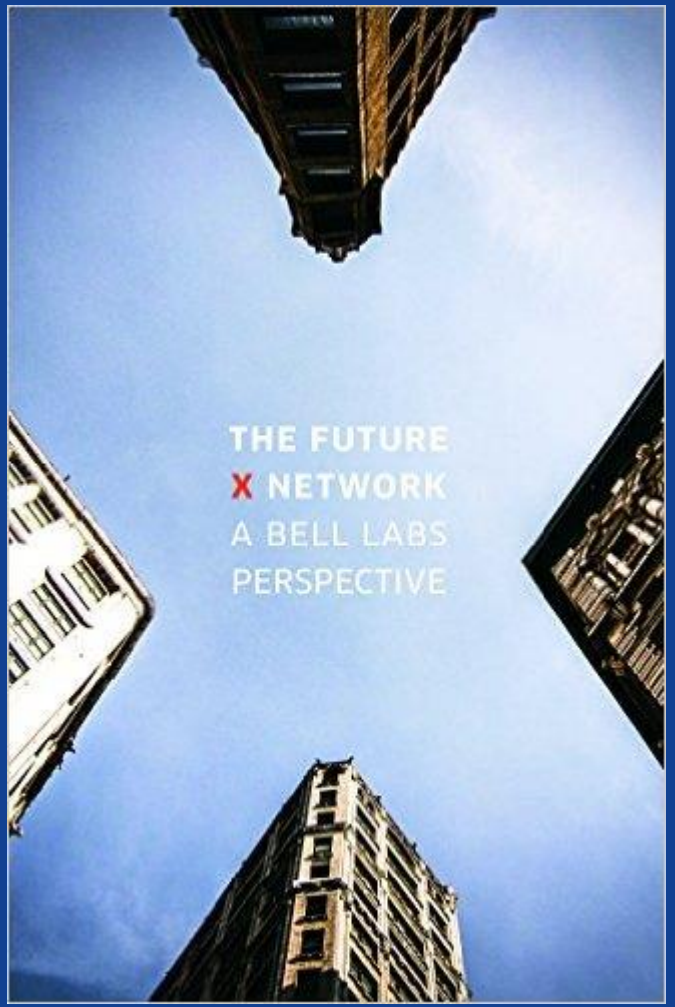
NOKIA Bell Labs

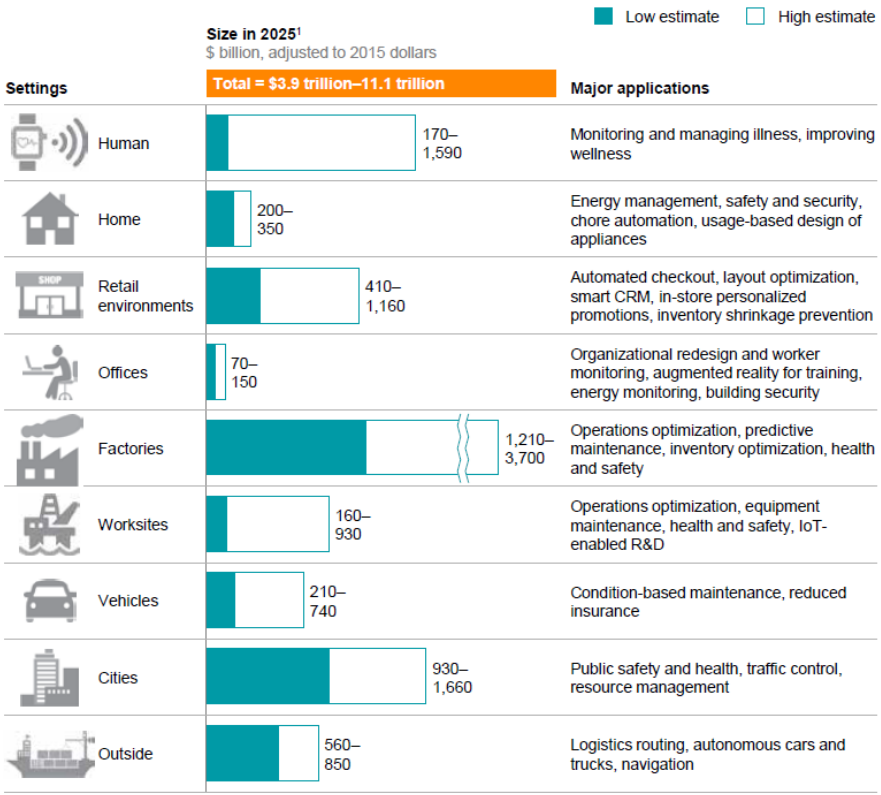
Future X: Building the digital networks, systems and platforms for the automation of everything and the creation of time



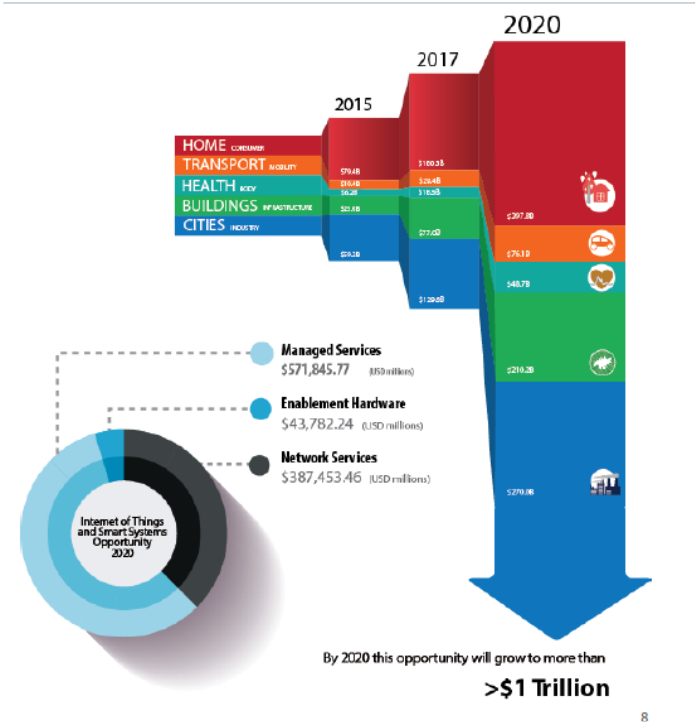
Marcus Weldon

President of Bell Labs & CTO of Nokia

Future of automated systems, platforms, infra



Source: McKinsey Global Institute, The Internet of Things: Mapping the Value Beyond the Hype, June 2015



Source: Harbor Research

NOKIA Bell Labs

The revolution

Technological Revolution (def):

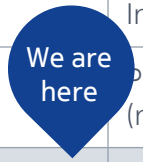
Interconnection of new systems and technologies + capacity to profoundly transform economies & society

Tech. Revolution	Enabling Technology	Connectivity
Financial (1600 – 1740)	Stocks & Bonds	Banking & Stock Market Infrastructure
1st Industrial (1780 – 1840)	Steam Engine & Iron Production	Rail and Shipping Networks
2nd Industrial (1880 – 1920)	Steel & Chemicals	Extended Transportation Networks Electricity & Telecom Networks
Scientific-Technical (1940 – 1970)	Analog & Digital Signal processing	Digital Communications Networks
Information (1985 – 2015)	The Web, Cloud computing & Mobile devices	Internet & Broadband Access
Automation of Everything (2015 –)	**Digital interfaces & Data analysis**	**Future X Network**

We are here

The end and the beginning

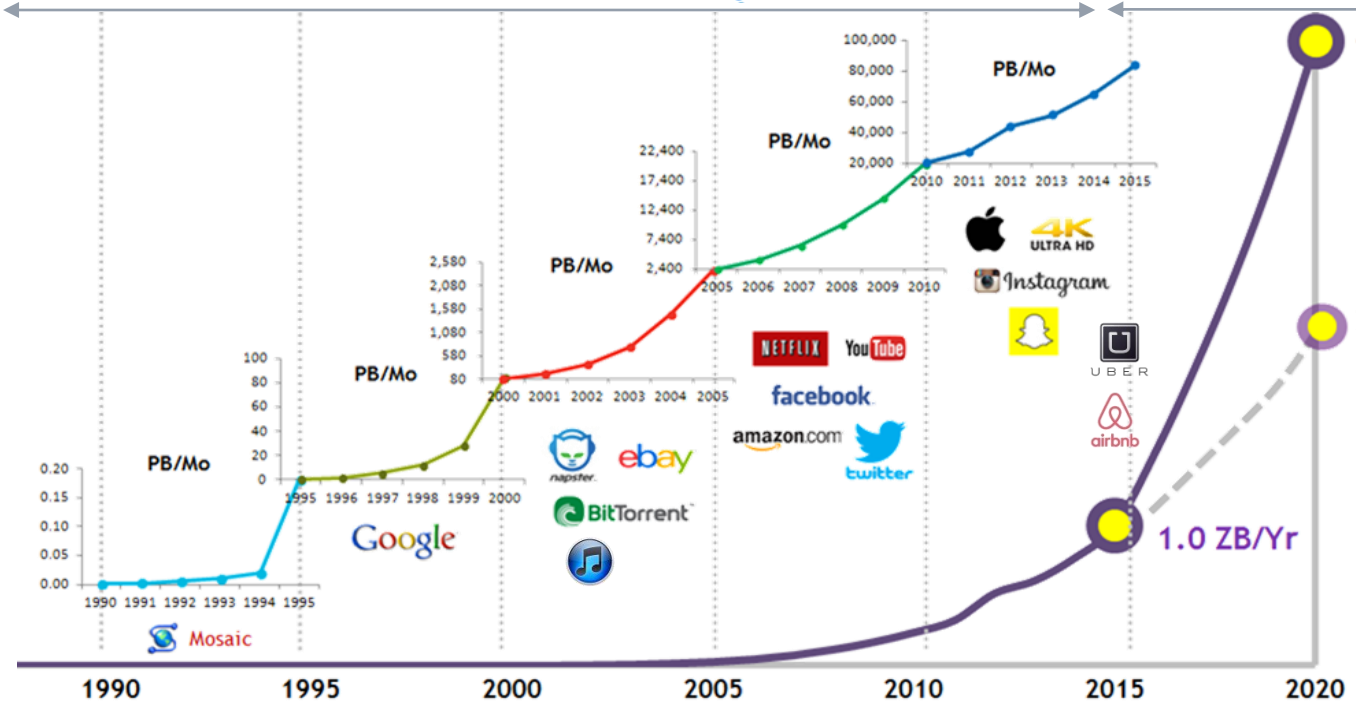
		Past/Present	Future
Business	Solutions	Technology-driven	Human/Business-driven
	Driver	Consumer (GB)	Industry (BW, Latency, SLA)
	Innovation Speed	Per decade (new services)	Per day (new apps)
Technology	Architecture	Heavily Centralized (100ms, 10M)	Massively Distributed (1ms, 1G)
	Flexibility	Limited (Provisioned)	Large (Software definable)
	Sharing	Static and Limited (HW VPNs)	Dynamic and Infinite (SW Slices)
Industry Dynamic	Investment	Singular (Operator only)	Multiple & Cooperative (Many contributors/new players)
	Standards	Definitive	Iterative
	Partnership	Limited w/APIs	Co-design w/Open specs



The new digital era

Digitization, delivery & sharing of:

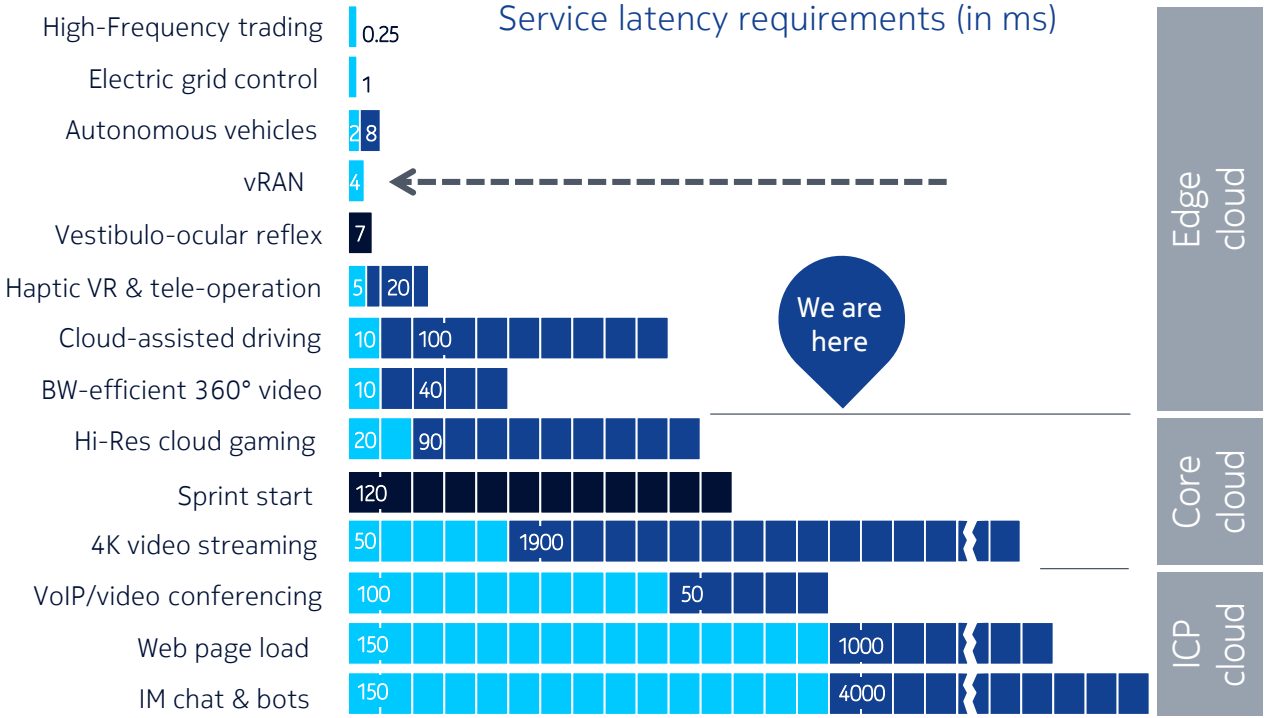
Digitization, distribution & optimization of:

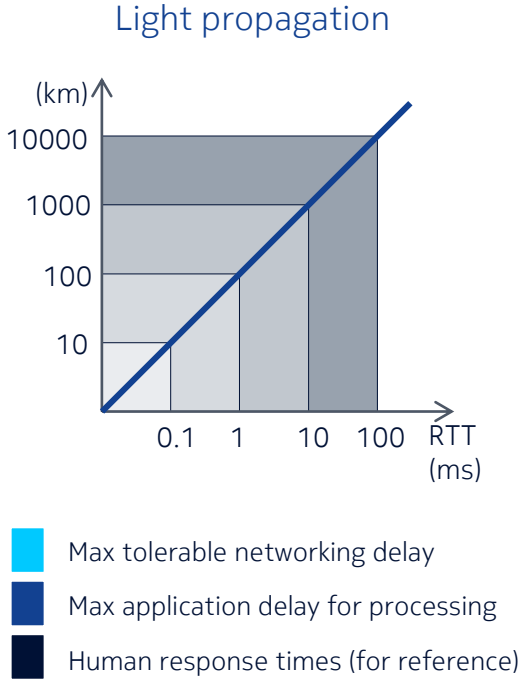


Enterprises & Verticals

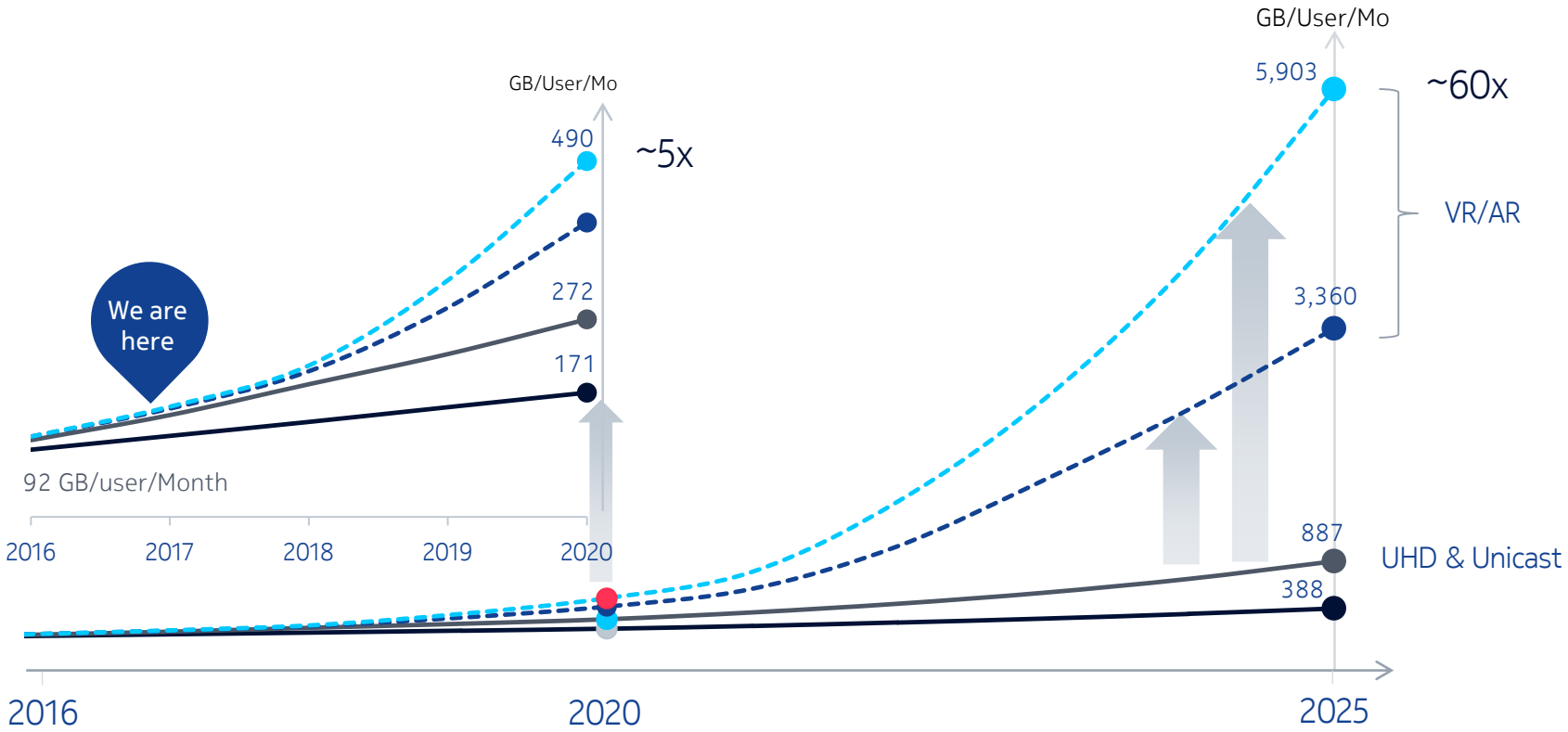
Consumers

Latency matters …





Bandwidth matters …



Industrial Internet Limits and Needs

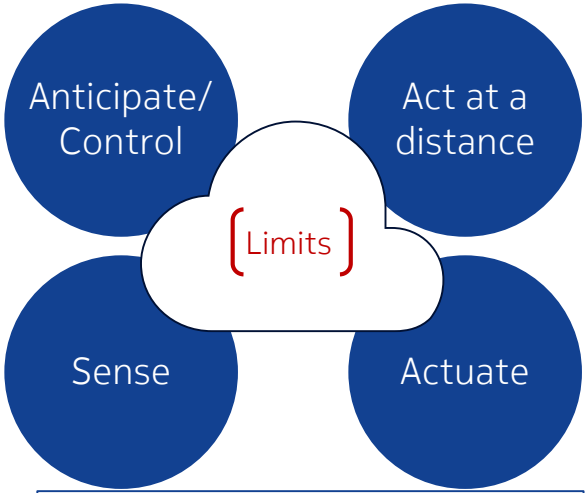
Requirements
Safety, Speed, Precision, Accuracy, Reliability, Adaptability

- Moore's Law
- AI Systems

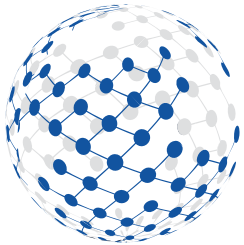
Digital models of the physical world

Telepresence (VR, haptics)

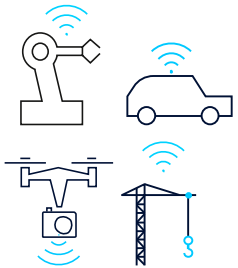
- Human VOR
- Response Time



- Device Phys/Chem
- New materials
- Speed of light



Digital nervous system



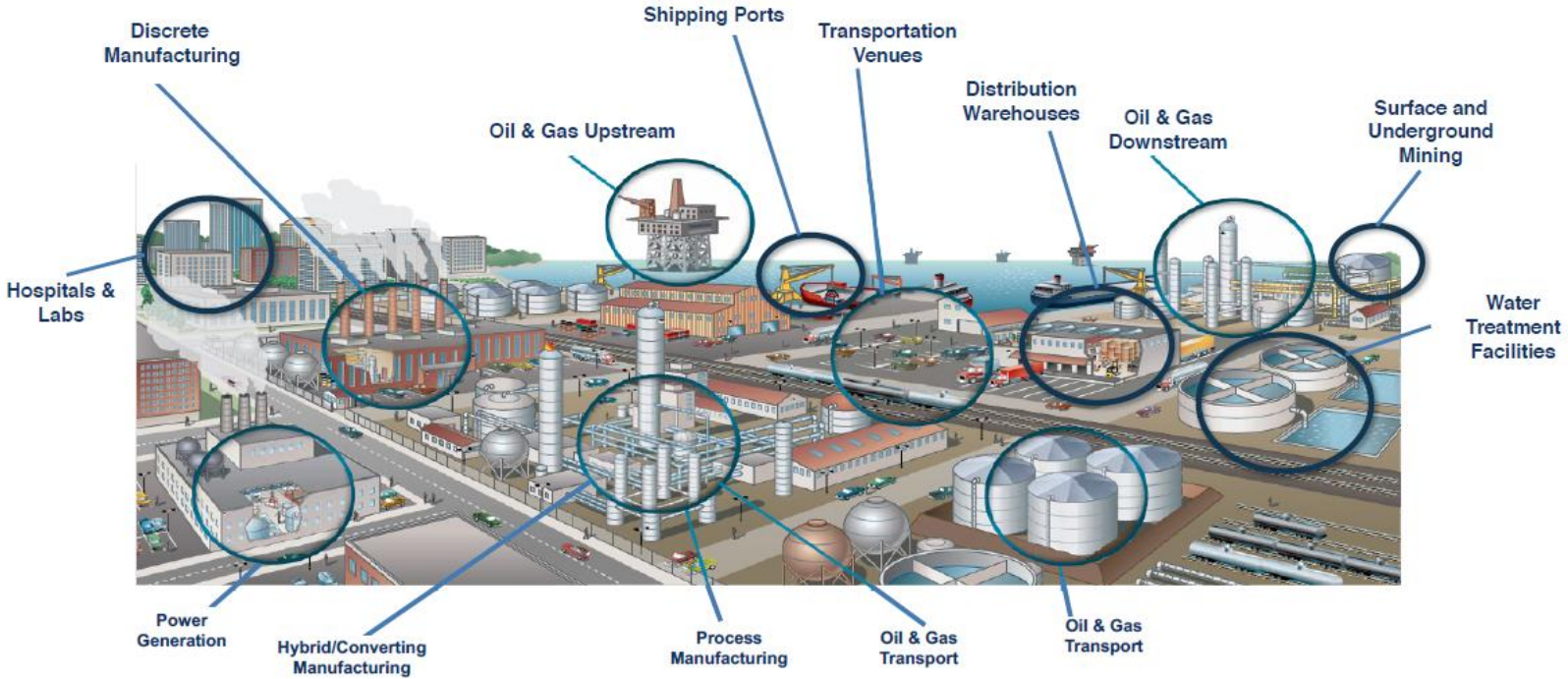
Hyper-automation

- System Engineering
- Precision Robotic control

Digital Solution (Network) Needs

Bandwidth
Latency
Scalability
Reliability
Security

MulteFire Industrial Advantage



“Mission critical” supply chains & industries

Source: Harbor Research

MulteFire Applications Advantage

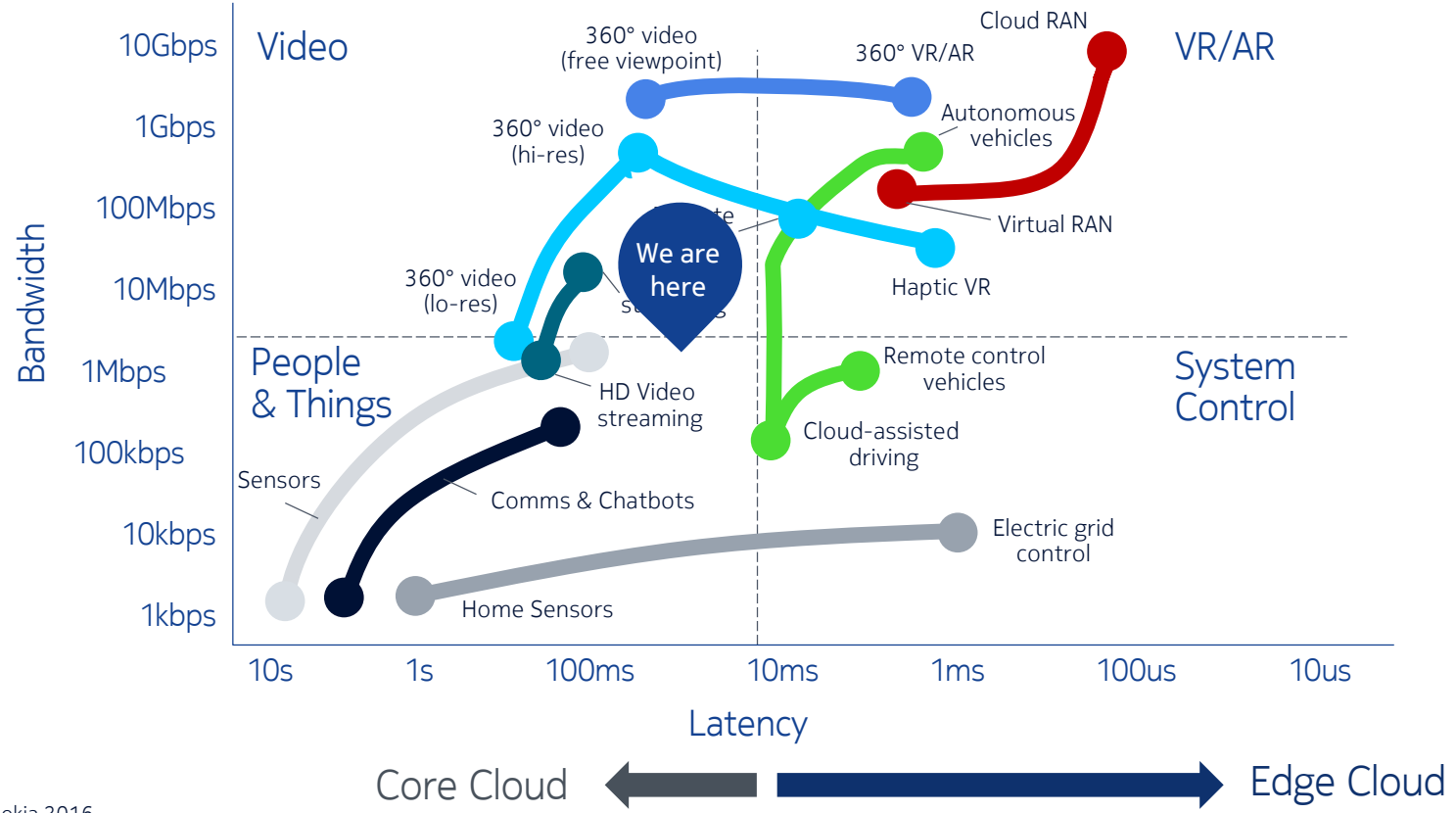
31B market, 500M units in 2022

	2016	2022	2016-2022 CAGR
Factories	24.5	99.6	26.3%
Borders & Ports of Entry	2.5	15.9	36.1%
Upstream	0.3	1.9	36.0%
Power Generation	1.8	11.4	36.0%
Military Bases	6.3	54.7	43.4%
Process Plants	14.4	70.5	30.3%
Warehouses	17.4	69.9	26.1%
Hospitals & Labs	2.2	18.5	42.6%
Surface	2.4	12.5	31.7%
Transport Venues	3.4	19.9	34.2%
Downstream	1.5	11.0	39.0%
Mills	16.8	85.9	31.2%
Underground	0.1	0.5	40.9%
Clinics	1.0	12.6	52.0%
Water Utility Plant	1.1	13.1	51.8%
Total	**95.7**	**497.8**	**31.6%**

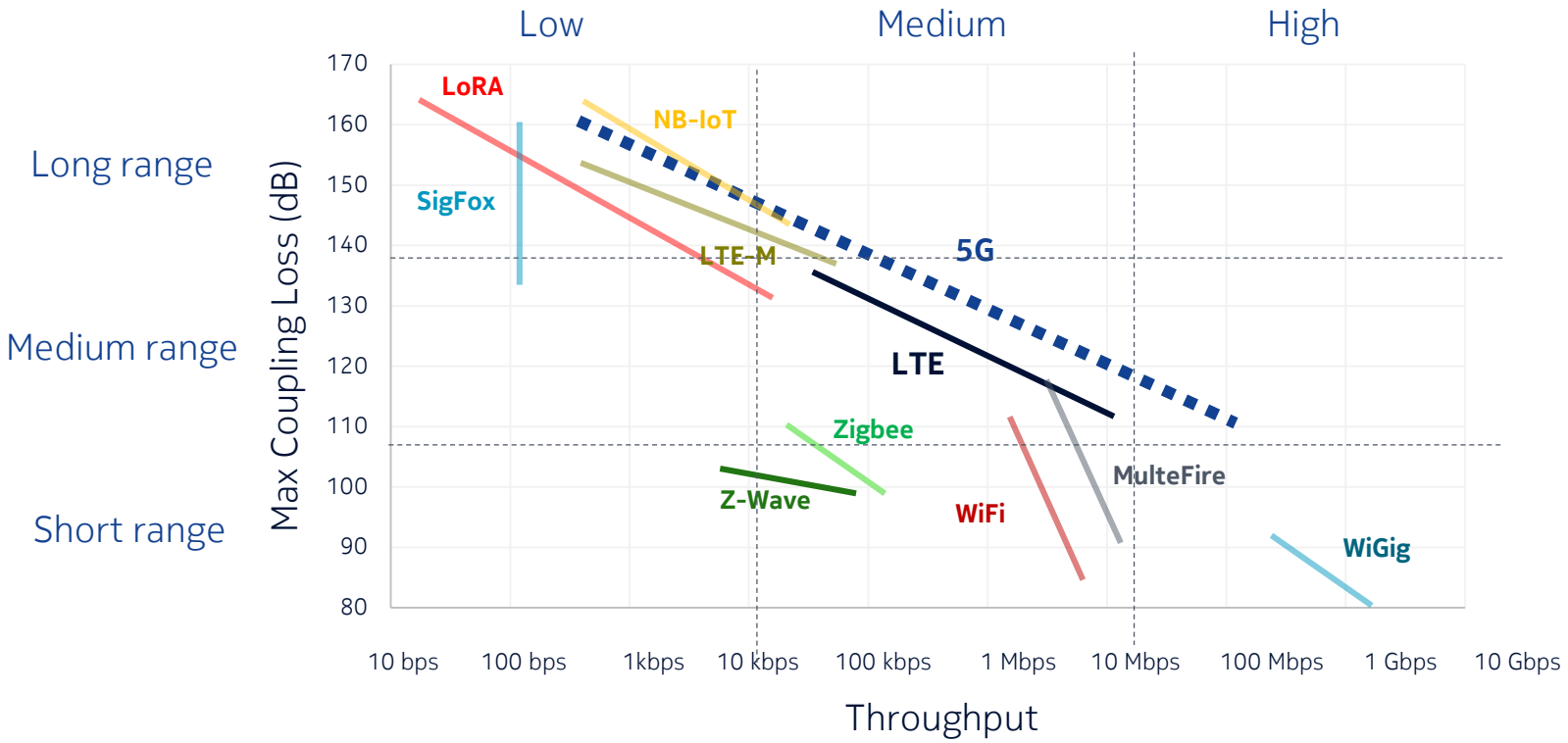
Hyperlocal, high reliability, high capacity, low latency applications

Source: Harbor Research

Latency & bandwidth matter …



A word on IoT



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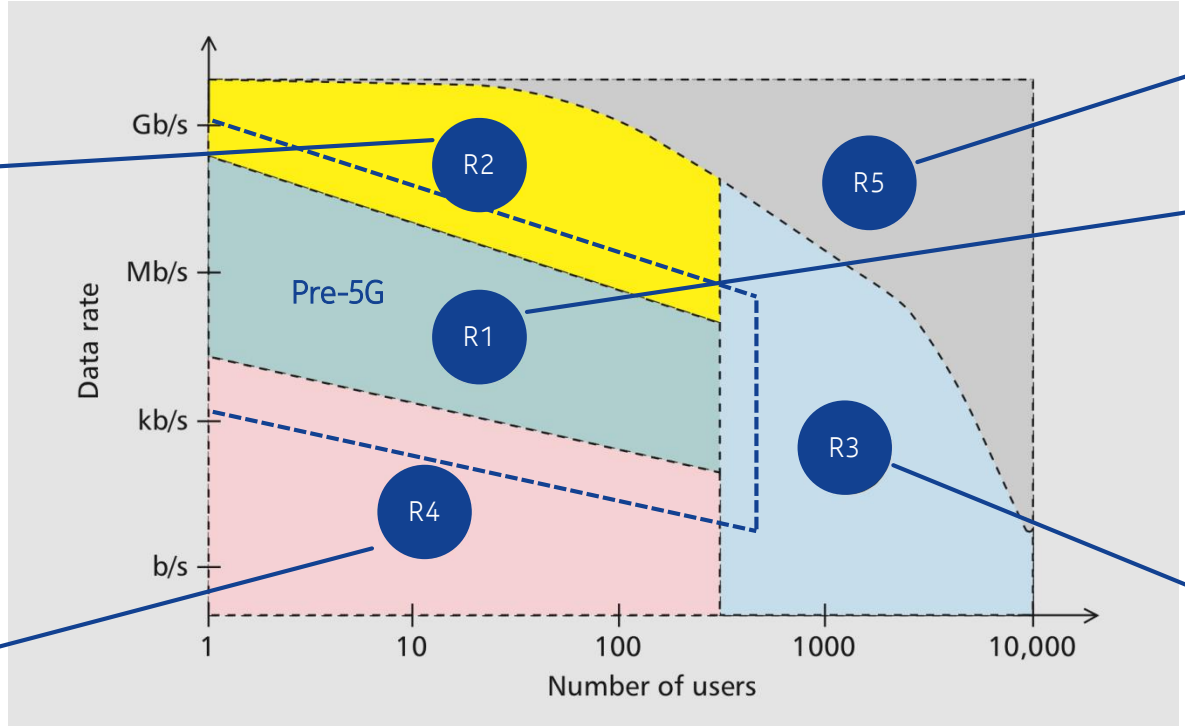
Essential 5G Perspective…



Ultra-broadband:
"VR/AR"

Forbidden region:
"Shannon Limit"

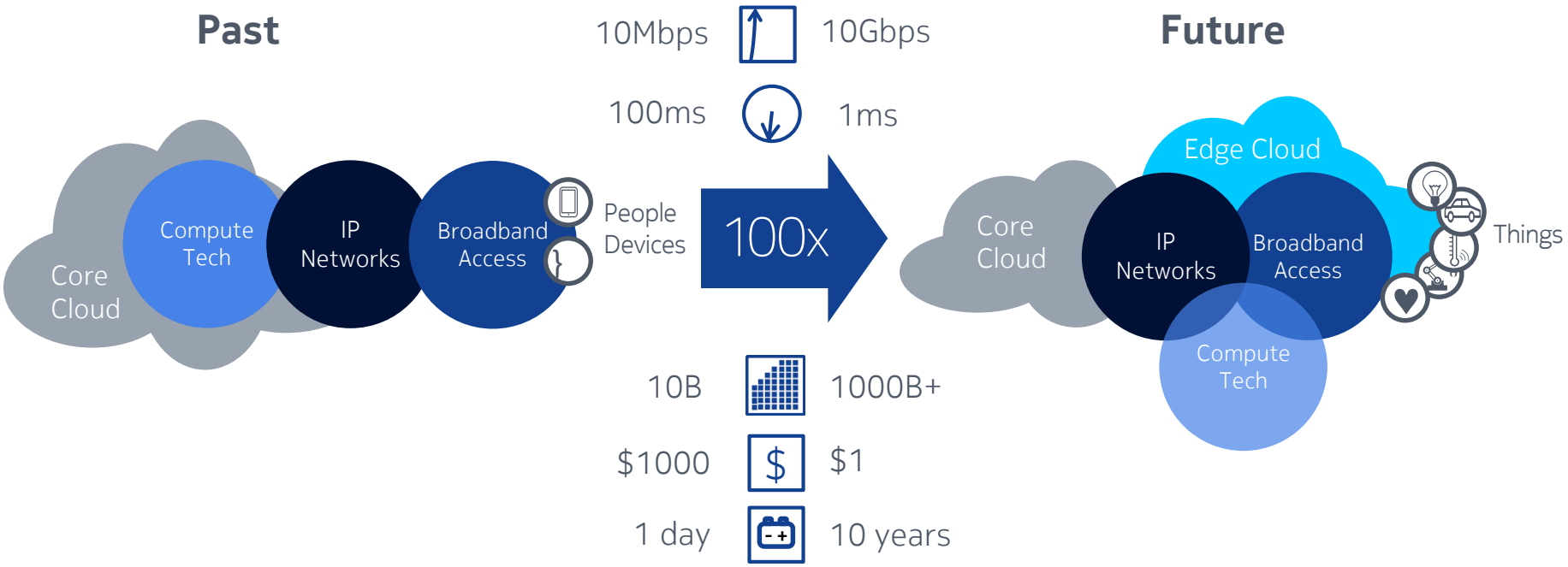
2G-4G:
"People & Video"

Ultra-narrowband:
"Things"

Ultra-low latency:
"System Control"

F. Boccardi, Bell Labs, IEEE Comms. Magazine, 201402

Summary: The 100yr, 100x shift



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