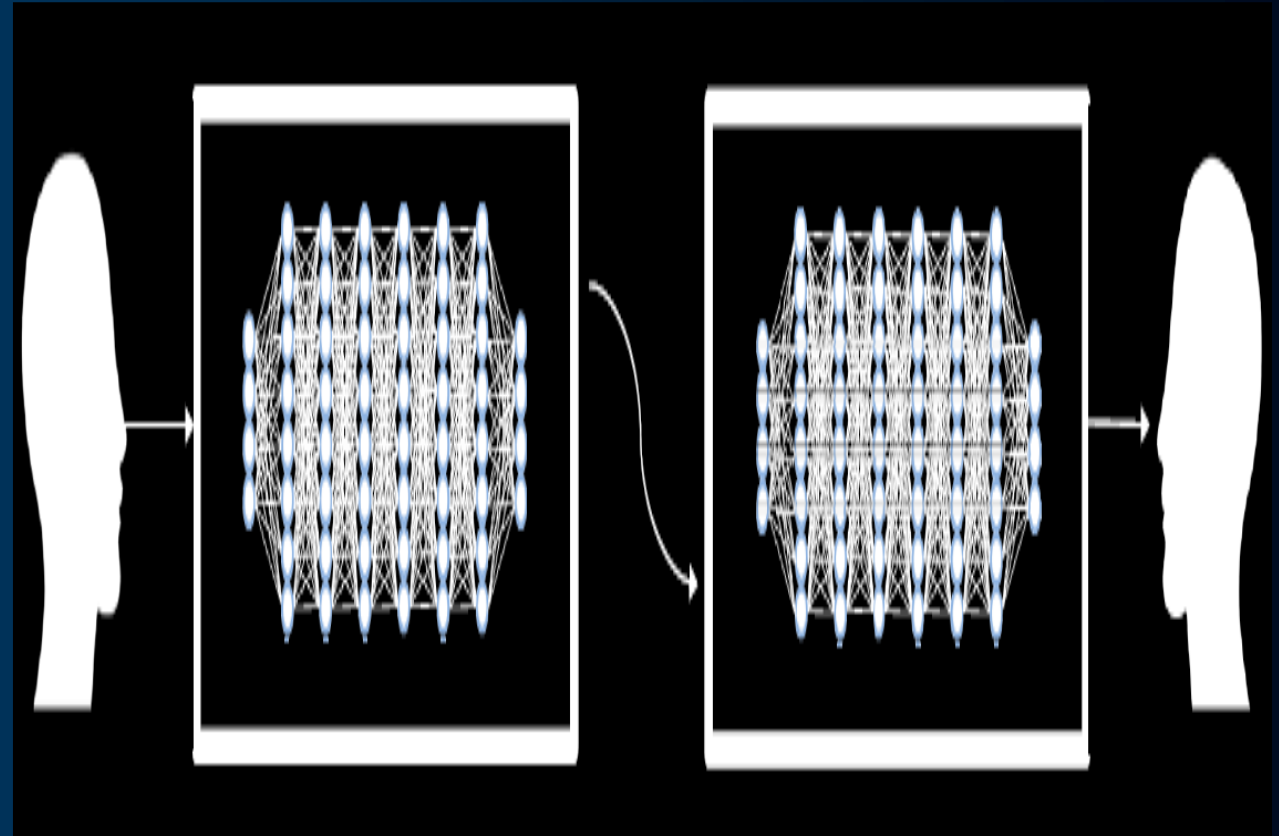
Huawei Mathematical and Algorithmic Sciences Lab

# 6G: Wireless for Intelligent Machines

“G” Waves

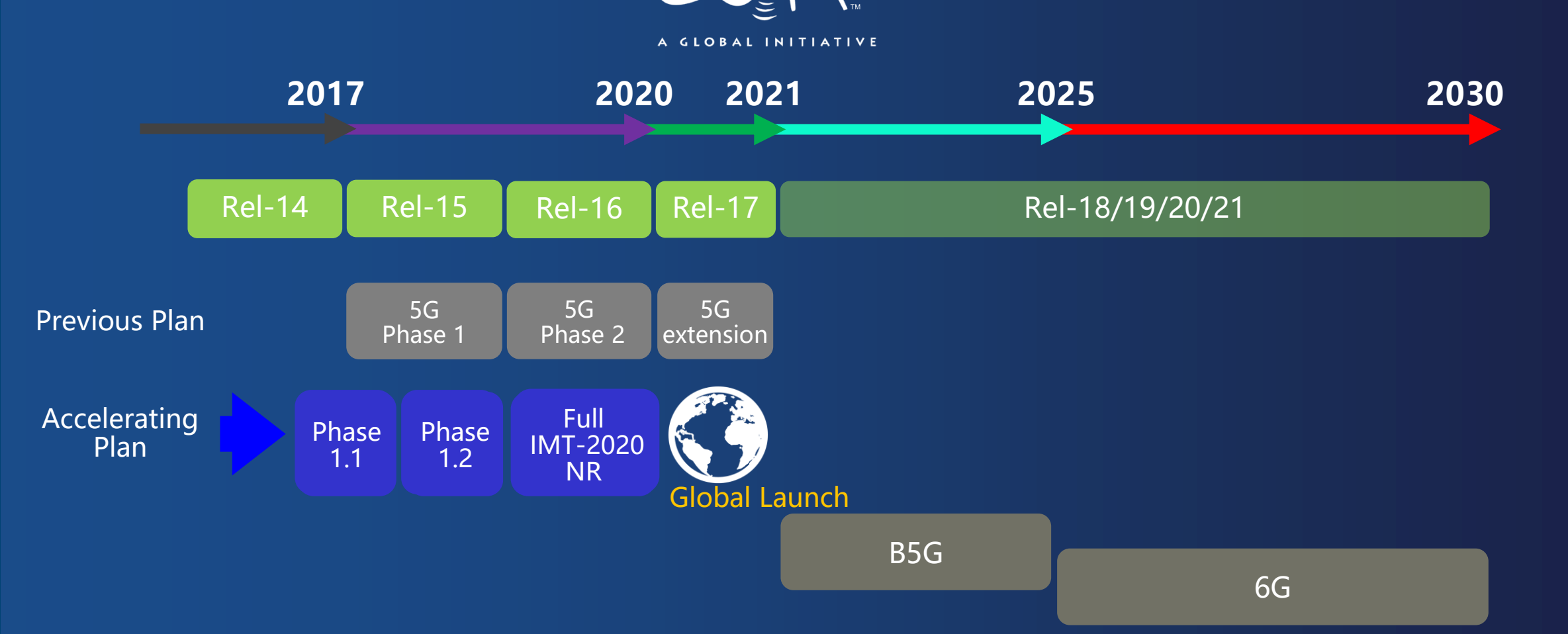
- 2G: Mobile for Voice
- 3G: Mobile for Visio-phony
- 4G: Mobile for Internet
- 5G: Mobile for Things
- 6G: Mobile for Machines

# 2035: Internet of Intelligent Machines?

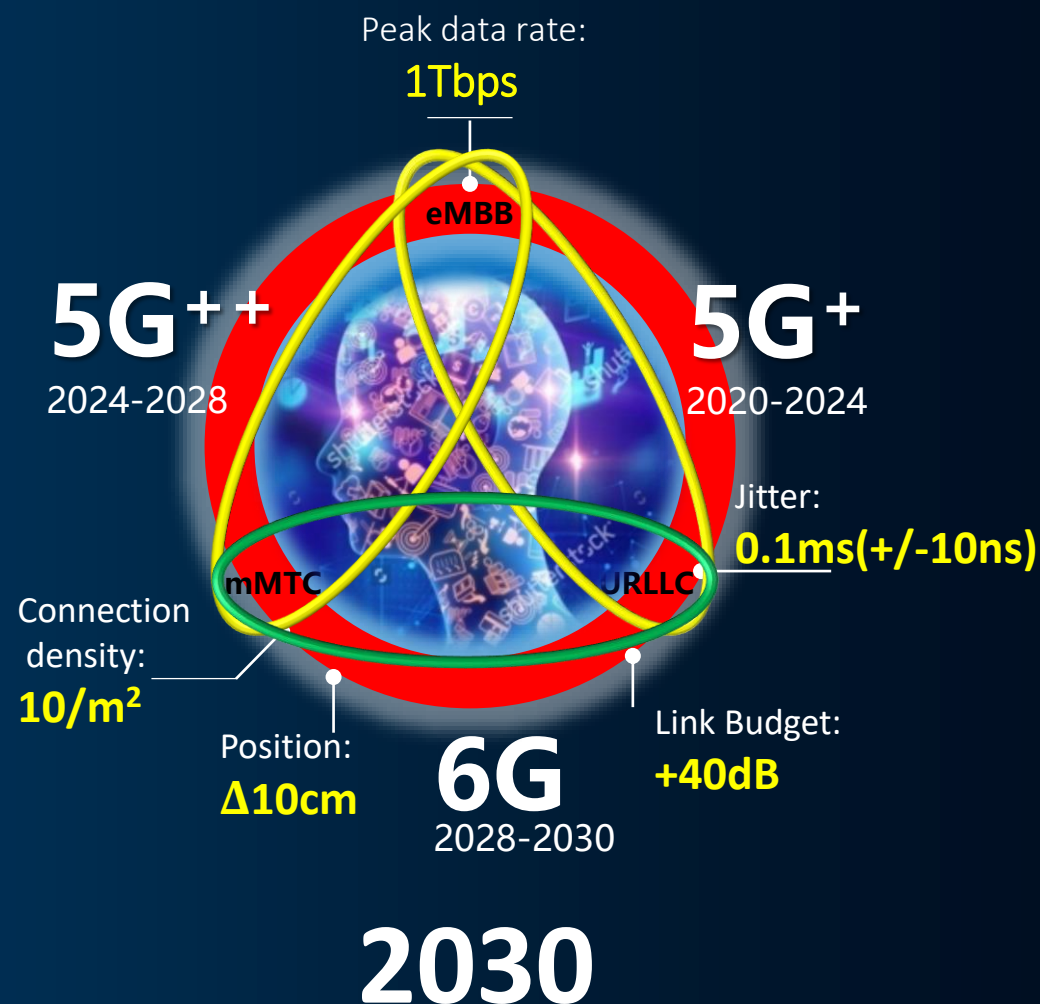
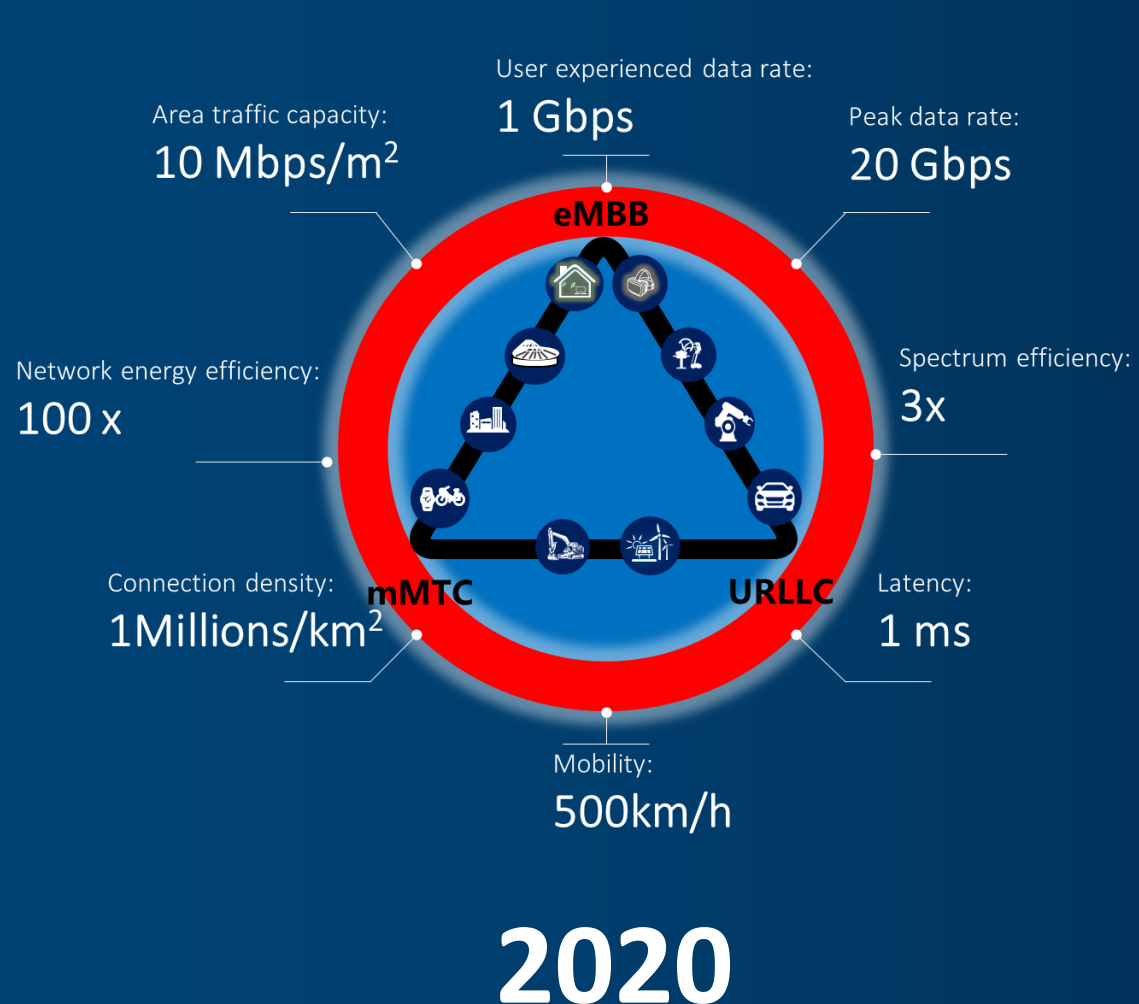


# 5G is Now

## Standardization Timetable



# 6G



# The 6G 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

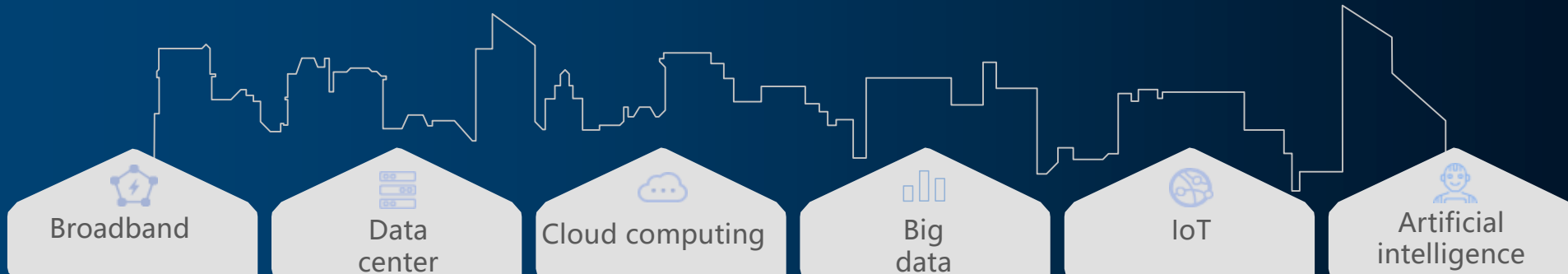
Ubiquitous connections, wide connections, multiple connections, and deep connections



## All Things Intelligent

Network integrated AI to power new applications

Digital twins  
Digital survival



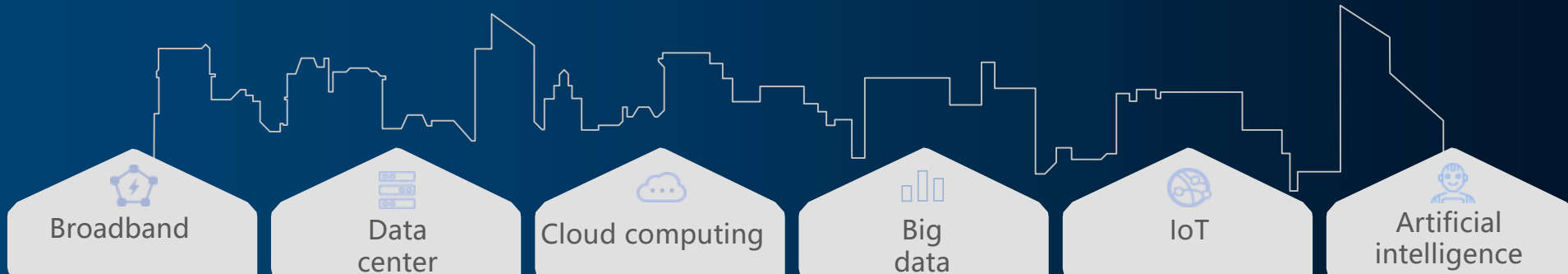
# We Are Entering a Hyper-connected Intelligent World



## All Things Sensed

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Temperature, space, and touch  
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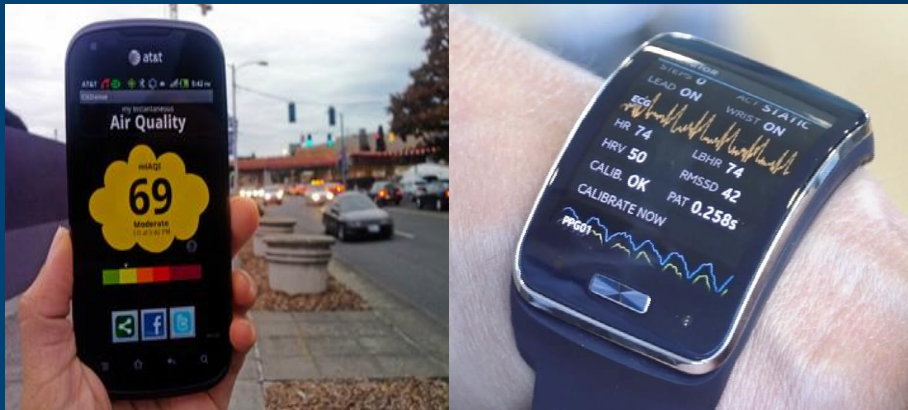


# Better Perception



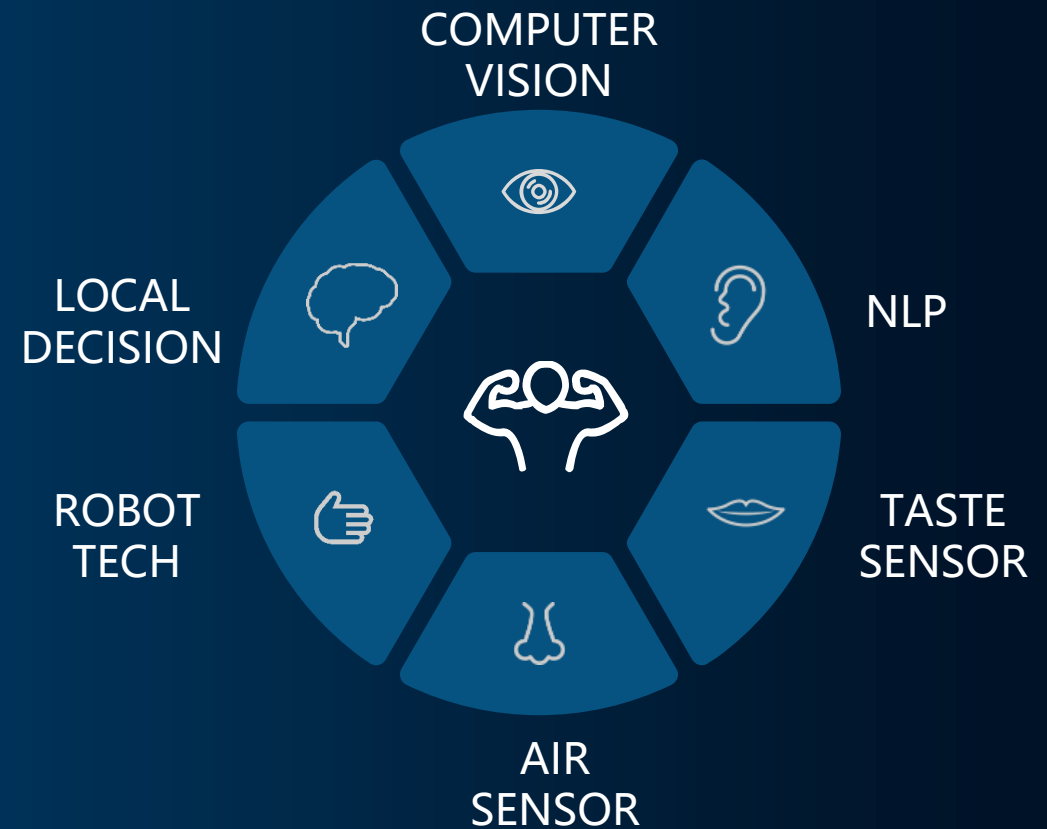
Naked Eyes

P30 Pro



Air Quality

Blood Pressure



**More Information, Better Service & Experience**



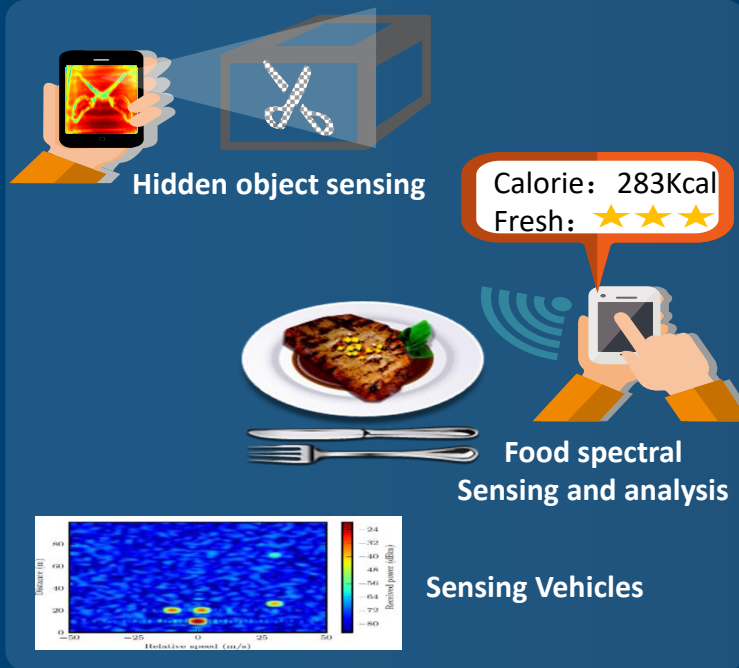
# Convergence of Wireless Transmissions and Sensing

Spatial Dimension

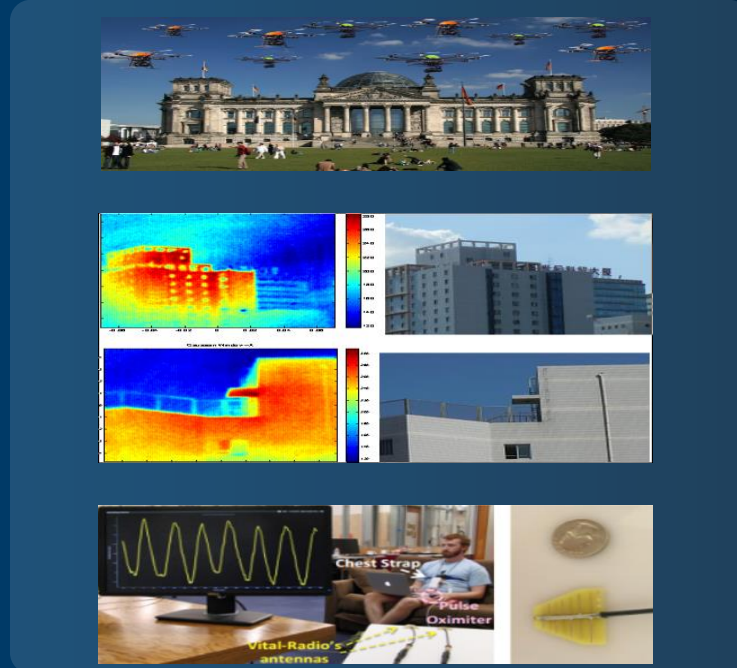
Chemistry

Biology

Medical



Terminal Sensing



Infrastructure Sensing



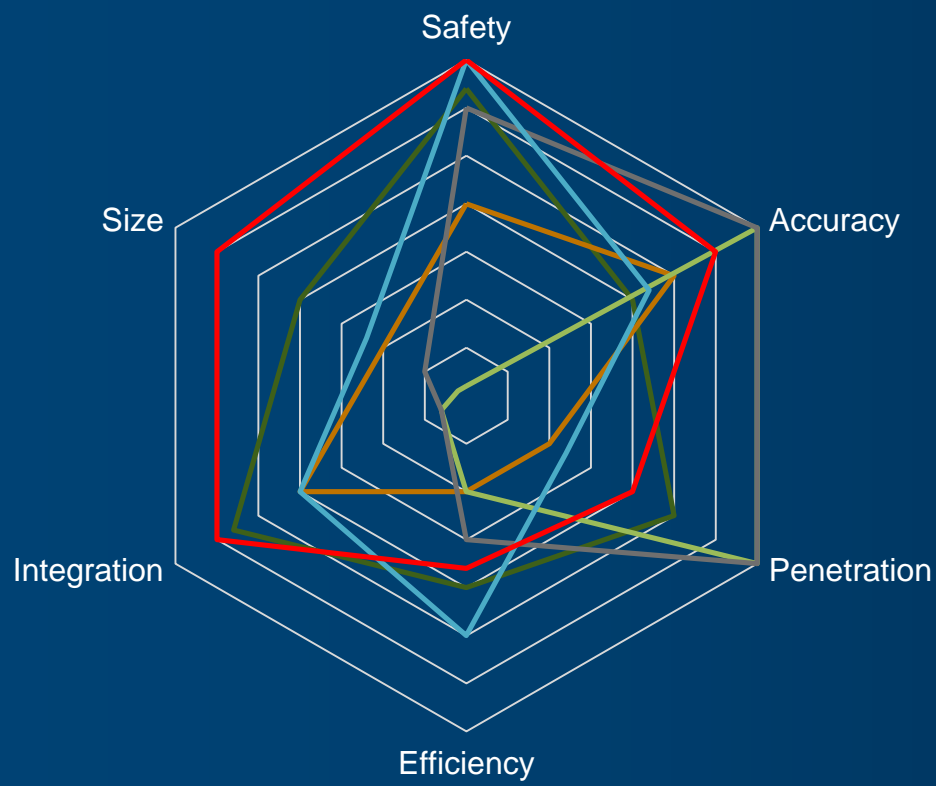
Analytics



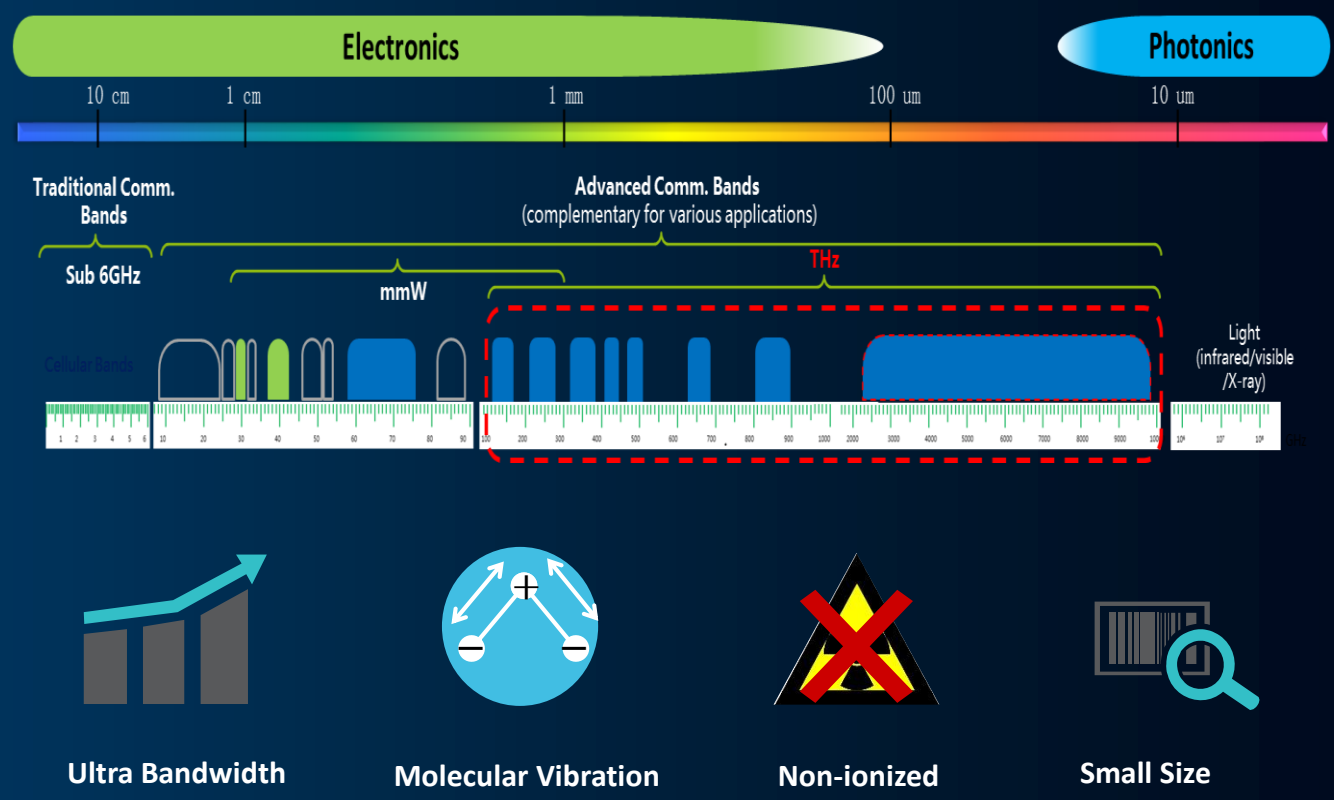
# Sensing and Spectrum

## TECHNOLOGY

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



## Tera-THz Extend the Scope of Sensing



# We Are Entering a Hyper-connected Intelligent World



## All Things Sensed

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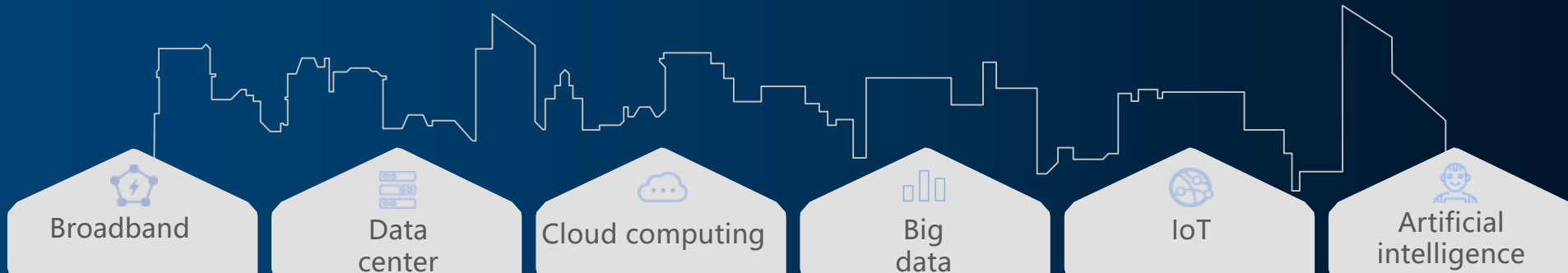
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## All Things Intelligent

Network integrated AI to  
power new applications

Digital twins  
Digital survival



# 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	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

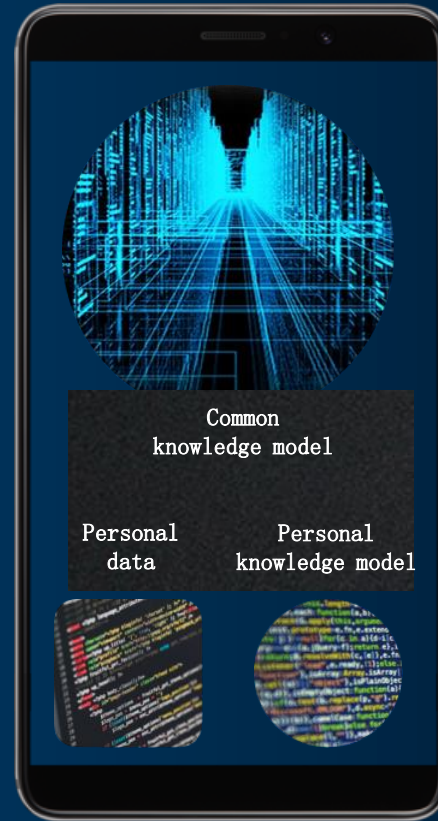
# Mobile AI: What is the right architecture?



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



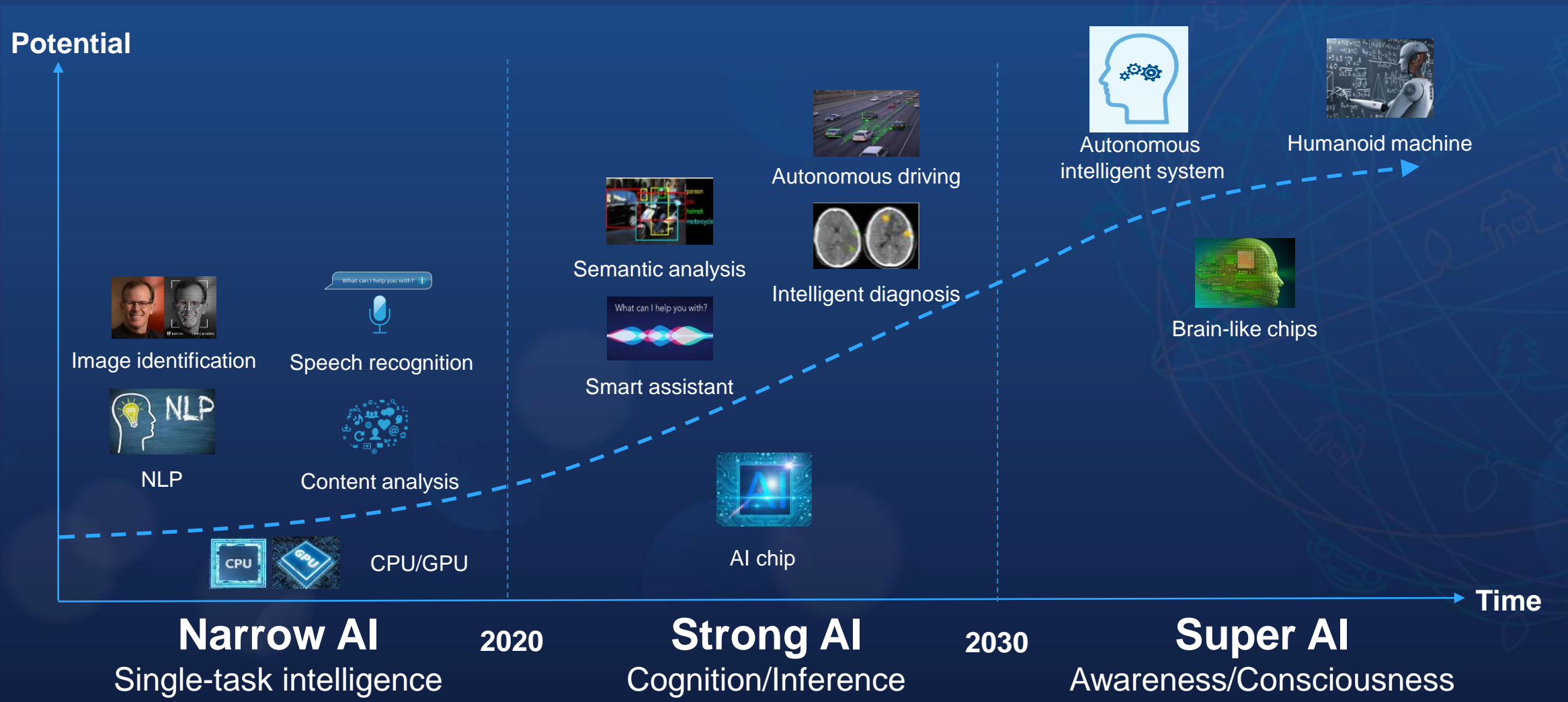
Cooperative Training/Inference

Cloud 云

Large-scale 大规模

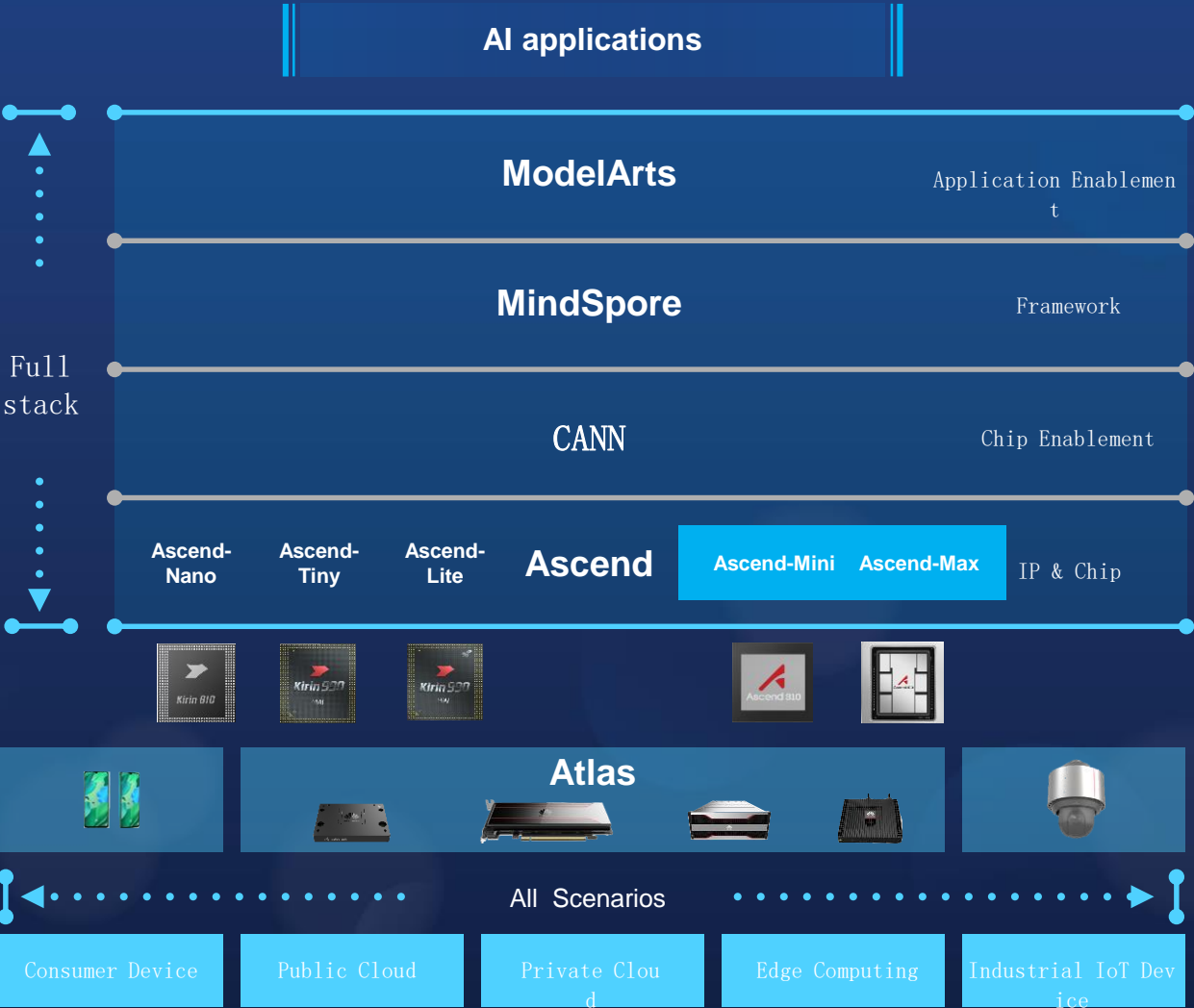


# AI Technologies Accelerate Industrial Intelligence





# Huawei Full-Stack, All-Scenario AI Solution



- Application enablement: whole-process services (ModelArts), layered APIs, and pre-integration solution
- MindSpore: unified training and inference framework for device/edge/cloud (independent or collaborative)
- CANN: chip operator library and highly automated operator development tool
- Ascend: a series of AI IPs and chips with unified and scalable architecture
- Atlas: various products built on Huawei Ascend AI processors for device-edge-cloud AI infrastructure for all scenarios

# What can already be done today

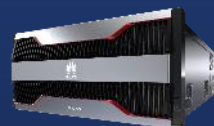
Ultimate computing power

Applicable to all scenarios

Cloud-edge-device collaboration



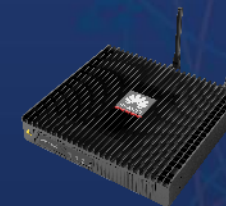
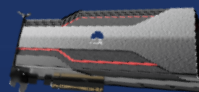
Atlas 900  
AI cluster



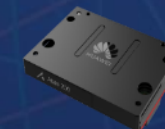
Atlas 800  
AI server



Atlas 300  
AI accelerator card



Atlas 500  
AI edge station



Atlas 200  
AI accelerator module



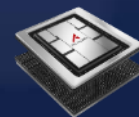
Cloud

Edge

Device



Ascend 310



Ascend 910

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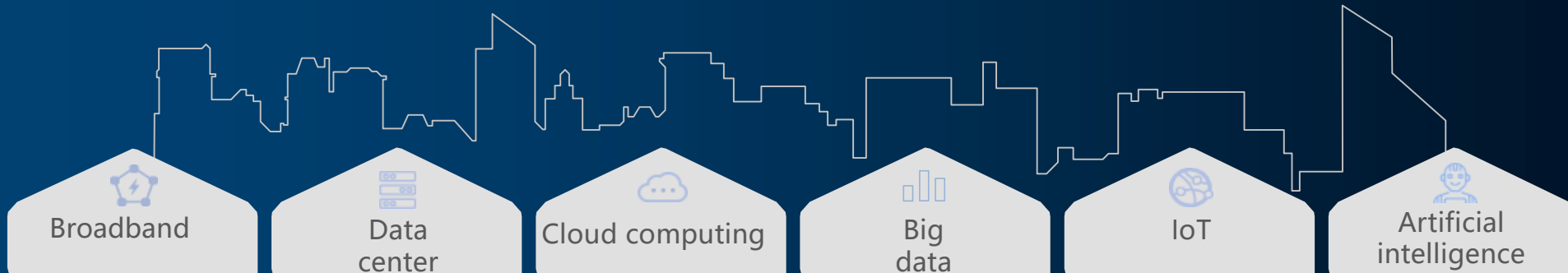
Ubiquitous connections, wide  
connections, multiple connections, and  
deep connections



## All Things Computed

Network integrated AI to  
power new applications

Digital twins  
Digital survival



# Better Connection



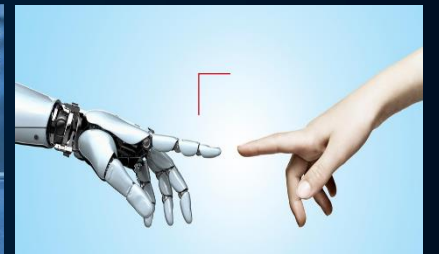
Holoportation  
& Edge  
Intelligence  
(4.62Tbps)



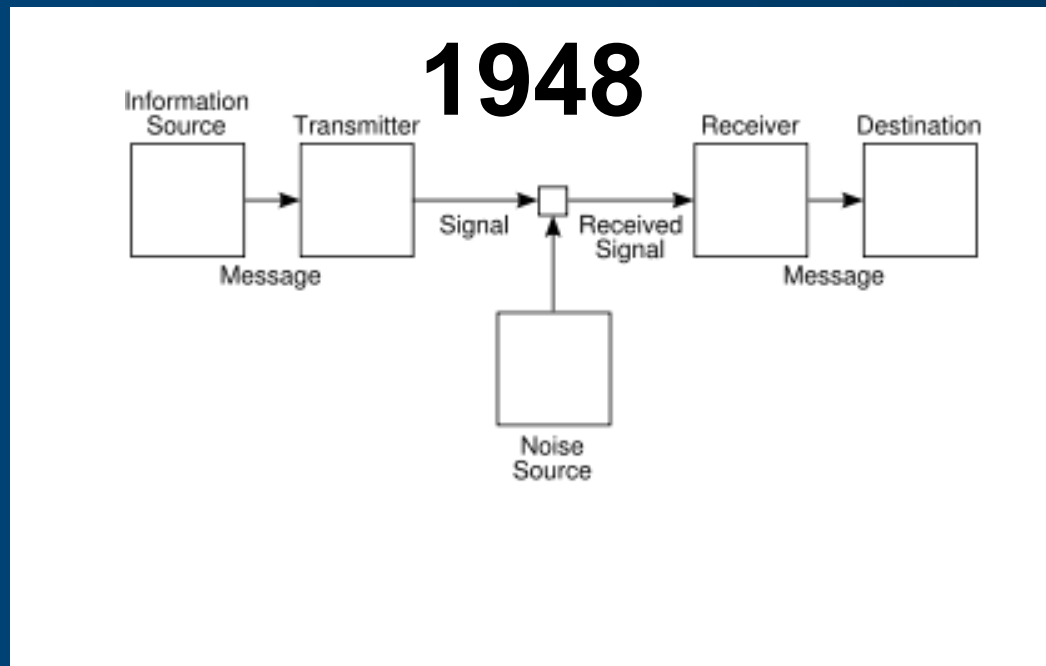
Autonomous /  
Flying  
Transportation  
(4T/day)



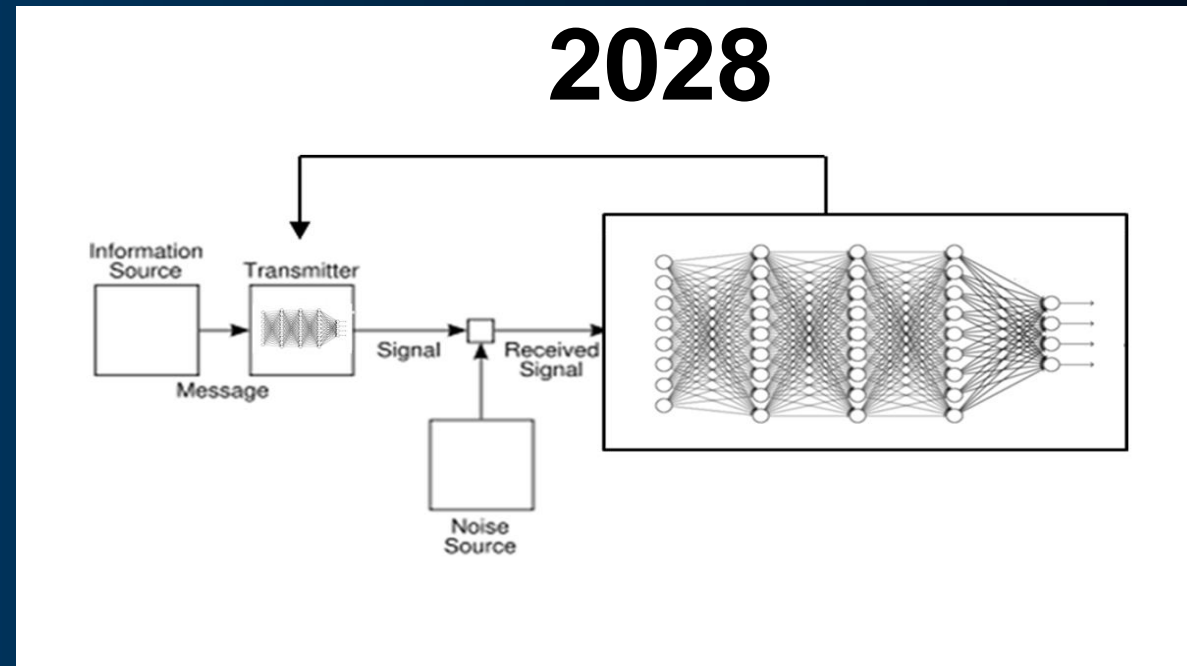
Digital Industry  
and Robotics  
( $< 1$ ms)



# Smart Communications



Shannon 1.0



Shannon 2.0

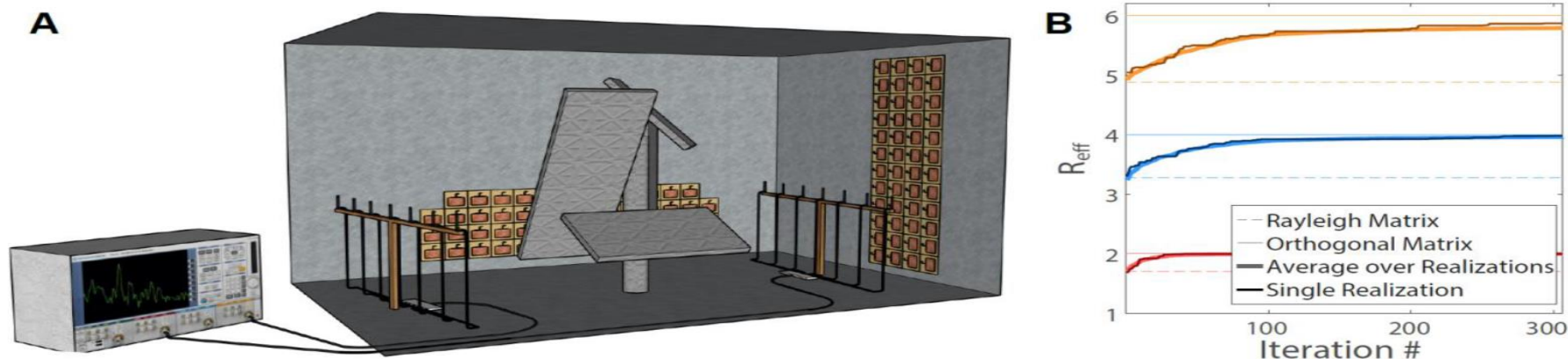




# Smart Channels

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

Authors: Philipp del Hougne<sup>1\*</sup>, Mathias Fink<sup>1</sup>, Geoffroy Lerosey<sup>2</sup>



**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  $R_{\text{eff}}$  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.

# Thank you.

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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