



ERICSSON

# The Convergence of 5G, AI and IoT

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# THE CONVERGENCE OF 5G, AI AND IOT

## GOALS FOR THIS SESSION



Gain insight on 5G, AI & IoT, their potential and state of development

Understand the new context of cross-industry ICT-enabled digitalization

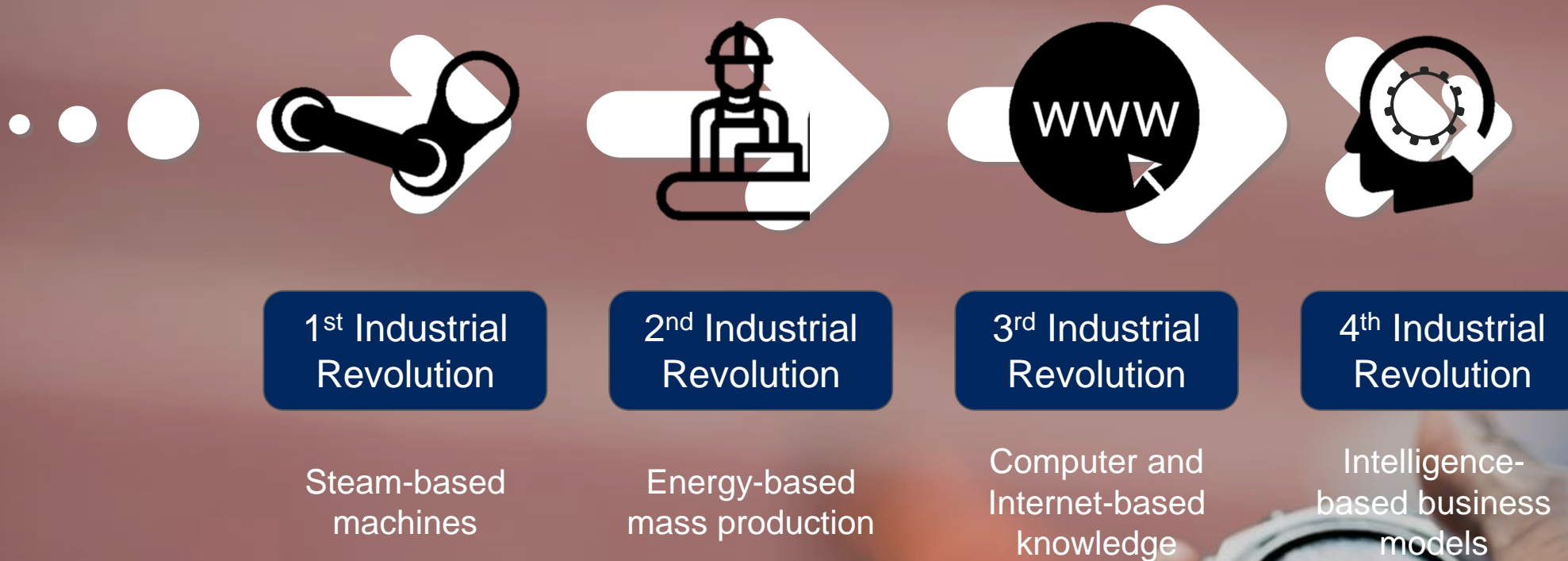
Review a few digitalization use cases leveraging the combination of 5G, AI and IoT

# THE CONVERGENCE OF 5G, AI AND IOT

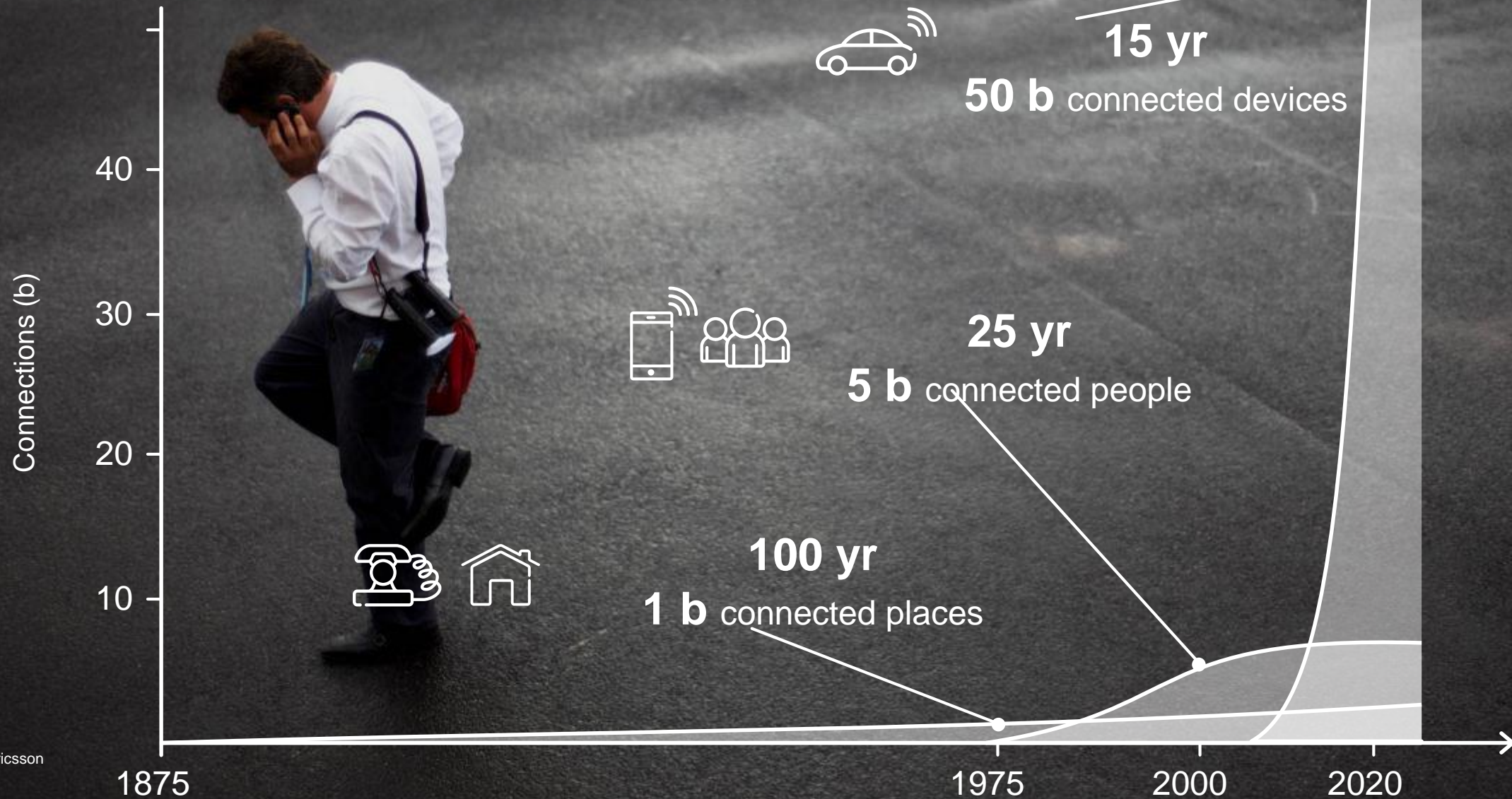


- 1. Introduction** 05'
- 2. IoT, AI, 5G: The Technology Ingredients** 15'
- 3. IoT+AI+5G: The new Innovation Factory** 20'
- 4. Challenges (and Opportunities) Ahead** 05'
- 5. Key Takeaways** 05'

# THE 4<sup>TH</sup> INDUSTRIAL REVOLUTION



# PACE OF CHANGE



# DIGITALIZATION DRIVERS 2015-2025



**REAL-TIME BIG DATA**



**AI**



**SUPER-CONNECTIVITY**



**CLOUD**

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# SELFIES ARE 100+ YEARS OLD !



1920



Source: Googling



# ARE IoT AND AI NEW STUFF AT ALL ?



**Kevin Ashton** coined the term '**Internet of Things**' (IoT) in **1999** at Procter & Gamble.

...  
everyday objects - such as a refrigerator- with embedded sensors or chips could connect to the Internet, enabling autonomous communication with each other and the environment.



The term **Artificial Intelligence**

was coined in **1955** by **John McCarthy**, a math professor at Dartmouth who organized the seminal conference on the topic. In **1957** **Herbert Simon** predicted that computers would beat humans at chess within 10 years

# CONNECTING "THINGS" IN 2001



ERICSSON  +  Electrolux = S C R **ee** N F R I D G E



Recipes



Shopping lists



Family calendar



Browser



Access

# IoT SIXTEEN YEARS LATER

smarter



2017

**Smarter wants to smarten up your dumb kitchen**

A trio of new smart devices aims to bring more intelligence to the way you manage your groceries



**Mat:** tells users when a product is almost empty



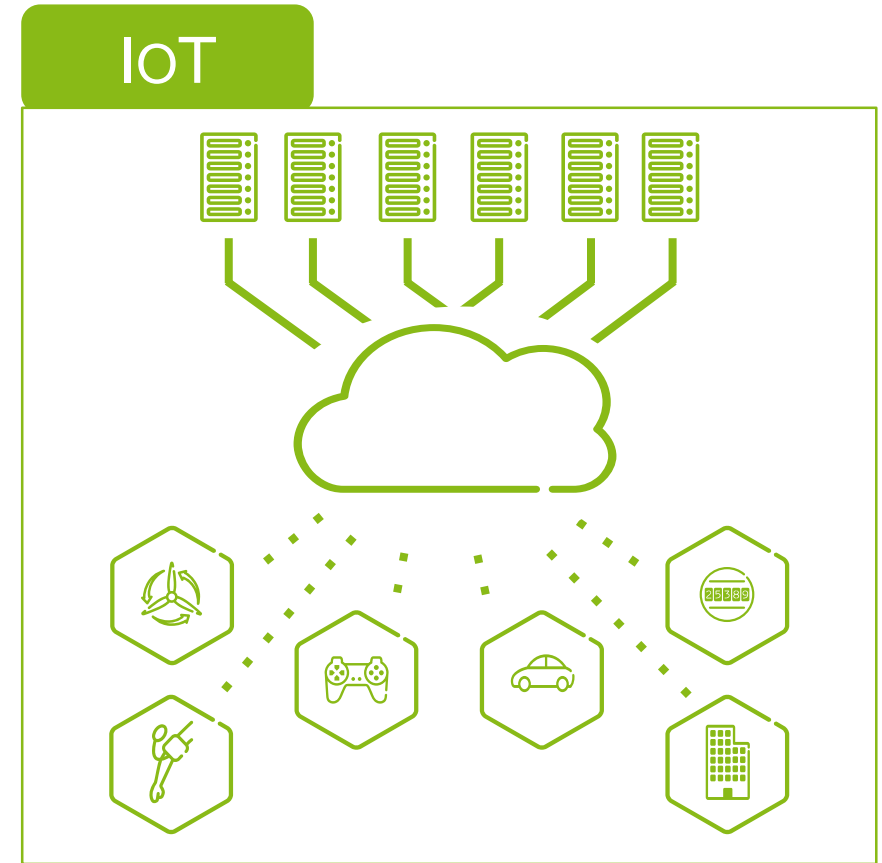
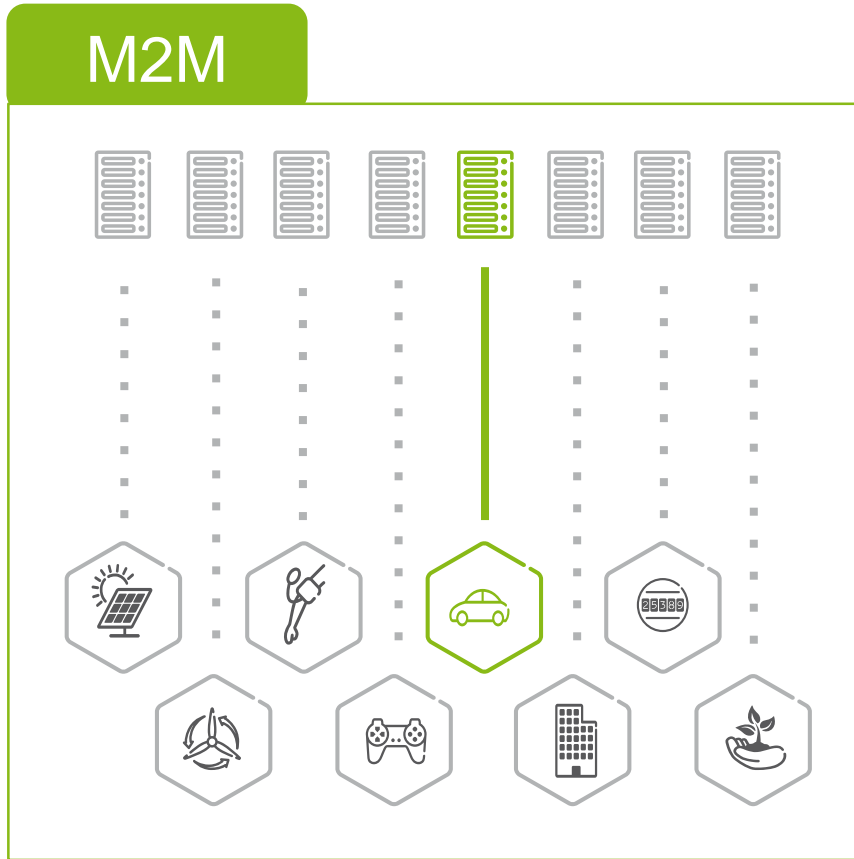
**Fridge Cam:** allows to see the contents of your refrigerator from anywhere



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



# M2M VS. INTERNET OF THINGS



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

# CELLULAR FOR MASSIVE IOT

Meeting diversity of use case requirements



Bandwidth



Coverage



Battery life



Throughput (peak)



Security



Mobility



Deployment

Cat-M1

1.4MHz

160dB  
(+15dB)

10+ Year

0.8/1 Mbps  
full duplex



Connected &  
idle mode  
mobility

SW

NB-IoT

200kHz

164dB  
(+20dB)

10+ Year

227/250kbps  
multi-tone UL



Idle mode  
mobility

SW

EC-GSM-IoT

600kHz

164dB  
(+20dB)

10+ Year

473/473  
kbps



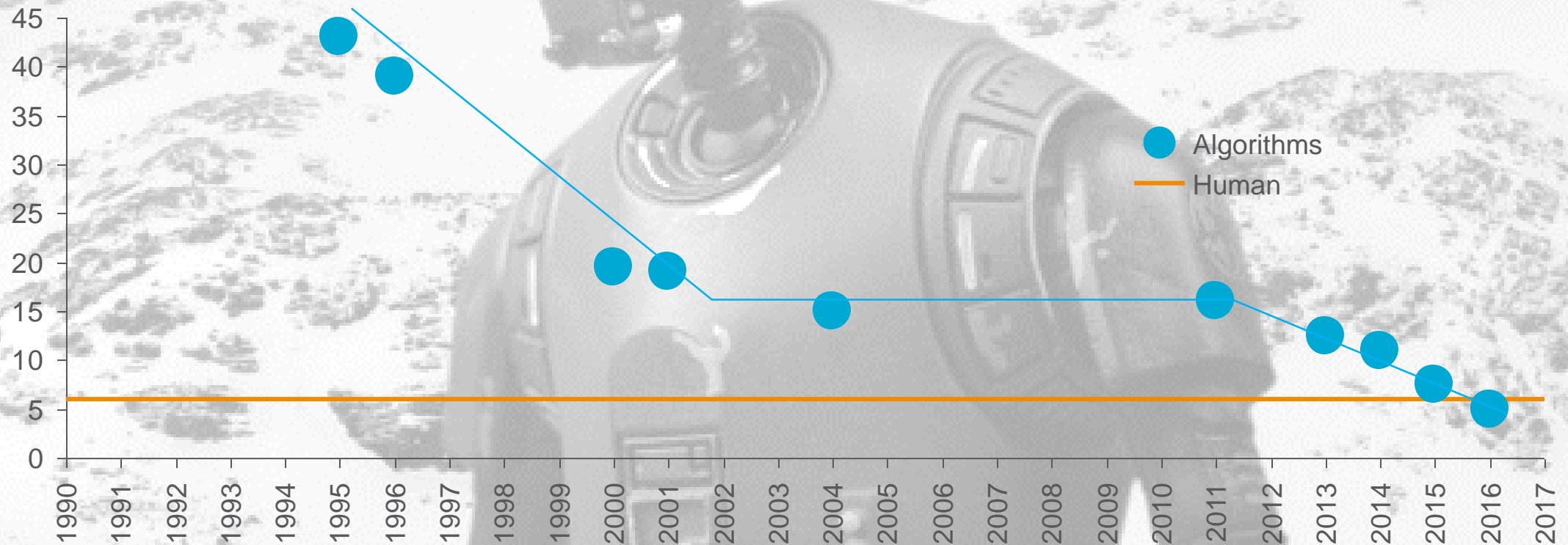
Idle mode  
mobility

SW

# 'AI WINTER'



Speech to Text Transcription error rate (%)



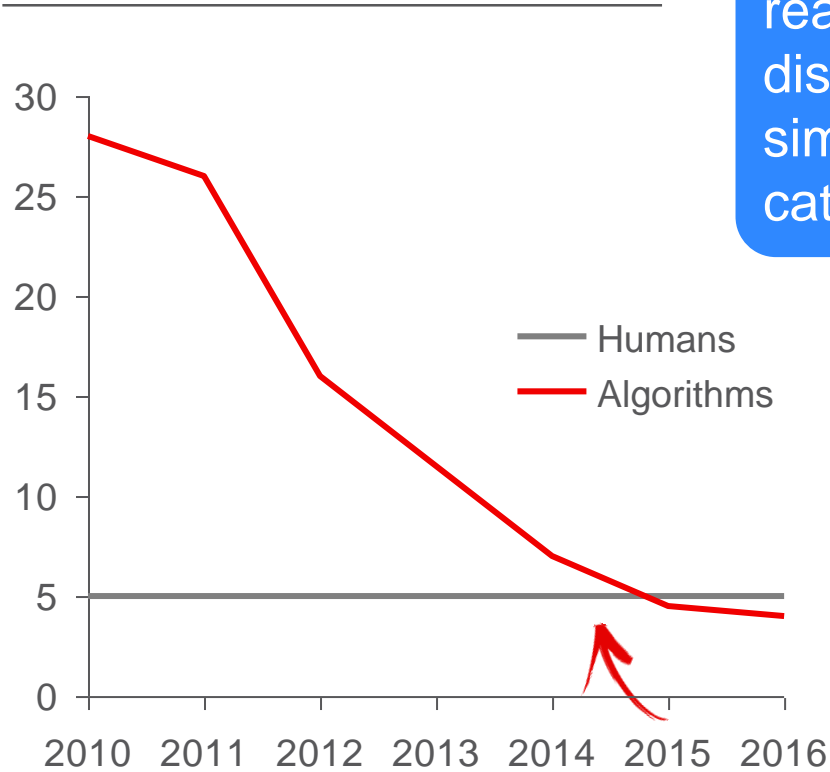
# ARTIFICIAL INTELLIGENCE 57 YEARS LATER



## Puppy or Muffin?

Machines have made real strides in distinguishing among similar-looking categories of images

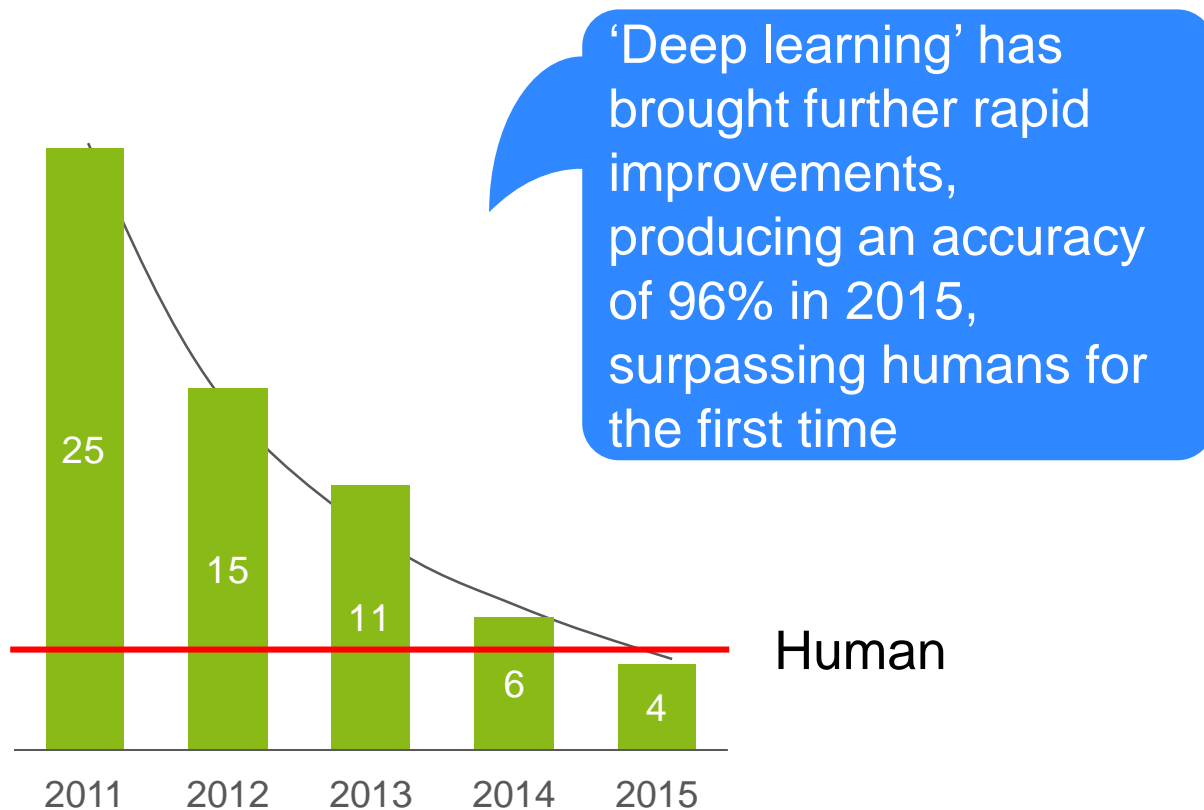
Vision error rate (%)



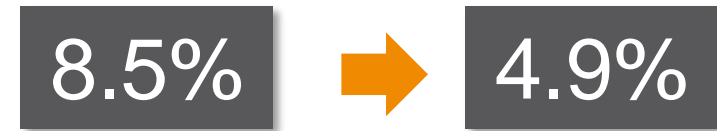
# ARTIFICIAL INTELLIGENCE PERFORMANCE HAS IMPROVED EXPONENTIALLY



## Error rates on ImageNet visual challenge, %



## Speech recognition on mobile phones



What's striking is that this substantial improvement has come not over the past 10 years but just since the summer of 2016

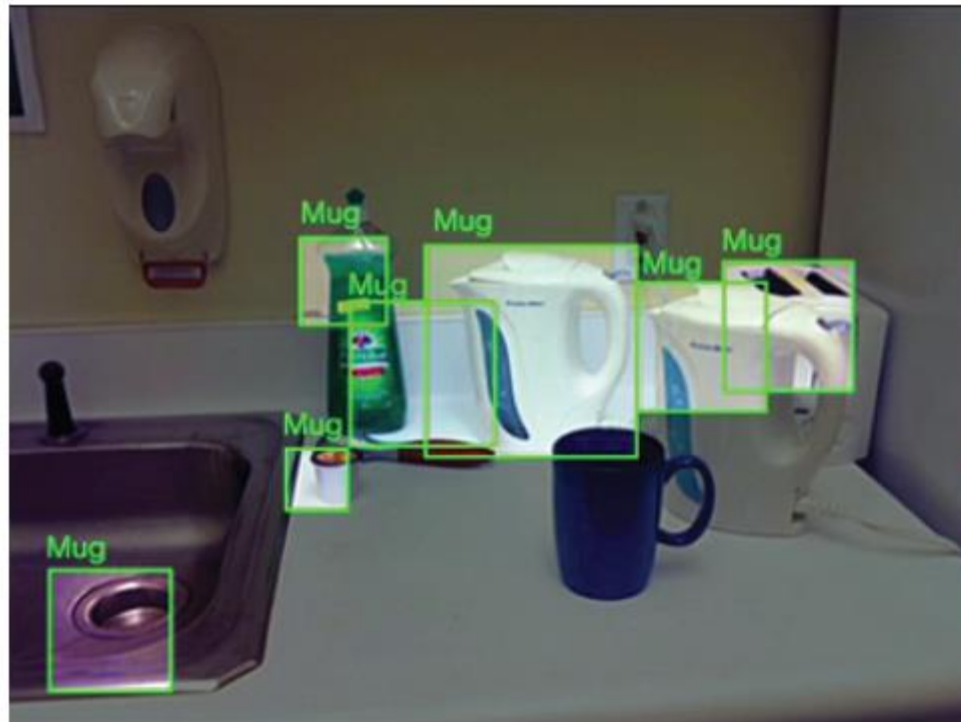


# ARTIFICIAL INTELLIGENCE IN FACT PROGRESS IS VERY RECENT

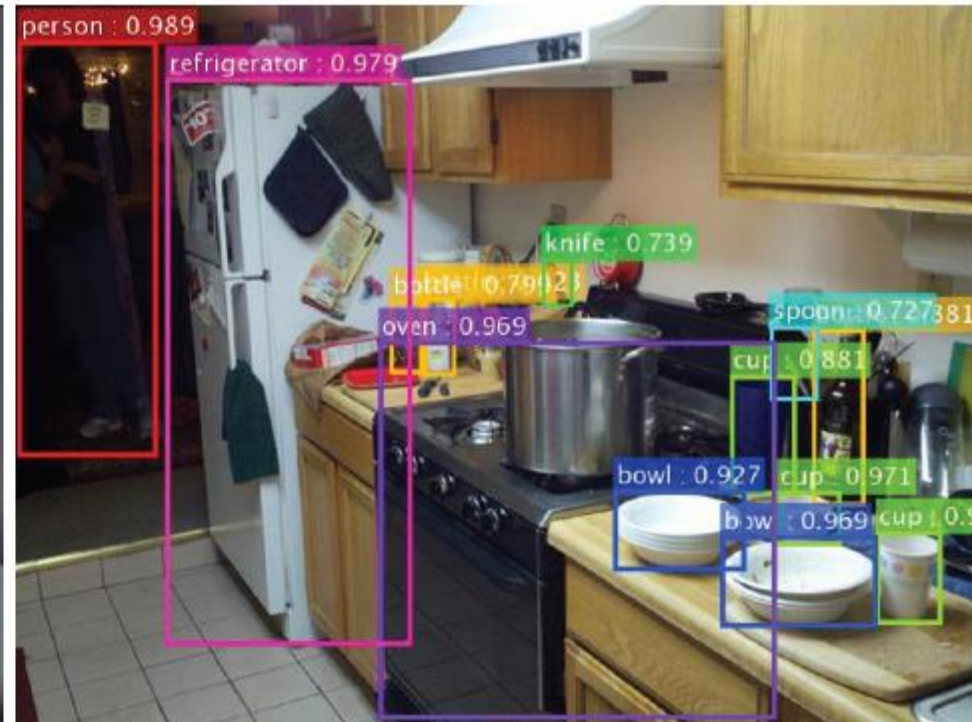


Computer vision accuracy, Microsoft ResNet deep learning algorithm

2008



2015



Source: ARK

# 5G IN THE DIGITALIZATION CONTEXT



**BIG DATA**



**AI**



**HYPER-CONNECTIVITY**

**5G**















**CLOUD**

# WHAT TO EXPECT FROM 5G



# WHAT TO EXPECT FROM 5G



	Peak Data Rate	1 - 20 Gbps		Connection Density	10k - 1m devices / km <sup>2</sup>		Reliability	99.999% (of packets)
	User Experienced Data Rate	10 - 100 Mbps		Network Energy Efficiency	×1 - ×100		Latency	1 - 10 ms
	Spectral Efficiency	×1 - ×3		Area Traffic Capacity	0.1 - 10 Mbps / m <sup>2</sup>		Battery life	10 years*
	Mobility	350 - 500 km/h		Availability	99.999% (of time)		Security	Strong subscriber authentication, user privacy and network security

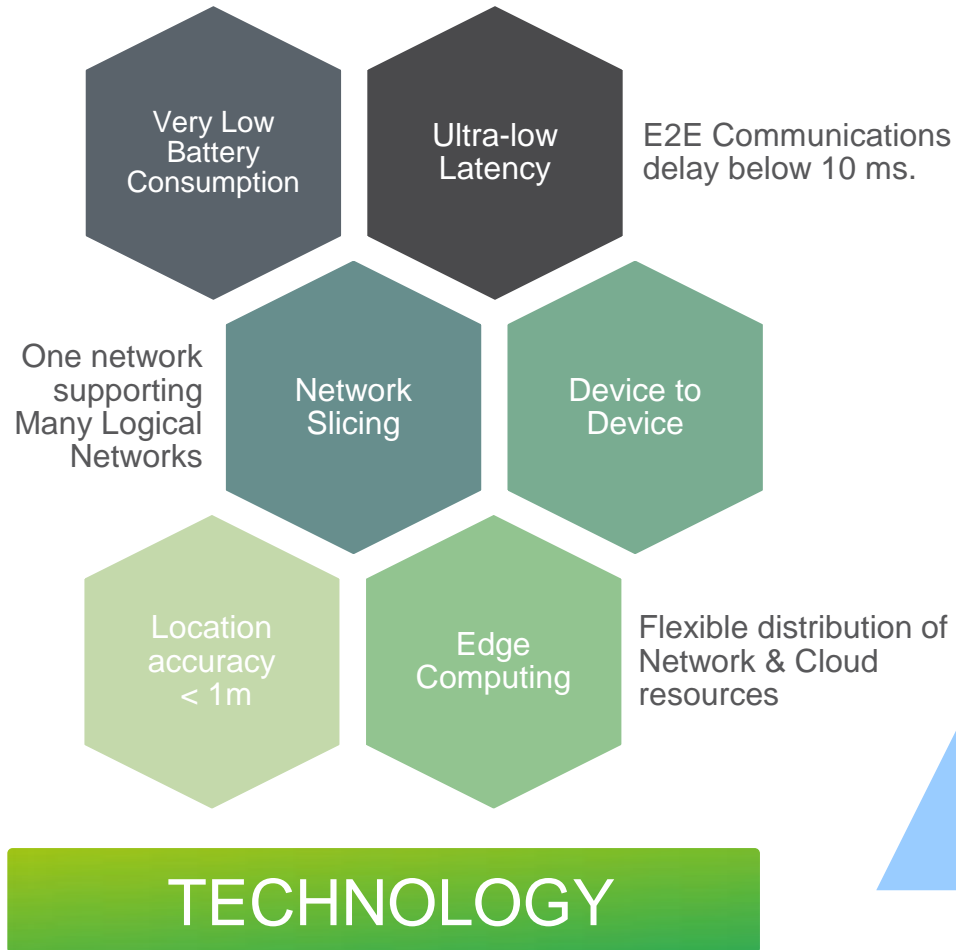
\*For low power IoT devices

Source: ITU-R, NGMN, 3GPP

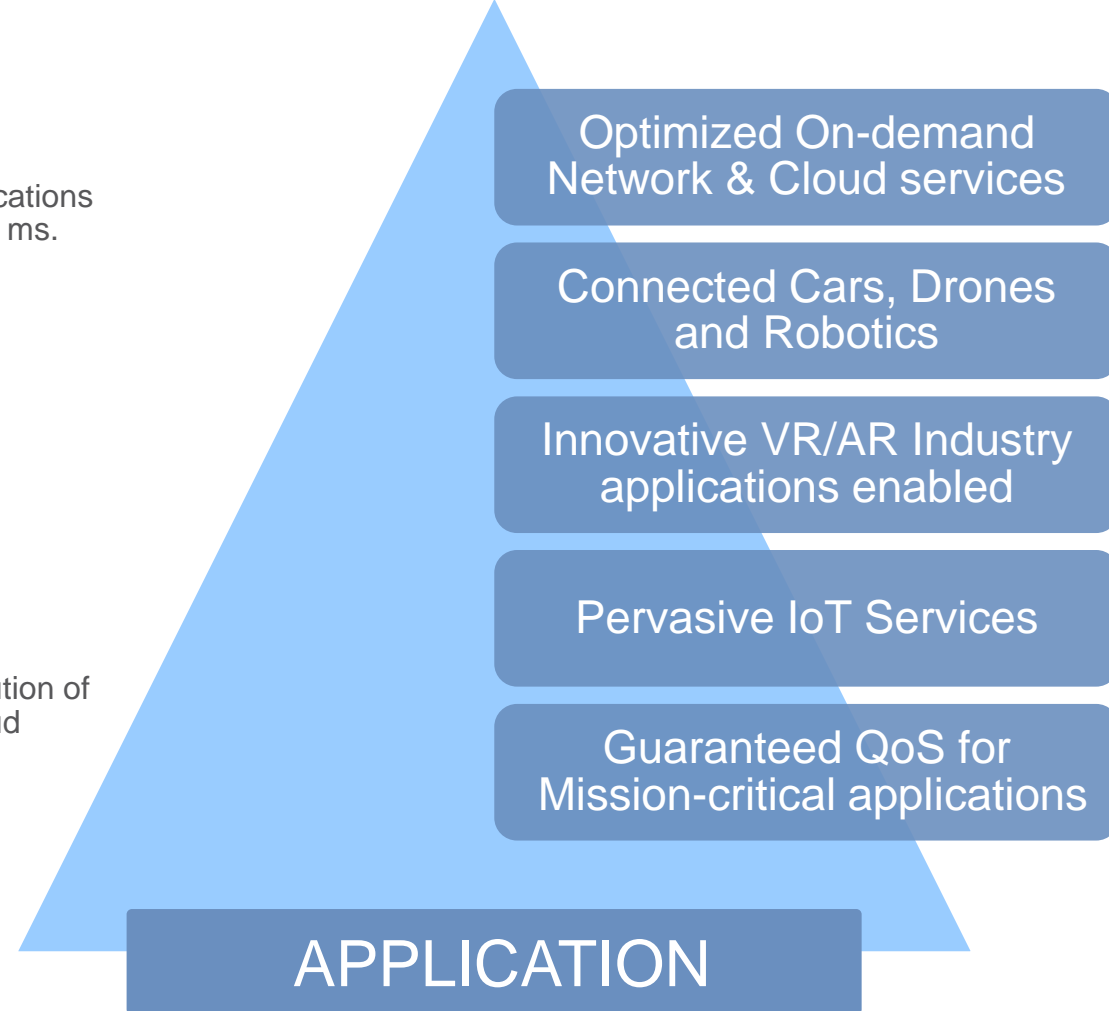
# ARE YOU LOST IN TRANSLATION?



## WHAT IS 5G?



## WHAT'S IN 5G FOR ME?



# 5G IS USE CASE DRIVEN



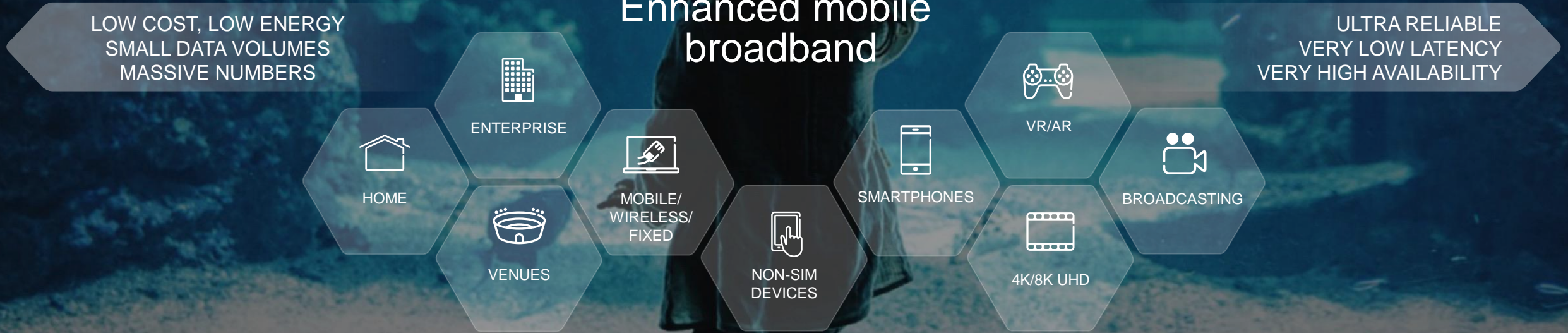
## Massive MTC



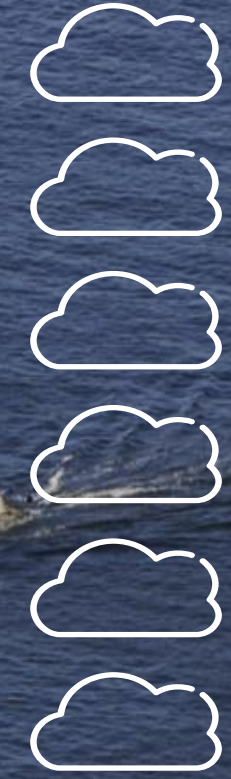
## Critical MTC



## Enhanced mobile broadband



# ONE NETWORK – MULTIPLE INDUSTRIES



Networks support, learn and adapt to users' and industries' needs

# USE CASE EVOLUTION FROM 4G TO 5G



Current

On the road to 5G

5G experience

Enhanced Mobile Broadband		Screens everywhere	New tools	Immersive experience
Automotive		On demand information	Real-time information vehicle to vehicle	Autonomous control
Manufacturing		Process automation	Flow management and remote supervision	Cloud robotics and remote control
Energy & Utilities		Metering and smart grid	Resource management and automation	Machine intelligence and real-time control
Health Care		Connected doctors and patients	Monitoring and medication e-care	Remote operations

Technologies	<ul style="list-style-type: none"> <li>Multi-standard network</li> <li>Cat-M1/NB-IoT</li> <li>Cloud optimized network functions</li> <li>VNF orchestration</li> </ul>	<ul style="list-style-type: none"> <li>Gigabit LTE (TDD, FDD, LAA)</li> <li>Massive MIMO</li> <li>Network Slicing</li> <li>Dynamic service orchestration</li> <li>Predictive analytics</li> </ul>	<ul style="list-style-type: none"> <li>NR</li> <li>Virtualized RAN</li> <li>Federated network slicing</li> <li>Distributed Cloud</li> <li>Real time Machine learning/AI</li> </ul>
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# IoT: ON THE CUSP OF SOMETHING HUGE



# AI: ON THE CUSP OF SOMETHING HUGE



Artificial Intelligence (AI) is a source of both huge excitement and apprehension. What are the real opportunities and threats for your business? Drawing on a detailed analysis of the business impact of AI, we at PwC identify the most valuable commercial opening in your market and how to take advantage of them.

### Sizing the prize

What's the real value of AI for your business and how can you capitalise?

**+14%**  
According to the CBO research, the global GDP could be up to 14% higher in 2030 as a result of AI - the equivalent of an additional \$15.7 trillion - making it the biggest commercial opportunity in today's fast changing economy.

**+26%**  
The impact goes even further. In China, the rise in GDP is up to 26% in 2030 and North America (potential 19% boost). The biggest gains come from AI in retail, financial services and health care as AI increases productivity, product quality and customer experience.



**pwc**

[www.pwc.com/ai](http://www.pwc.com/ai)

Global GDP will be up to 14% higher in 2030 as a result of the accelerating development and take-up of AI

The equivalent of an additional

\$15.7 T



# 5G: ON THE CUSP OF SOMETHING HUGE



5G deployment will represent **~€56 bn** in 2020 (EU 28). Analysis suggest that 5G investment will have a multiplier impact totaling **€141 bn in 2025** in 4 sectors. These effects are likely to create **2.3 m jobs**

Source EU, 2016



The deployment of 5G in Smart Cities could create up to **3 m jobs** and boost GDP by **\$500 bn**; operators are expected to invest **~\$275 bn** in infrastructure **by 2024** in the US

Source: Accenture, 2017



The global 5G value chain will invest **\$200 bn** annually, will generate **~\$3.5 tn** in output **by 2035**, 5G will enable **\$12.3 tn** of global economic output and create **22 m jobs**

Source: IHS, 2017

# 'A CAMBRIAN EXPLOSION'

## AI & 5G WILL DISRUPT VIRTUALLY ALL SECTORS



### AI

Sector	Subsector	Potential AI Consumption Impact	Personalisation	Time Saved	Utility	Data Availability
<b>Healthcare</b>		<b>3.7</b>	3.8	2.7	3.9	4.4
	Providers/Health Services	3.9	4.1	3.0	3.9	4.7
	Pharma/Life Sciences	3.8	3.9	2.8	4.2	4.1
	Insurance	3.6	3.6	2.6	3.8	4.2
	Consumer Health	3.5	3.4	2.3	3.4	4.8
	<b>Automotive</b>	<b>3.7</b>	3.9	2.9	3.8	3.9
	Aftermarket & Repair	3.9	4.2	2.8	3.6	4.6
	Component suppliers	3.9	4.0	2.0	3.5	5.0
	Personal Mobility as a Service	3.8	4.0	3.7	4.0	3.7
	OEM	3.6	4.0	3.0	4.0	3.5
	Financing	3.3	3.3	3.0	3.7	3.0
	<b>Financial Services</b>	<b>3.3</b>	2.8	2.6	3.2	4.6
	Asset Wealth Management	3.4	2.9	2.2	3.7	4.3
	Banking and Capital	3.3	2.5	2.9	3.0	5.0
	Insurance	3.2	3.1	2.4	3.1	4.4
<b>Transportation and Logistics</b>		<b>3.2</b>	3.5	2.6	3.3	3.7
	Transportation	3.5	3.0	2.8	3.5	5.0
	Logistics	3.1	3.9	2.5	3.1	3.0
<b>Technology, Communications and Entertainment</b>		<b>3.1</b>	2.5	2.1	3.3	4.3
	Technology	3.3	2.7	2.4	3.6	4.1
	Entertainment, Media and Communication	3.0	2.5	2.0	3.3	4.4
<b>Retail</b>		<b>3.0</b>	2.8	2.1	3.3	3.8
	Consumer Products	3.1	3.0	2.3	3.3	3.8
	Retail	3.0	2.6	2.0	3.3	3.7
<b>Energy</b>		<b>2.2</b>	3.2	2.1	3.1	3.1
	Oil & Gas	2.3	4.0	2.1	2.9	3.0
	Power & Utilities	2.1	2.0	2.1	3.3	3.2
<b>Manufacturing</b>		<b>2.2</b>	2.0	1.2	3.7	3.8
	Industrial manufacturing	2.2	2.0	1.4	3.7	3.9
	Industrial Products/Raw Materials	2.1	NA	1.0	3.6	3.7

### 5G

	Challenge	Need	How 5G will help
Automotive	<ul style="list-style-type: none"> <li>- Strict CO<sub>2</sub> emission goals</li> <li>- Strong competition</li> <li>- Pressure for innovation</li> <li>- Globalisation</li> </ul>	<ul style="list-style-type: none"> <li>- Autonomous and connected cars</li> <li>- Innovative infotainment solutions</li> </ul>	<ul style="list-style-type: none"> <li>- Dynamically configure networks and resources to address different demands</li> </ul>
Media and entertainment	<ul style="list-style-type: none"> <li>- Quality of experience constantly increasing</li> <li>- New devices and services</li> <li>- Explosion of mobile data usage</li> </ul>	<ul style="list-style-type: none"> <li>- Networks which can support new media and entertainment services and devices (VR &amp; AR)</li> </ul>	<ul style="list-style-type: none"> <li>- Support massive increases in data rules</li> <li>- Guarantee a good quality of service</li> </ul>
Energy and utilities	<ul style="list-style-type: none"> <li>- Decentralised generation</li> <li>- Pressure on consumption</li> <li>- Increase in renewables</li> <li>- Fines when outage</li> </ul>	<ul style="list-style-type: none"> <li>- Dynamic smart grids, which can be monitored and controlled remotely throughout the entire network</li> </ul>	<ul style="list-style-type: none"> <li>- Real-time control of grids and remote generators where fibre has not been rolled out</li> </ul>
Public transport	<ul style="list-style-type: none"> <li>- Stronger focus on safety and security</li> <li>- Growing number of passengers</li> <li>- Higher service expectations</li> </ul>	<ul style="list-style-type: none"> <li>- Real-time information and entertainment for passengers</li> <li>- More efficient operations and maintenance of infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- Provide coverage and bandwidth for infotainment and more efficient operations</li> </ul>
Agriculture	<ul style="list-style-type: none"> <li>- Growing global population</li> <li>- Pressure on use of pesticides</li> <li>- Lack of farmers</li> <li>- Climate change</li> </ul>	<ul style="list-style-type: none"> <li>- Increased productivity and efficiency of farming</li> <li>- Sustainable farming solutions</li> </ul>	<ul style="list-style-type: none"> <li>- Remotely connect and control farming equipment</li> <li>- Provide bandwidth for advanced imagery and use of drones</li> </ul>
Healthcare	<ul style="list-style-type: none"> <li>- Ageing population</li> <li>- Increase in people with chronic diseases</li> <li>- Personalised care expectations</li> </ul>	<ul style="list-style-type: none"> <li>- Affordable healthcare solutions</li> <li>- Personal, wearable devices for monitoring and treatment</li> <li>- Remote patient care and follow up</li> </ul>	<ul style="list-style-type: none"> <li>- Enable mobile remote care solutions through guaranteed and secured connection</li> </ul>
Manufacturing	<ul style="list-style-type: none"> <li>- Ageing workforce</li> <li>- Manufacturing skills gap</li> <li>- Pressure on costs</li> <li>- More environmental concerns</li> </ul>	<ul style="list-style-type: none"> <li>- Robotics and automation inside the factory</li> <li>- Solutions which decrease production costs</li> </ul>	<ul style="list-style-type: none"> <li>- Provide the highly resilient, secure and low latency communication platform in the factory</li> </ul>
Security	<ul style="list-style-type: none"> <li>- Higher security alerts</li> <li>- Increased terrorist threats</li> </ul>	<ul style="list-style-type: none"> <li>- More monitoring and screening in public places</li> <li>- Better and faster reaction</li> </ul>	<ul style="list-style-type: none"> <li>- Support wireless security applications both for monitoring and detection</li> </ul>

# THE NEW FACTORY OF INNOVATION



$$\text{Innovation} = F(\text{IoT}, \text{AI}, \text{5G})$$



# THE NEW FACTORY OF INNOVATION





# 5TONIC INNOVATION FACTORY



## EMERGENCIES

- Save lives of chronic patients, by improving time-to-attention a 50%
- 5G Wearables, Edge Computing, IoT, Device-to-Device Comms, Network Slicing
- Demos scheduled: Sep 2018 and Jan 2019



## TOURISM



- First Augmented Fair in the World
- Mixed Reality and Augmented Hearing over 5G & Distributed Cloud and Network Slicing
- Demoed at FITUR2018(Jan 2018)



- 5G-enabled AGV's (Automated Guided Vehicles)
- Autonomous Vehicles, Cloud Robotics, 5G & Distributed Cloud
- Demo scheduled for Global Robot Expo 2018 (Apr 2018)



5TONIC



## SPACE & DEFENSE



ROHDE & SCHWARZ

- MoU just signed

## INDUSTRY 4.0

Telefonica

institute  
idea  
networks



COMMScope



cohere  
technologies

ARTESYN  
EMBEDDED TECHNOLOGIES

INTERDIGITAL



ALTRAN



# CASE 1: 'FULLY AUTONOMOUS VEHICLES WOULD BE IMPOSSIBLE WITHOUT 5G & AI'

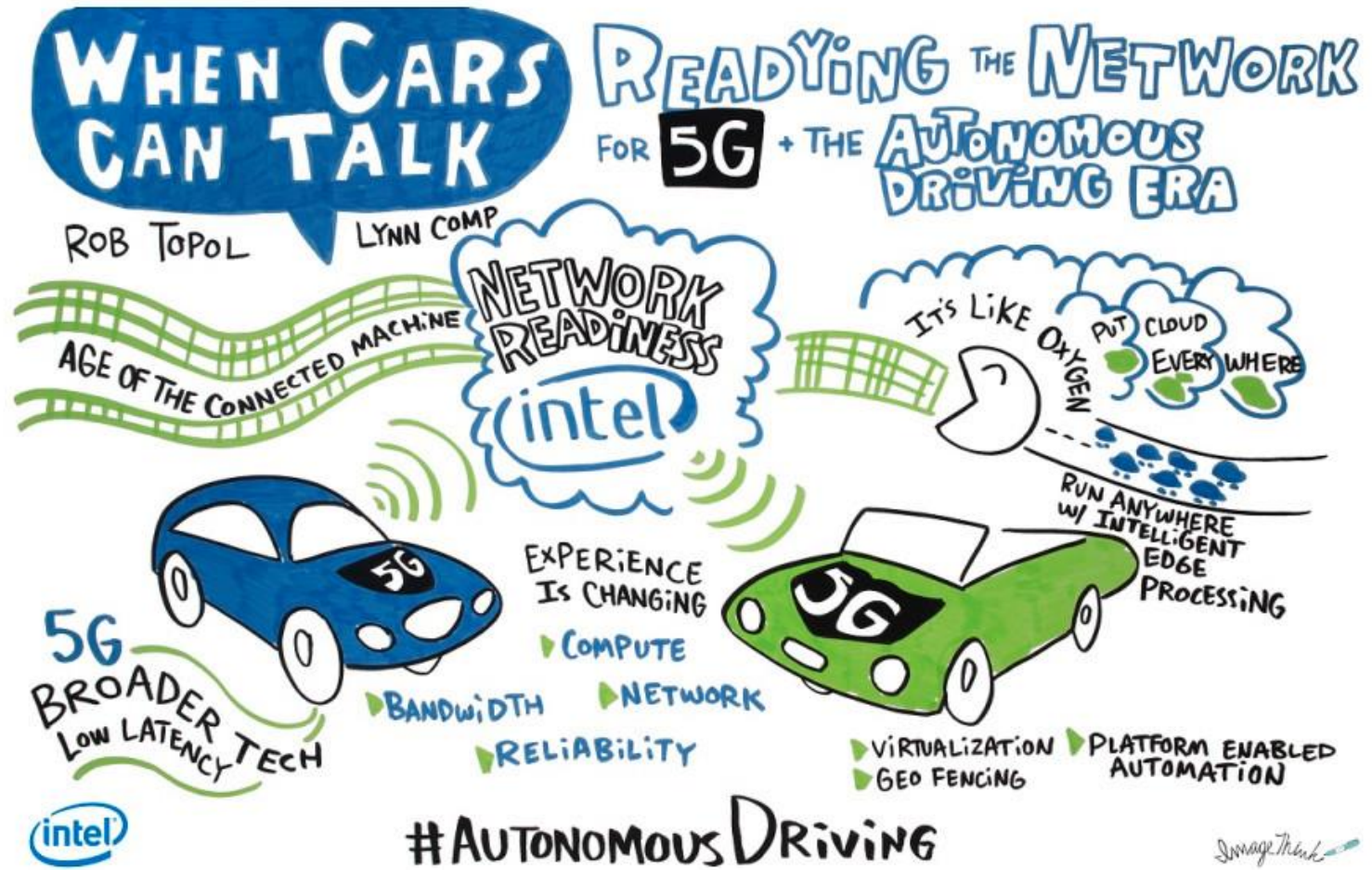


**VB**

5G wireless will make autonomous cars smarter  
VentureBeat

**Forbes**

AI critical to the future of autonomous vehicles  
Forbes



Source: Intel, Forbes, VentureBeat

# CASE 2: REMOTE ROBOTIC SURGERY



\$20.8 BN

Estimated surgical robot market size (2024)



- ✓ Improved outcomes
- ✓ Patient convenience
- ✓ Reduced cost

Role and key dimensions of 5G



SECURITY



AVAILABILITY



RELIABILITY

# CASE 3: REMOTE CONTROL OF PRODUCTION LINE ROBOTICS



Critical control of production line robotics includes **tethered or untethered production line robotics that are controlled, monitored, and can be reconfigured remotely**

## Technical features


- › **Production line robot**
- › **Control center**
- › **Connection** between robot and control center
- › Specialized **tools**
- › **Datacenter/cloud**
- › **Haptic feedback** controlling device
- › **Cameras and other sensing devices** for feedback to control center

## Applications

- › **Production** on factory floor
- › **Reset and reconfiguring** of task
- › Reconfiguration of **production layout** with mobile robotics
- › **Real-time analysis and steering** of robot movements
- › Remote control **for turning robotics on and off**
- › **Analysis** and follow-up

## What role does 5G play?

- › **Mobile high performance connectivity** for robotics removing the need for fiber tethering
- › **Quick reactions to discrepancies** helps avoid damaging expensive components
- › **Live remote monitoring of video stream** from robotics
- › Low latency enable **remote control applications**



**Peak data rate**



**Reliability**



**Latency**



**Position accuracy**



**Availability**



**Security**

Source: 3GPP, Arthur D. Little

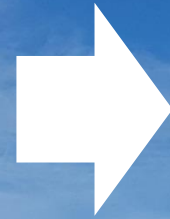
# CASE 4: TRUE REAL-TIME SIMULTANEOUS TRANSLATION



## APPLICATION



True Real-time Simultaneous Translation Service



## 5G ROLE



Latency



Security

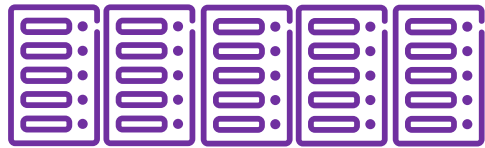


Connection density



Reliability

## REMOTE CLOUD SERVICE



## NETWORK



## TRADE FAIR CENTER



Edge Computing Infra



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5. Q&A 10'

# CHALLENGES (AND OPPS) AHEAD



- Industries in Transformation vs New Entrants
- Legacy Systems and Emerging Technologies
- Standard vs Proprietary Solutions
- Established Technology Firms and Start-ups
- Traditional vs New Business Models
- Senior Experienced Staff and Young Talent
- Bilateral vs Multilateral collaborations

# TECH DISRUPTION PRESENTS A CHALLENGE FOR ORGANIZATIONS



If managers aren't ramping up experiments in the area of machine learning, they aren't doing their job.

Over the next decade, AI won't replace managers, but managers who use AI will replace those who don't.

Erik Brynjolfsson

# CHANGE MINDSETS ON AI & IoT CHALLENGES



**MIT  
Technology  
Review**

**Intelligent Machines**

## **The Machines Are Getting Ready to Play Doctor**

An algorithm that spots heart arrhythmia shows how AI will revolutionize medicine—but patients must trust machines with their lives.

by Will Knight July 7, 2017



# AI KNOWS WHAT YOU'RE GOING TO DO CHALLENGES



**Mashable**

**The  
Economist**

China is using AI to predict who will commit crime next

Share on Facebook Share on Twitter +

WHAT'S THIS?



IMAGE: AGGETTY IMAGES

Facial technology

Advances in AI are used to spot signs of sexuality

*Machines that read faces are coming*



Sally Mayer

# HOW SECURE ARE AI & IoT? CHALLENGES



**eWEEK**



DDoS attack disrupted the controlling server for the **heating system** in two blocks of apartments in Finland

*(Nov, 2016)*

**TE**



FDA issues new **security guidelines** so that your **pacemaker** won't get hacked

*(Dec 2016)*

**WIRED**



Inside the Cunning, Unprecedented Hack of Ukraine's **Power Grid**

*(Mar, 2016)*

# NEW TERMS: RANSOMWARE OF THINGS



# WHO'S RESPONSIBLE IN AI & IoT? CHALLENGES



Tesla Autopilot appears  
to 'predict' **accident** in  
front of it

*(Dec 28, 2016)*



An Amazon Echo may be  
the key to solving a  
**murder** case

*(Dec 27, 2016)*

# WHERE ARE THE JOBS IN AI & IoT?

## CHALLENGES



**Daily Mail**

Amazon's robot army revealed: now has more than **45,000 bots** around the world  
*(Jan 4, 2017)*

**BI**

A Japanese insurance firm replaced 30 workers with IBM's **artificial intelligence** technology  
*(Jan 5, 2017)*

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## KEY TAKE-AWAYS



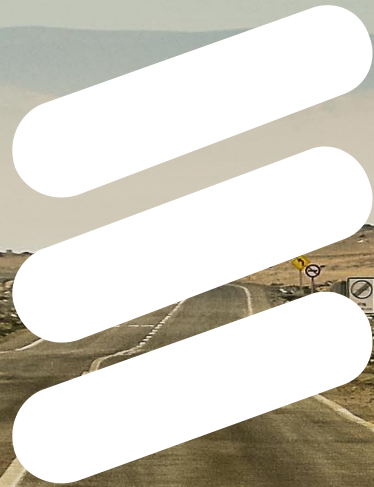
5G, AI and IoT trigger disruption and innovation in multiple industry sectors



Ecosystem-based Innovation approaches are key to differentiation



Digitalization Challenges = Great Professional Opportunities



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