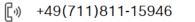


Dr. Alexander Artemenko



Alexander.Artemenko@de.bosch.com

KEYNOTE: ADVANCES AND CHALLENGES OF INDUSTRIAL IOT

INTERNATIONAL WORKSHOP ON MOBILE AND PERVASIVE INTERNET OF THINGS (PERIOT) (CO-LOCATED WITH IEEE PERCOM 2021) 26.03.2021



6GBRAINS

Demography: 2030 average expectation of life 81,5 years in Germany

Society

Urbanization: 70% of the population lives in cities by 2050

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Digitization: Bandwidth for data transfer doubles roughly every 21 month

Technology

Connectivity: 125 billion connected things by 2030

Al & Automation: 15,7 trillion \$ is the expected contribution of AI to worldwide economy until 2030

BOSCH

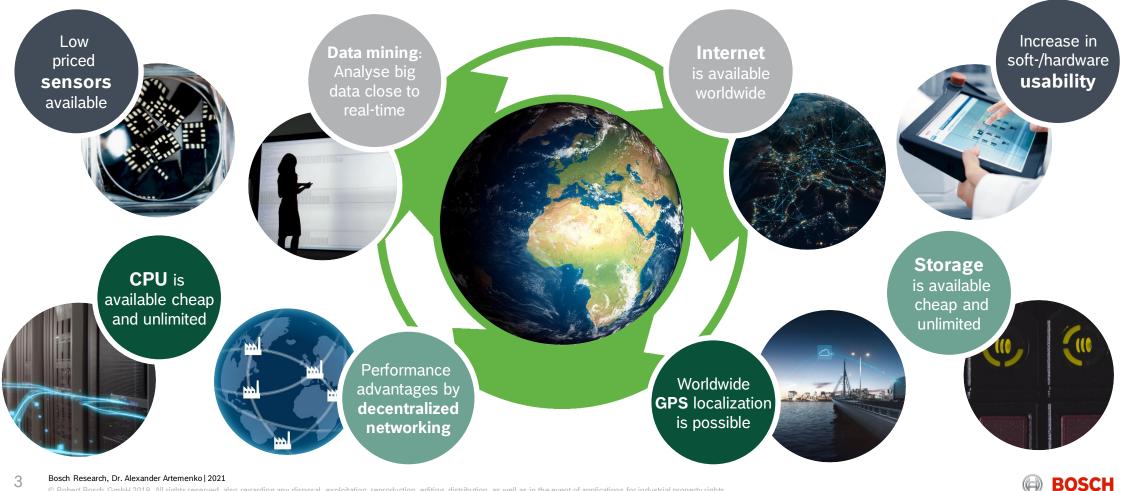
Climate: The probability that global warming will be limited to 2 degree is very low

Environment

Energy: 30% more energy consumption worldwide until 2035



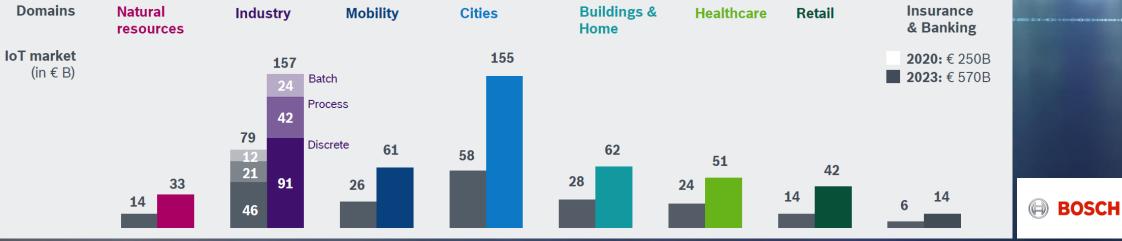
Important changes in recent years



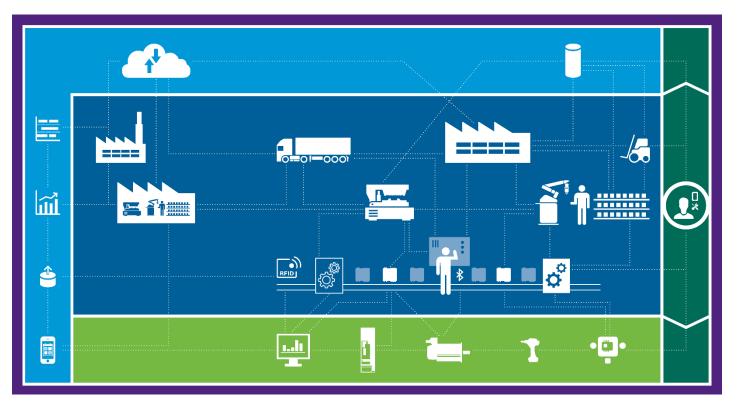
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Internet of things





Industrial IoT



Software Solutions

The element that links all modules and subsystems along the value stream with people and third-party systems.

Services and Consulting

A broad range of services and consulting including collaborative projects to test new business models.

Logistics and Manufacturing

Solutions that connect machines and whole manufacturing lines to value-creation networks.

Field Level Equipment

Components, modules and systems that enable the integration of equipment into networked i4.0 environments.

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Key enablers for IIoT:



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Agenda

- Who am I? What is Bosch?
- Industrial IoT: <u>NOW</u>
- Industrial IoT: <u>TOMORROW</u>
- Industrial IoT: THE DAY AFTER TOMORROW



1. BOSCH - WORLDWIDE LEADING IOT COMPANY





Bosch – The "Invented for life" company



Our motivation – what drives us

Invented for life: we want our products to spark enthusiasm, improve quality of life, and help conserve natural resources





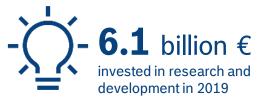
1. Bosch - worldwide leading IoT Company





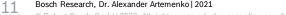


subsidiaries and regional companies in appr. 60 countries



72,600 Bosch researcher and developer







1. Bosch - worldwide leading IoT Company



Mobility Solutions

46.8 billion €

 One of the world's largest suppliers of mobility solutions



Industrial Technology

7.5 billion €

 Leading in drive and control technology, packaging, and process technology





5.6 billion €

- One of the leading manufacturers of security & communication technology
- Leading manufacturer of energyefficient heating products and hot-water solutions

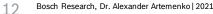


Consumer Goods

17.8 billion €

- Leading supplier of power tools and accessories
- Leading supplier of household appliances

Figures represent sales as of December 2019

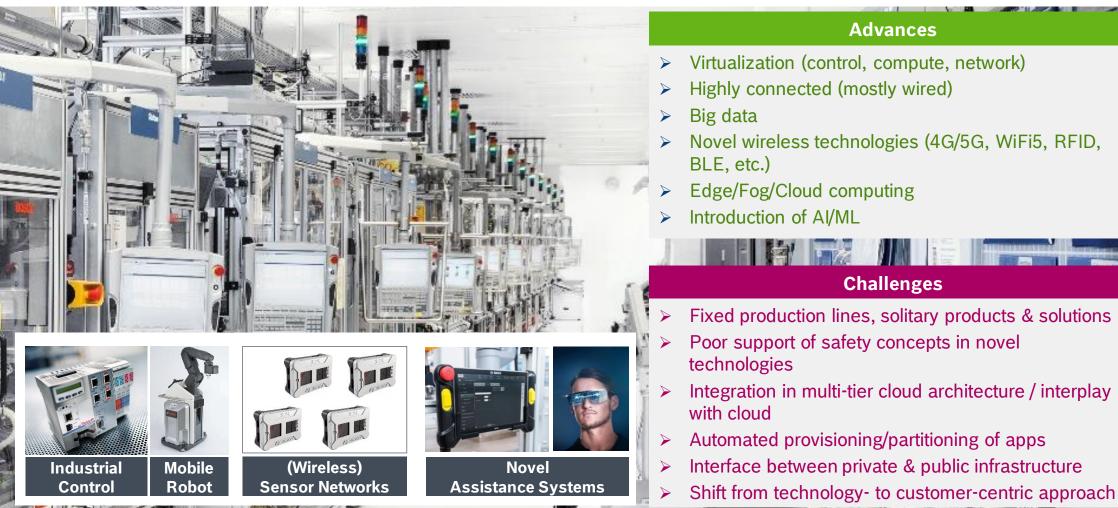




2. INDUSTRIAL IOT: NOW



Industrial IoT: NOW

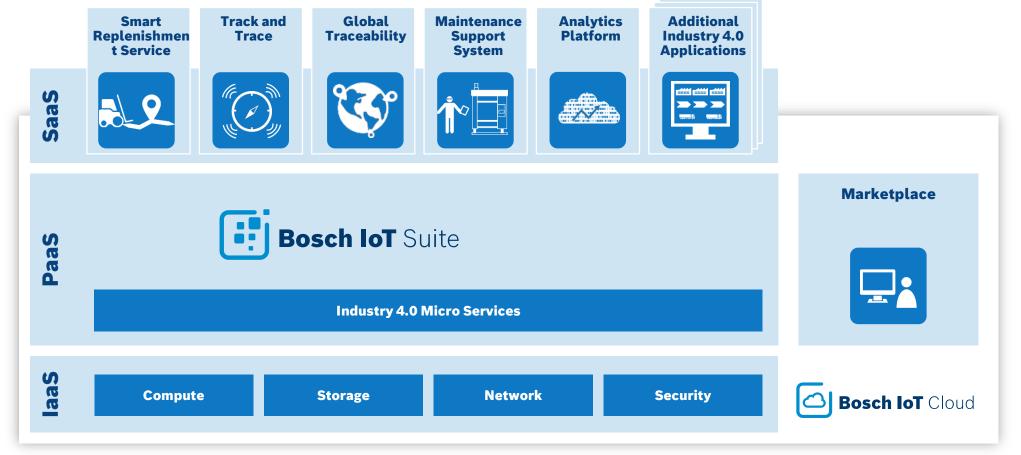


Pictures source: http://www.bosch-presse.de/pressportal/de/de/news/

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Industrial IoT: NOW IIoT Cloud Example



IaaS / PaaS / SaaS = Infrastructure / Platform / Software as a Service

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Industrial IoT: NOW Logistics with RFID





Industrial IoT: NOW Production quality: Smart tightening

Failure reaction time drastically reduced

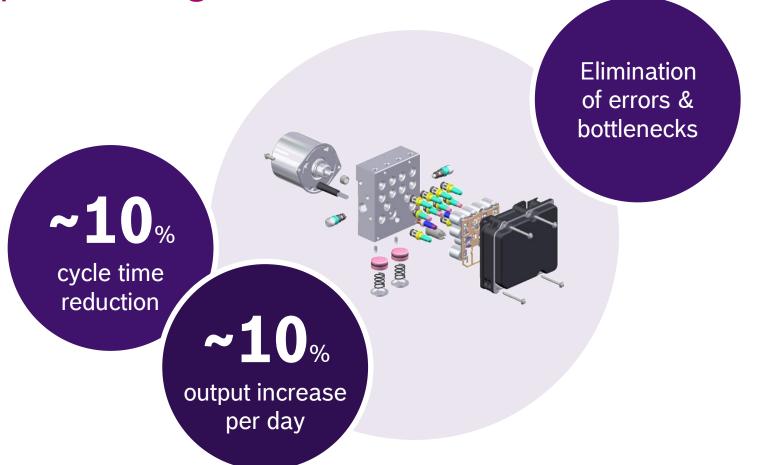


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9



Industrial IoT: NOW Smart Adaptive Testing



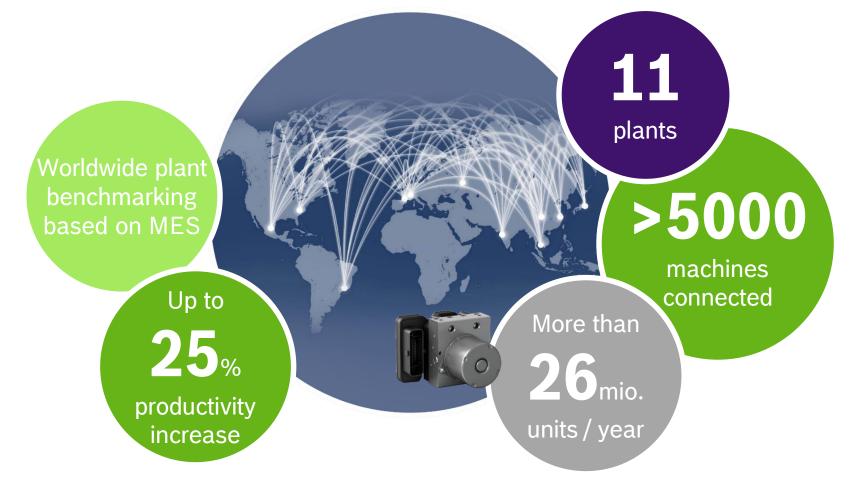


Industrial IoT: NOW i4.0 in an entire line – example Homburg





Industrial IoT: NOW i4.0 in an International Production Network – example ABS / ESP





2. INDUSTRIAL IOT: TOMORROW





Industrial IoT: TOMORROW



Advances

- Fully virtualized (devices, products, control, compute, network)
- Fully connected (wired and wireless)
- Compute everywhere
- Flexible customer-centric production
- Improved downtime
- Advanced AI/ML
- High mobility

Challenges

- Multi-tier connectivity and compute platforms
- Vast cloud native landscape
- Embedded compute
- Support in network QoS, highly deterministic traffic
- Support of brown field
- Private & public infrastructure mix
- Focus on the customer needs first



Industrial IoT: TOMORROW Video Offloading to Zero-Downtime Edge Cloud



Requirements

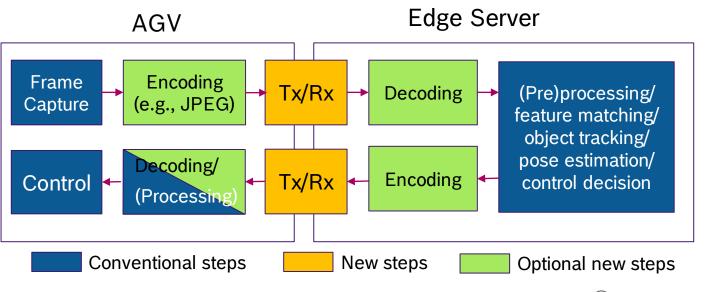
- Motion-to-Photon latency < 100 ms</p>
 - > High throughput (>500 Mbps), short latency
- Costs, size and weight constraints
- Use by multiple collaborating users simultaneously

Benefits of offloading:

- Offloading enabling complex video processing for resource-constrained devices
- Video processing as a service
- Server-side rendering of complex
 3D models
- Enabler for collaborative and context-sensitive video processing

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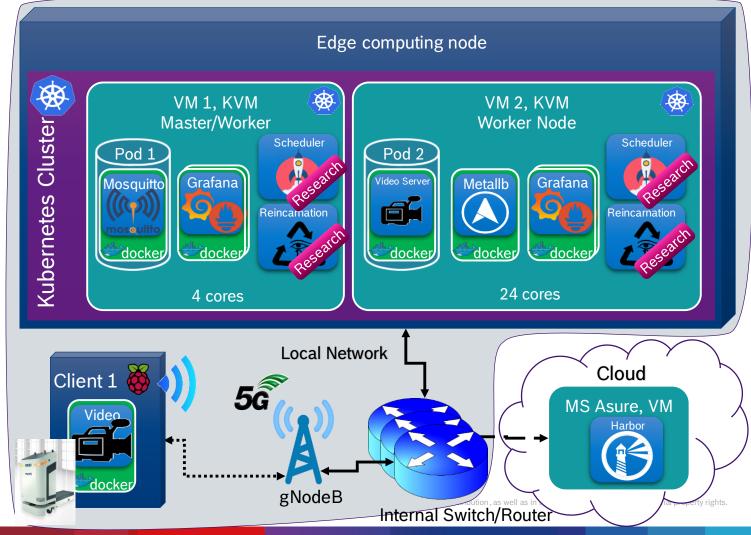




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Pictures source: http://www.bosch-presse.de/pressportal/de/de/news/

Industrial IoT: TOMORROW Video Offloading to Zero-Downtime Edge Cloud

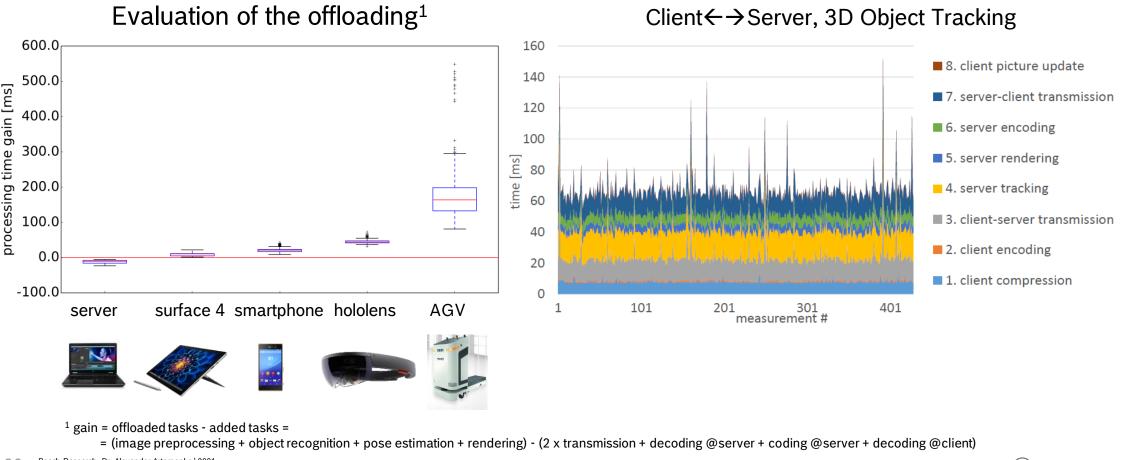


Edge Platform Redundant Services Live Service Migration Dedicated Orchestration

5G Platform Guaranteed Bandwidth Stable Latency Dedicated Service

Video Application Short Latency < 100 ms High Data Rates > 70 Mbps Complex Processing

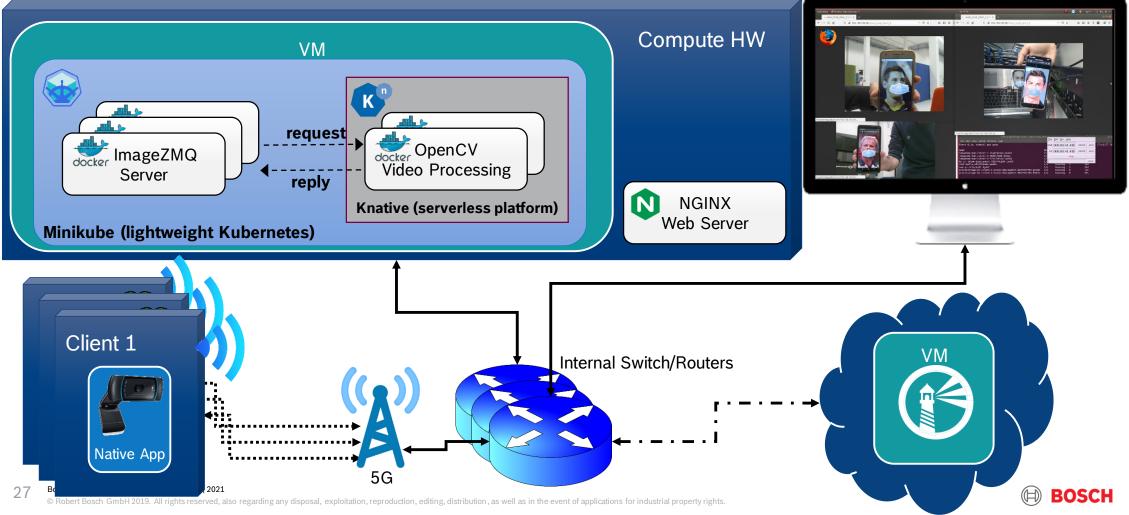
Industrial IoT: TOMORROW Video Offloading to Zero-Downtime Edge Cloud

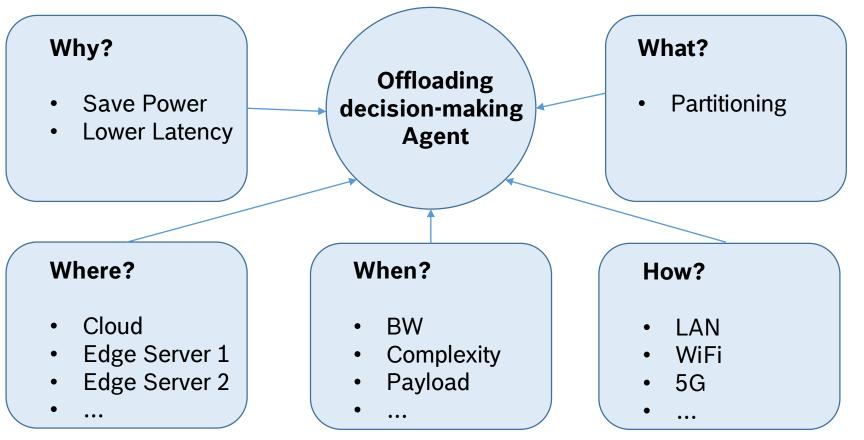


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Industrial IoT: TOMORROW Video Offloading to Zero-Downtime Edge Cloud (Serverless)

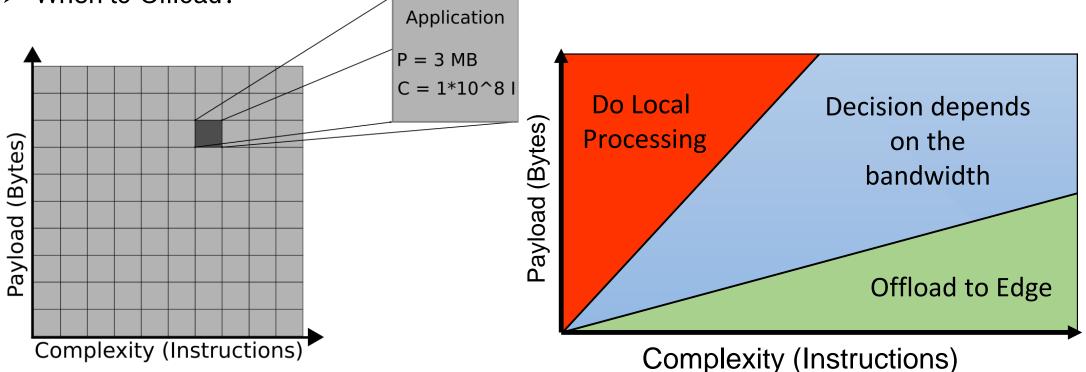




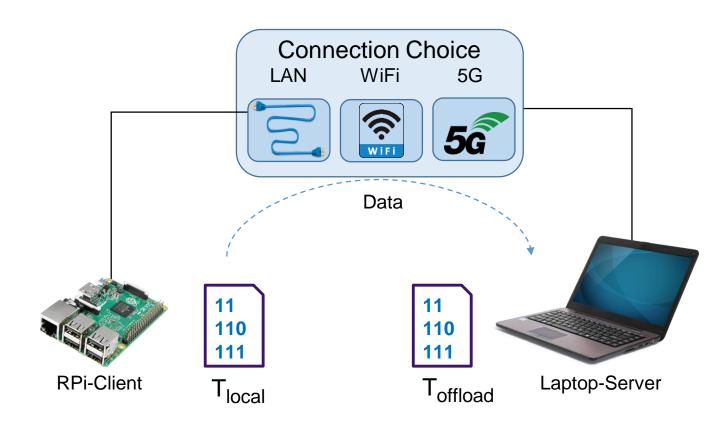
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> When to Offload?





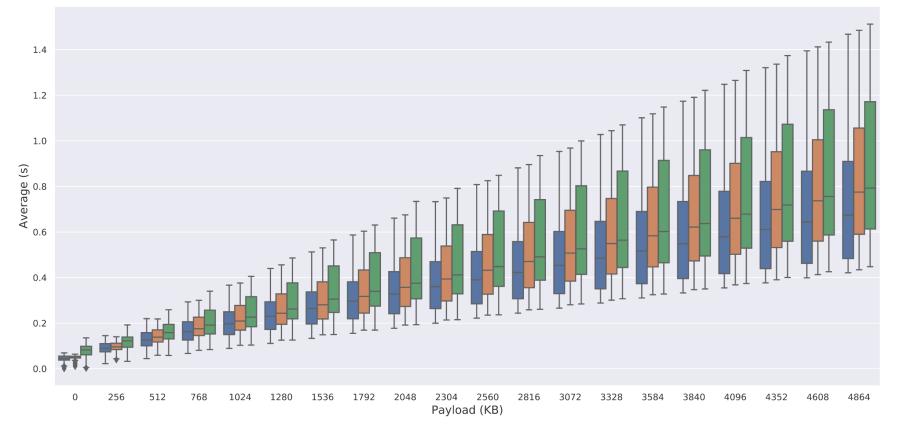


Parameter	Value			
Client				
Туре	Raspberry PI 3B			
CPU Model	Cortex-A53			
CPU MIPS	2162.82 MIPS			
Data Range	1 B – 5 MB (Step: 256KB)			
Protocol	ТСР			
Infrastructure				
Bandwidth: 100 Mbps				
Ethernet	1 Gbps			
WiFi	IEEE 802.11 (5 GHz)			
5G	SA 5			
Server				
Туре	Fujitsu			
CPU Model	Intel(R) Core(TM) i7-4810MQ			
CPU MIPS	23741.92 MIPS			
Application Complexity	0 – 600x10^6 Instructions (Step: 9000)			

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Average latency, all complexities



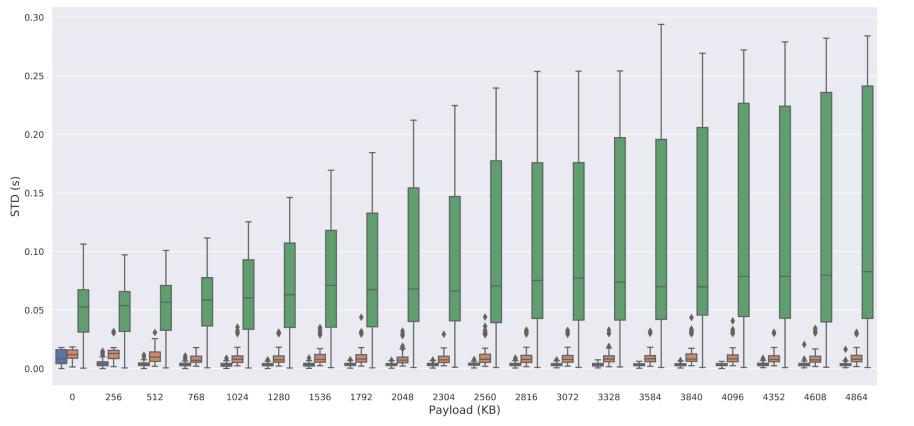


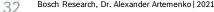
Case

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Standard Deviation from the mean, all complexities





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Case LAN 5G

WiFi

Industrial IoT: TOMORROW Mobile Communication: Use Case Requirements

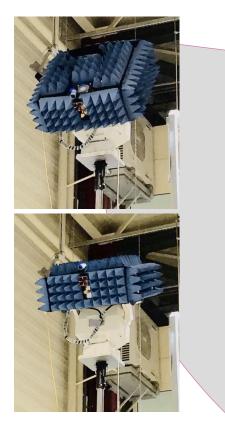
Use case (high level)		Availability	Cycle time	Typical payload size	# of devices	Typical service area
Motion control	Printing machine	>99.9999%	< 2 ms	20 bytes	>100	100 m x 100 m x 30 m
	Machine tool	>99.9999%	< 0.5 ms	50 bytes	~20	15 m x 15 m x 3 m
	Packaging machine	>99.9999%	< 1 ms	40 bytes	~50	10 m x 5 m x 3 m
Mobile robots	Cooperative motion control	>99.9999%	1 ms	40-250 bytes	100	< 1 km²
	Video-operated remote control	>99.9999%	10 – 100 ms	15 – 150 kbytes	100	< 1 km ²
Mobile control panels with safety functions	Assembly robots or milling machines	>99.9999%	4-8 ms	40-250 bytes	4	10 m x 10 m
	Mobile cranes	>99.9999%	12 ms	40-250 bytes	2	40 m x 60 m
Process automation (process monitoring)		>99.99%	> 50 ms	Varies	10000 devices per km ²	

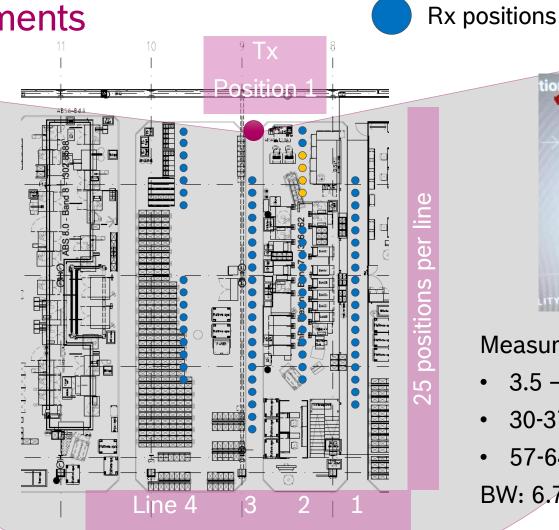
Source: 5G-ACIA www.5g-acia.org



Industrial IoT: TOMORROW **Channel Measurements**

See Acknowledgements for pictures used on this slide





Tx position 323

Measured resources:

- 3.5 10 GHz •
- 30-37 GHz •
- 57-64 GHz •

BW: 6.75 GHz (x1, x5, x9)

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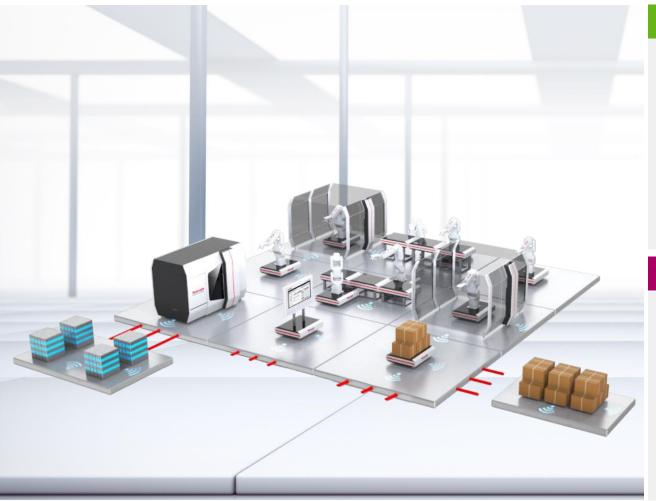
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4. INDUSTRIAL IOT: THE DAY AFTER TOMORROW





Industrial IoT: THE DAY AFTER TOMORROW



Advances

- Highly flexible, variable production
- Factory-as-a-service
- Lot size 1 at large-scale conditions
- Very high productivity
- Low invest and low cost
- Complete automation
- > Highest connectivity, unlimited compute
- Very high mobility

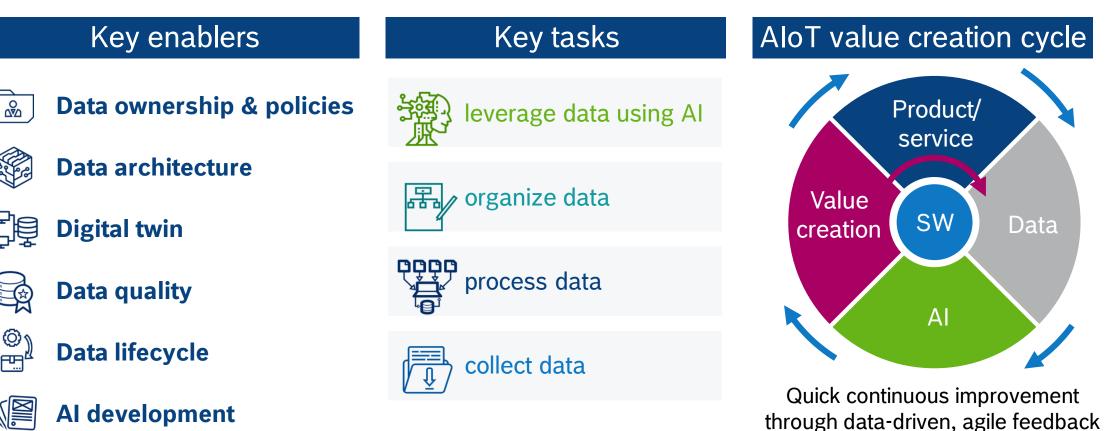
Challenges

- Integration of novel technologies into brown field:
 - Connectivity: THz, OWC
 - > Compute: Quantum computing
- Very short product life cycles
- Very low communication cycle times and expected jitter
- Highly volatile requirements on communication and compute infrastructures

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Industrial IoT: THE DAY AFTER TOMORROW AloT – Al-enabled IoT



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cycles

Acknowledgements and Sources



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- This presentation reflects the author's view, only, and the Commission is not responsible for any use that may be made of the information provided.
- Many thanks to Robert Müller (Fraunhofer IIS) for enabling usage of the antenna and hand scanner pictures.

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- 8. https://www.nginx.com/
- 9. https://knative.dev
- 10. https://prometheus.io

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