Fusion of AI, IoT and 5G – the Perfect Storm

Moshe Sheier, VP Marketing, CEVA

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SYMPOSIUM SERIES
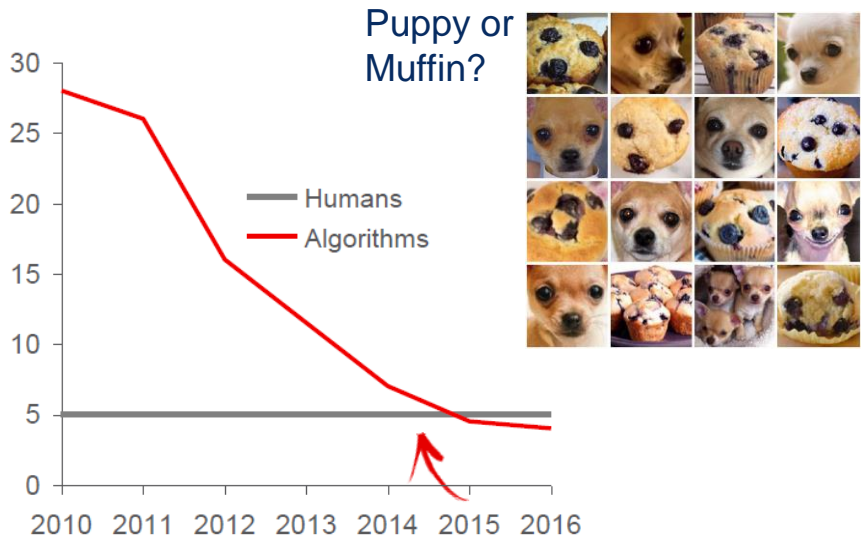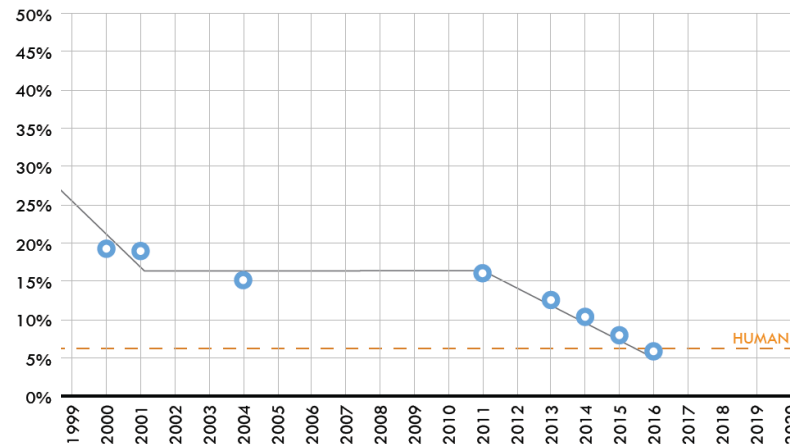
12th YEAR

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AI – Accelerated Growth

ImageNet visual challenge error rate (%)

Speech to Text Transcription error rate (%)

Puppy or Muffin?

Cognitive machines are getting smarter than humans

AI has Many Forms

Artificial Intelligence:
Umbrella term for machines acting as though they are 'thinking'

Machine Learning:
Machines adapting algorithms based on experience (e.g. labelled pictures)

Deep Learning:
Machine learning using Deep Neural Network approaches

Algorithms:
CNNs, RNNs, etc

Training

Training data → Neural network → Model

Inference

New inputs → Neural network w/model → ✓ 97.4% confidence

→ ✗ 96.4% confidence

▶ Inference is the AI element that mostly happens at end nodes

IoT – Accelerated Growth
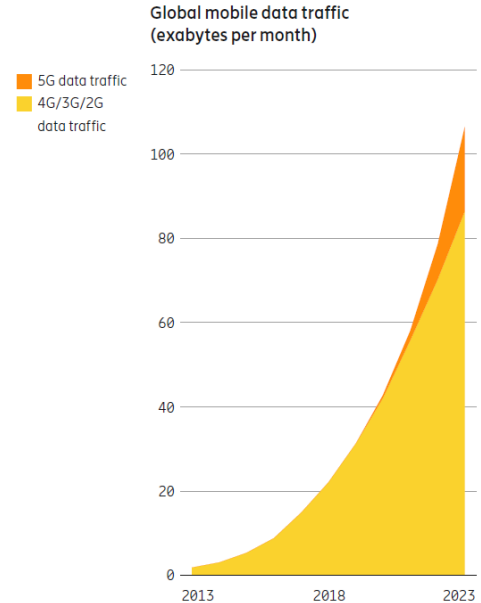

Source: Ericsson
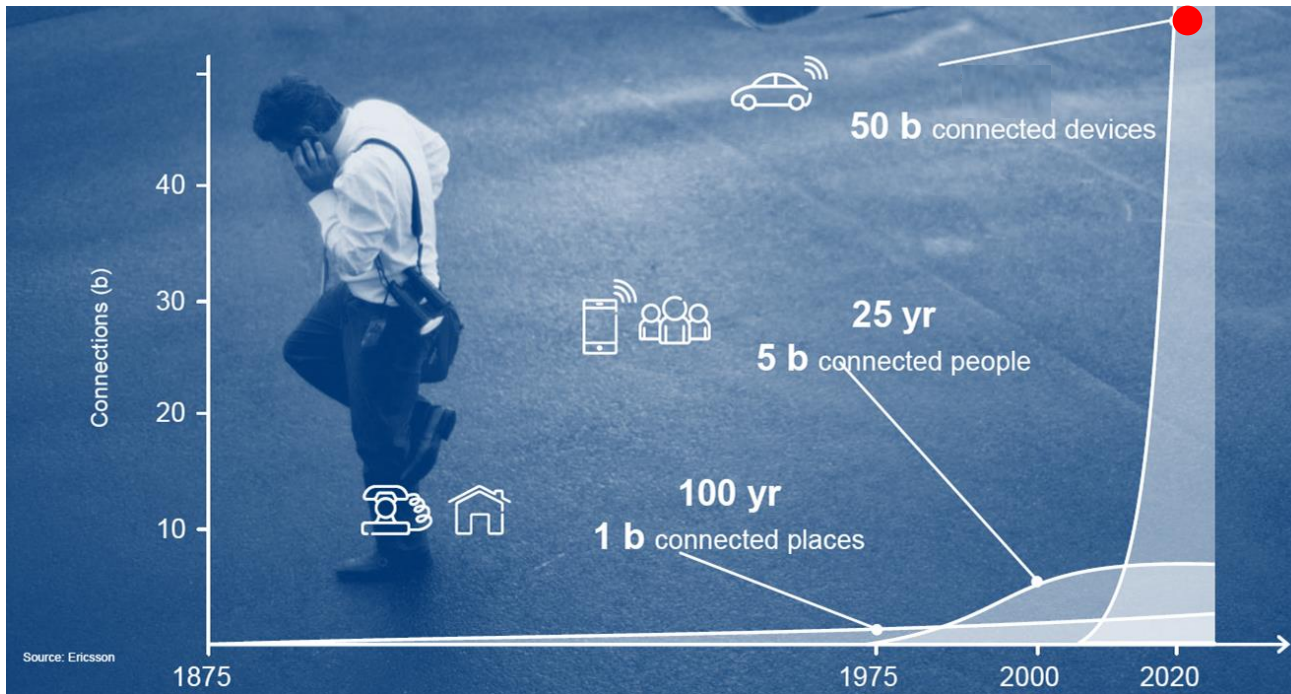
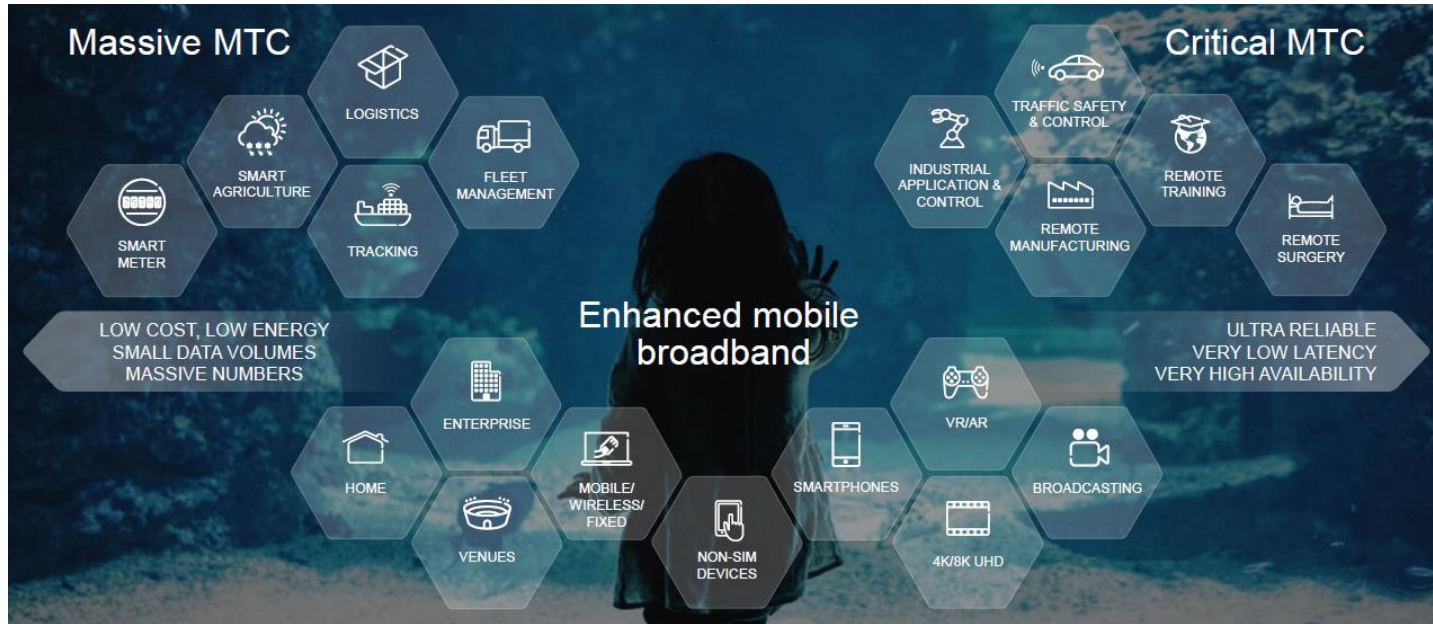**30-50 Billion connected devices by 2023**

IoT is not M2M

M2M

IoT
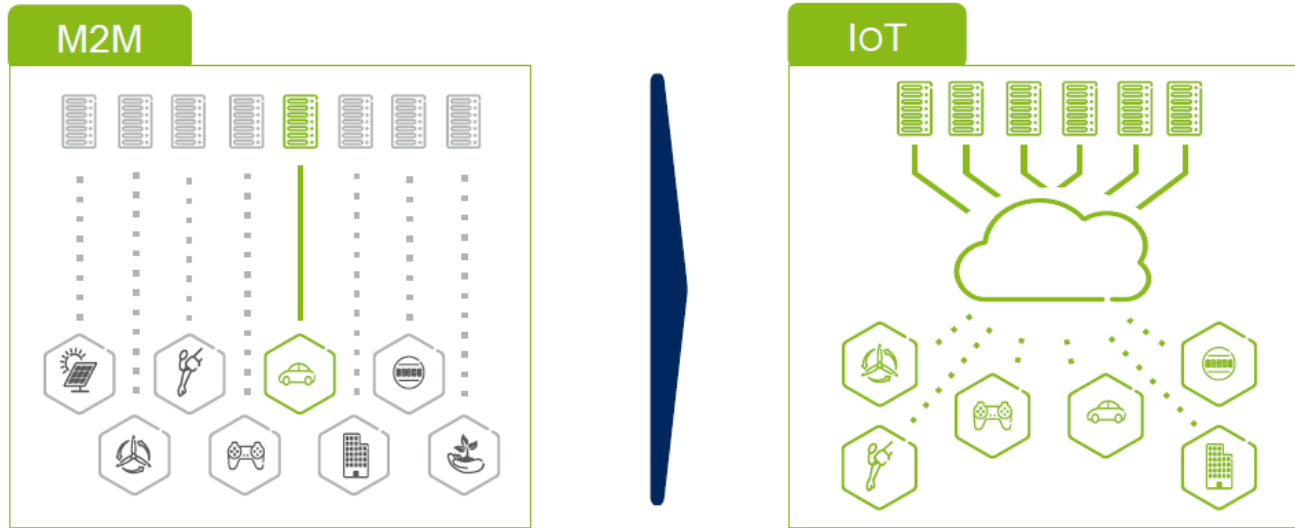
▶ IoT is not just a technology that brings efficiencies and value within **industry verticals**, but a way of tying **industries, people, and society together** to create substantial value

5G – Accelerated Growth

5X increase in mobile data – 110 Exabyte by 2023

5G is Use Case Driven (not 4G evolution)

▶ 5G supports cellular IoT (e.g. asset tracker), eMBB (e.g. mobile, AR), and critical MTC (e.g. automotive, industrial)
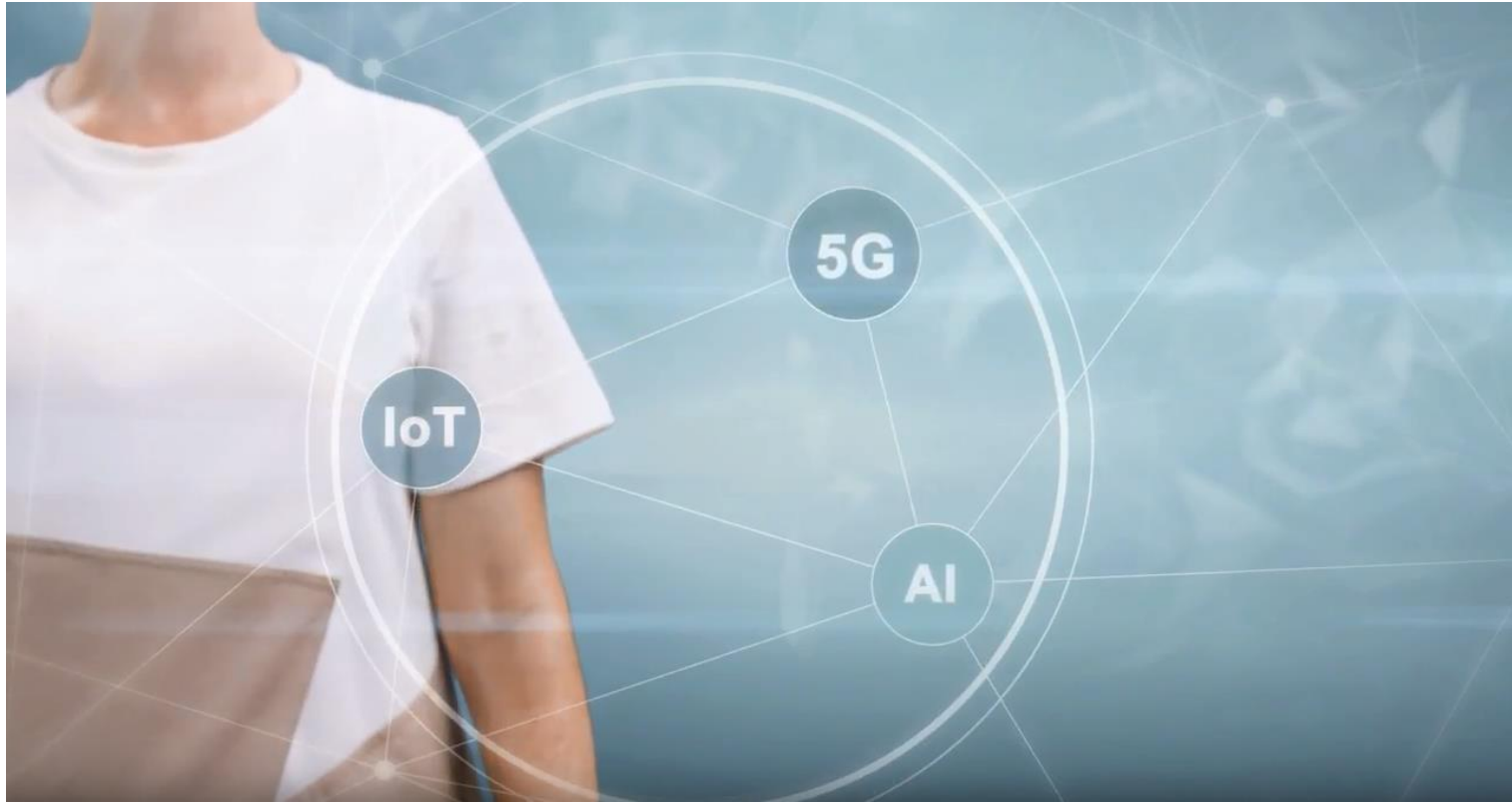
Combined Together … The Perfect Storm

"A perfect storm is an unusual combination of events or things that produce an unusually powerful result"

AI

IoT

?

5G

AI + IoT + 5G = Intelligent Connectivity

Intelligent Connectivity

Source:

Automotive Use Case

Forbes

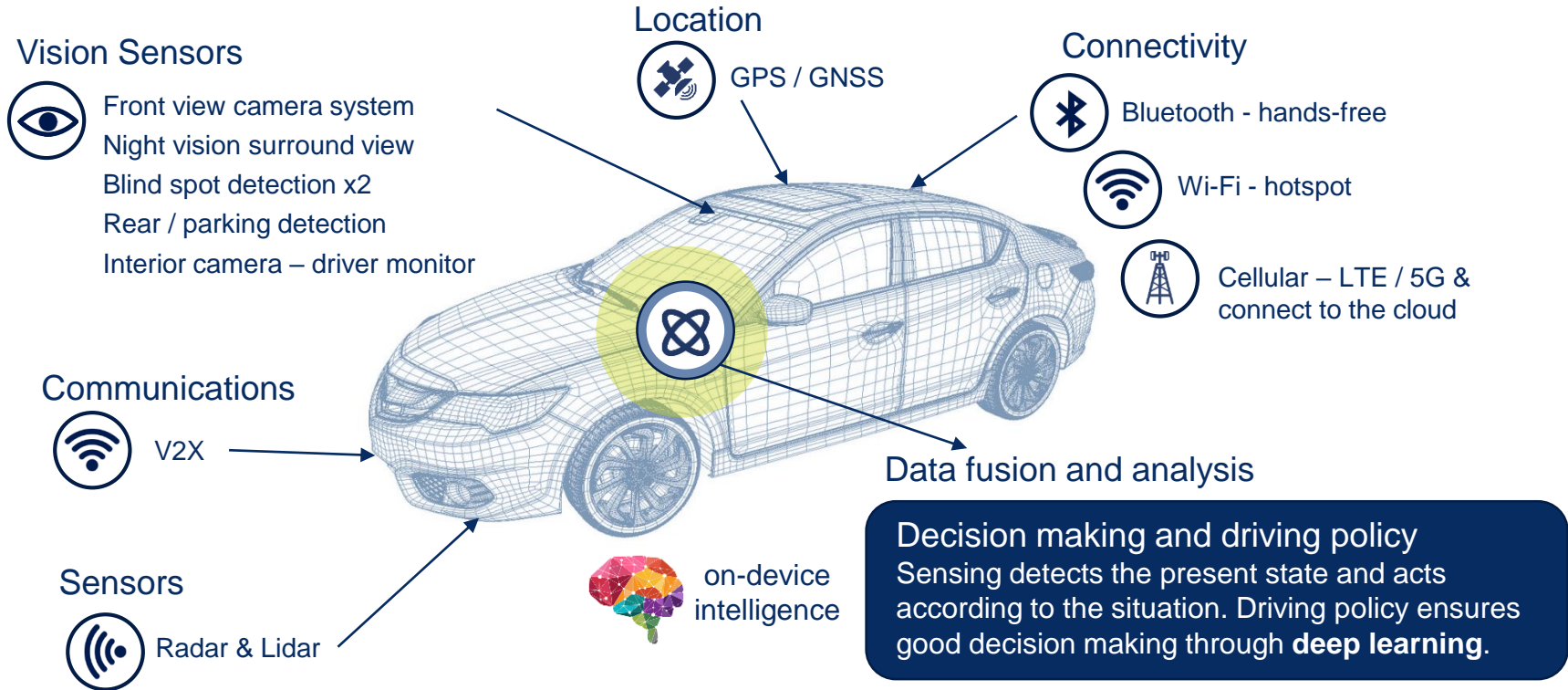AI critical to the future of autonomous vehicles

Forbes

VB

5G wireless will make autonomous cars smarter

VentureBeat

▶Fully autonomous vehicles would be impossible without AI and 5G

Intelligent Connectivity – Automotive

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Location
GPS / GNSS

Connectivity
Bluetooth - hands-free
Wi-Fi - hotspot
Cellular – LTE / 5G & connect to the cloud

Vision Sensors
Front view camera system
Night vision surround view
Blind spot detection x2
Rear / parking detection
Interior camera – driver monitor

Communications
V2X

Sensors
Radar & Lidar

Data fusion and analysis

on-device intelligence

Decision making and driving policy
Sensing detects the present state and acts according to the situation. Driving policy ensures good decision making through **deep learning**.

Intelligent Connectivity – Robots

Amazon may launch versatile robots integrating new-generation tech in 2019

Cage Chao, Taipei; Willis Ke, DIGITIMES | *Tuesday 16 October 2018*

Amazon is likely to launch in 2019 a versatile robot integrating cloud service, big data, smart voice, IoT, AI and even 5G technologies, which is expected to serve as the web giant's secret weapon for outracing its rivals in developing innovative smart devices, according to Taiwan supply chains sources.
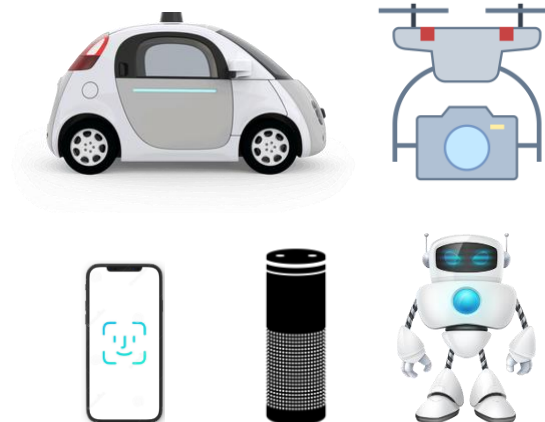
Intelligence Moving to the Edge

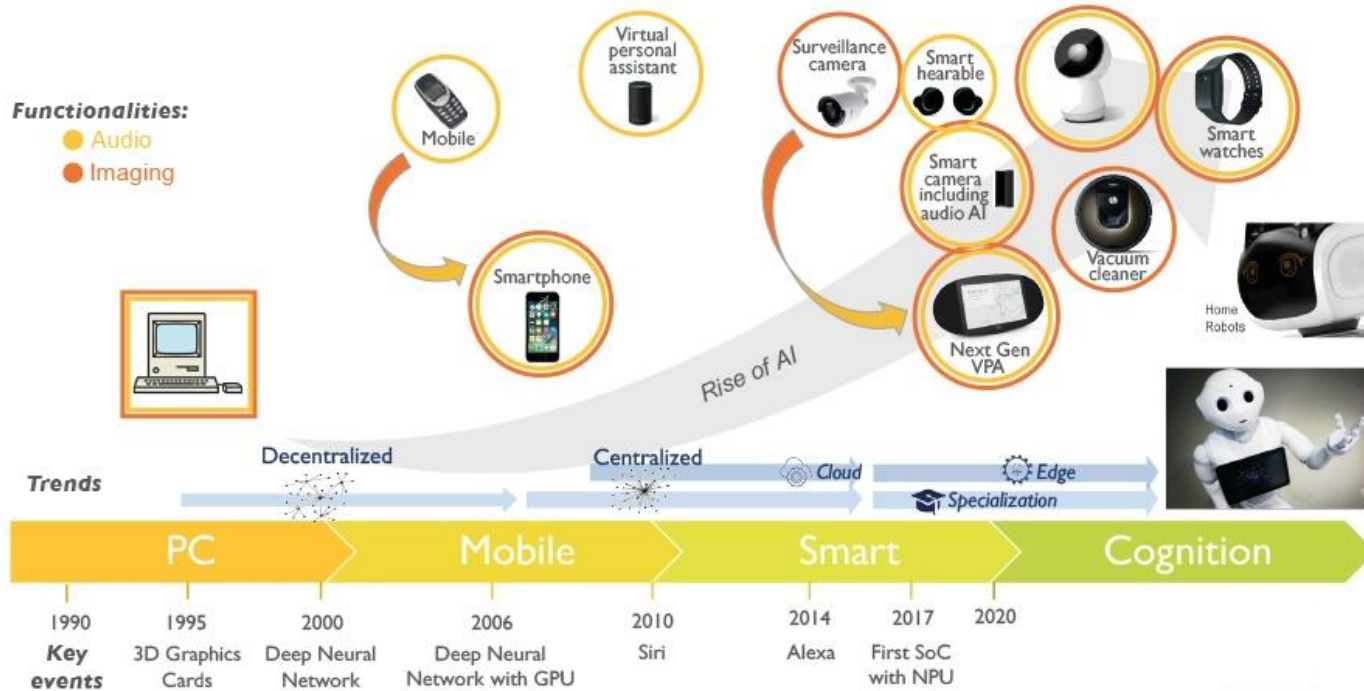**Cloud AI**

Intelligence & Analytics

Edge Devices

Key Benefits

Low Latency / Low Power / Low Cost / High Privacy / High Reliability

AI on Edge is Driving Cognitive Machines

On the road to an intelligent interface

(Source: Hardware and Software for AI 2018 – Consumer focus, Yole Développement, September 2018)

IoT Use Case

Mat:
tells users when
a product is
almost empty

Fridge Cam:
allows to see
the contents of
your refrigerator
from anywhere

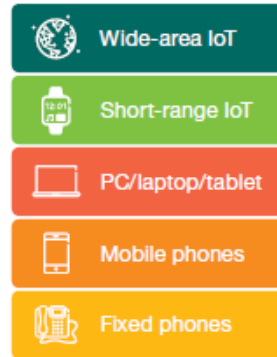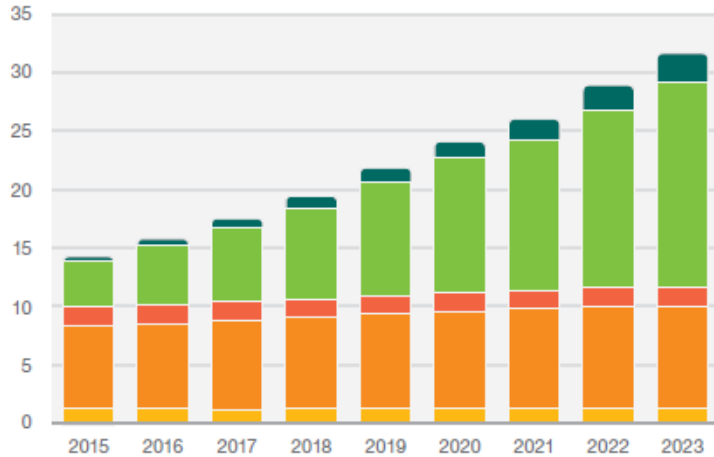**Microphone**:
detects beeps
and alarms from
other
appliances

▶ Microwave with camera sees an unrecognized new food; Microwave has small food DB

▶ Microwave connects to fridge via BT to ask what is it? Fridge has larger food DB

▶ If the fridge doesn't recognize it, it goes to the cloud via Wi-Fi to get an answer …

IoT Connections

Connected devices (billion)

IoT	2017	2023	CAGR
Wide-area IoT	0.8	4.1	30%
Cellular IoT[2]	0.7	3.5	30%
Short-range IoT	6.2	15.7	17%
Other devices			
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.5	8.6	2%
Fixed phones	1.4	1.3	0%
Total connected devices	17.5	31.4	11%

Legend: Wide-area IoT, Short-range IoT, PC/laptop/tablet, Mobile phones, Fixed phones

▶ Long range **cellular IoT** connections will reach **3.5 billion in 2023** – 30% CAGR

▶ Short range **BT/Wi-Fi** connections will reach **15.7 billion in 2023** – 17% CAGR

What will 5G bring?

	Peak Data Rate	1 - 20 Gbps
	User Experienced Data Rate	10 - 100 Mbps
	Spectral Efficiency	×1 - ×3
	Mobility	350 - 500 km/h

	Connection Density	10k - 1m devices / km²
	Network Energy Efficiency	×1 - ×100
	Area Traffic Capacity	0.1 - 10 Mbps / m²
	Availability	99.999% (of time)

	Reliability	99.999% (of packets)
	Latency	1 - 10 ms
	Battery life	10 years*
	Security	Strong subscriber authentication, user privacy and network security

▶ 5G supports multiple use-cases in cellular IoT, eMBB, and critical MTC

5G Use Case

▶ Remote robotic surgery

Improved outcomes
Patient convenience
Reduced cost

▶ What is the role of 5G?

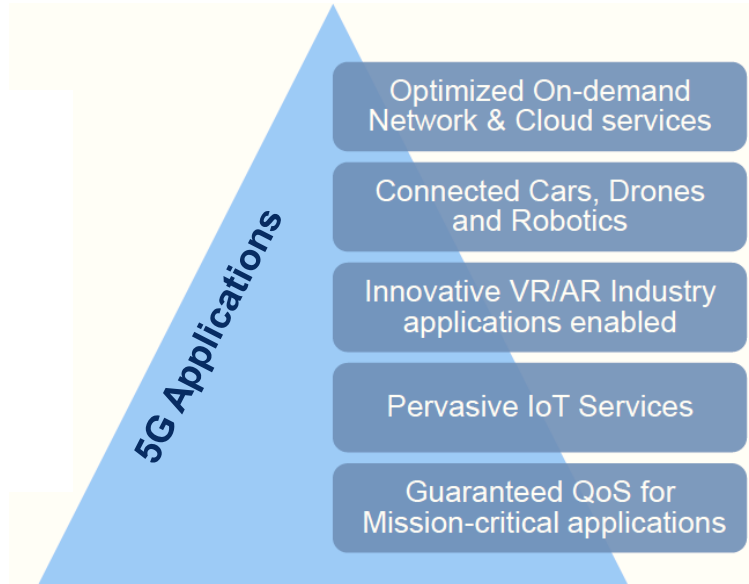Latency   Security   Availability   Reliability

5G Experience

5G Applications

- Optimized On-demand Network & Cloud services
- Connected Cars, Drones and Robotics
- Innovative VR/AR Industry applications enabled
- Pervasive IoT Services
- Guaranteed QoS for Mission-critical applications

5G Experience

Enhanced Mobile Broadband		Immersive experience
Automotive		Autonomous control
Manufacturing		Cloud robotics and remote control
Energy & Utilities		Machine intelligence and real-time control
Health Care		Remote operations

▶ **5G Technologies:** NR, Virtualized RAN, Federated network slicing, Distributed Cloud, Real time Machine learning/AI
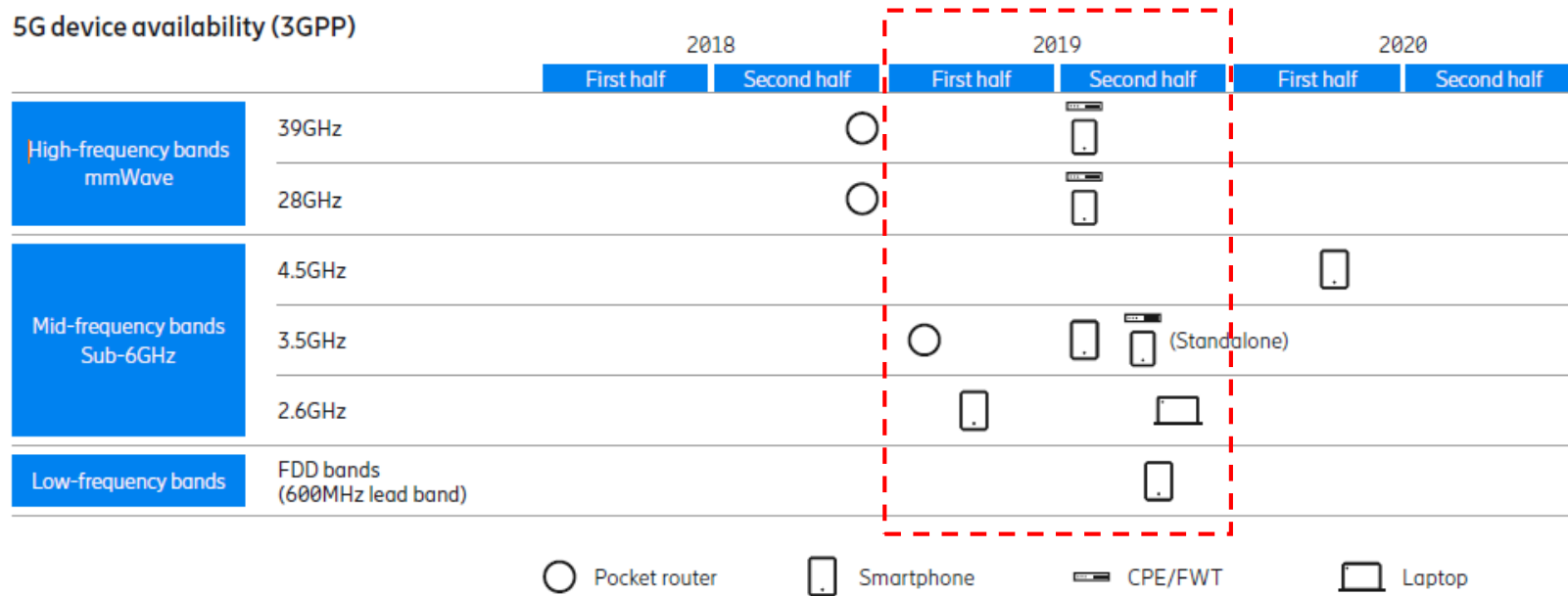
AI to Lead Semiconductor Growth

▶ **Global semiconductor** market is expected to grow **5-6% CAGR** from 2018-2022

▶ During the same period, **AI semiconductor** revenue will grow at **59% CAGR**

Semiconductor Market Revenue for AI
Source: J.P. Morgan

$ billion

CAGR = 59%

■ AI training market   ■ AI inference market
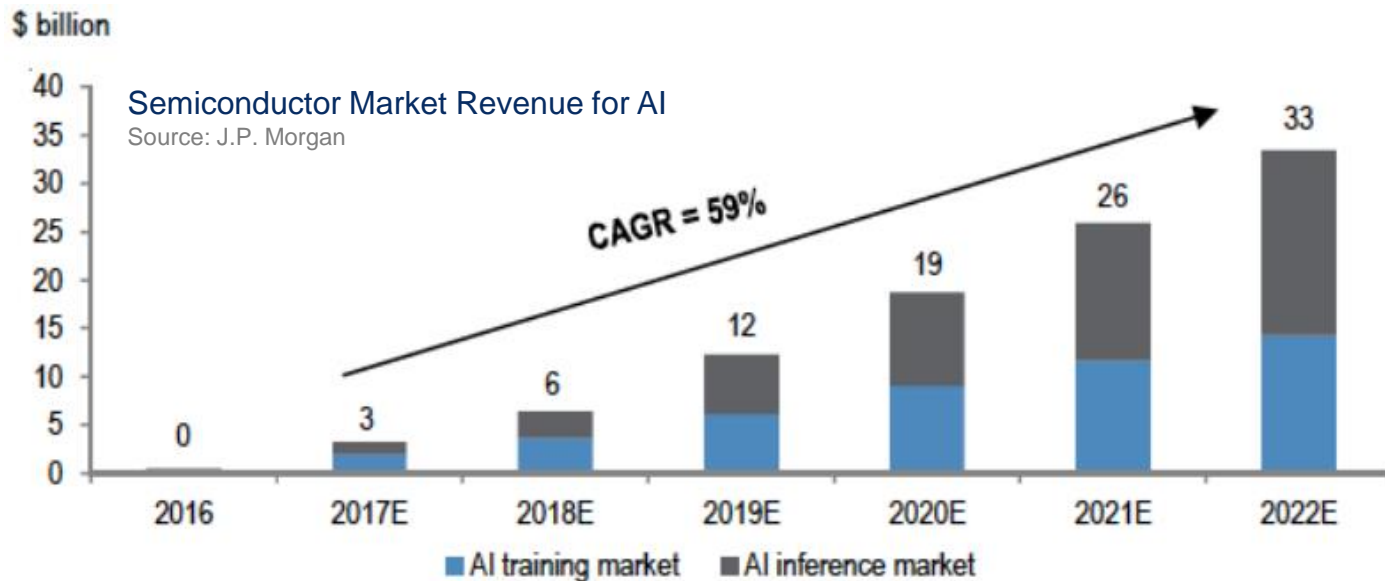
5G Chipsets are needed in 2019

▶ By 2023, **1 billion 5G devices** for enhanced mobile broadband are expected to be connected worldwide … first ones are due in 2019

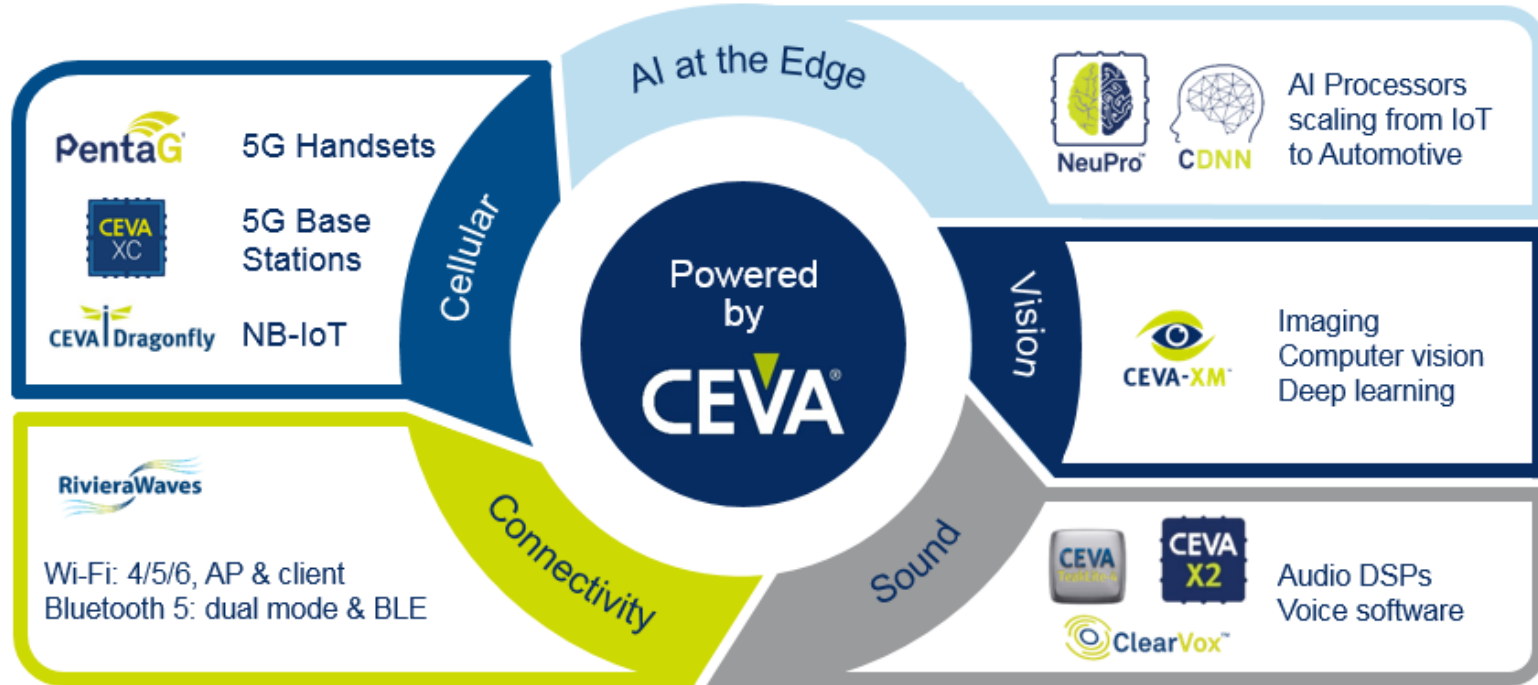**5G device availability (3GPP)**

		2018		2019		2020	
		First half	Second half	First half	Second half	First half	Second half
High-frequency bands mmWave	39GHz		Pocket router		Smartphone / CPE		
	28GHz		Pocket router		Smartphone / CPE		
Mid-frequency bands Sub-6GHz	4.5GHz					Smartphone	
	3.5GHz		Pocket router	Smartphone	CPE (Standalone)		
	2.6GHz			Smartphone	Laptop		
Low-frequency bands	FDD bands (600MHz lead band)				Smartphone		

○ Pocket router   ▯ Smartphone   ▭ CPE/FWT   ▭ Laptop

Thank You

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