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# SMART FACTORIES: TODAY, TOMORROW AND THE DAY AFTER TOMORROW

WIRELESS INTELLIGENT NETWORKS 2021 23.06.2021







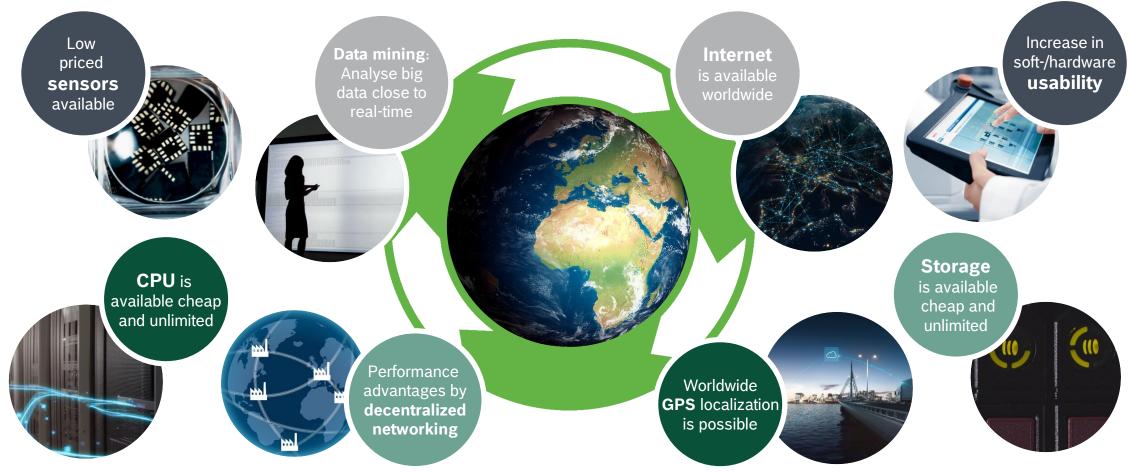
**Connectivity:** 125 billion connected things by 2030

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

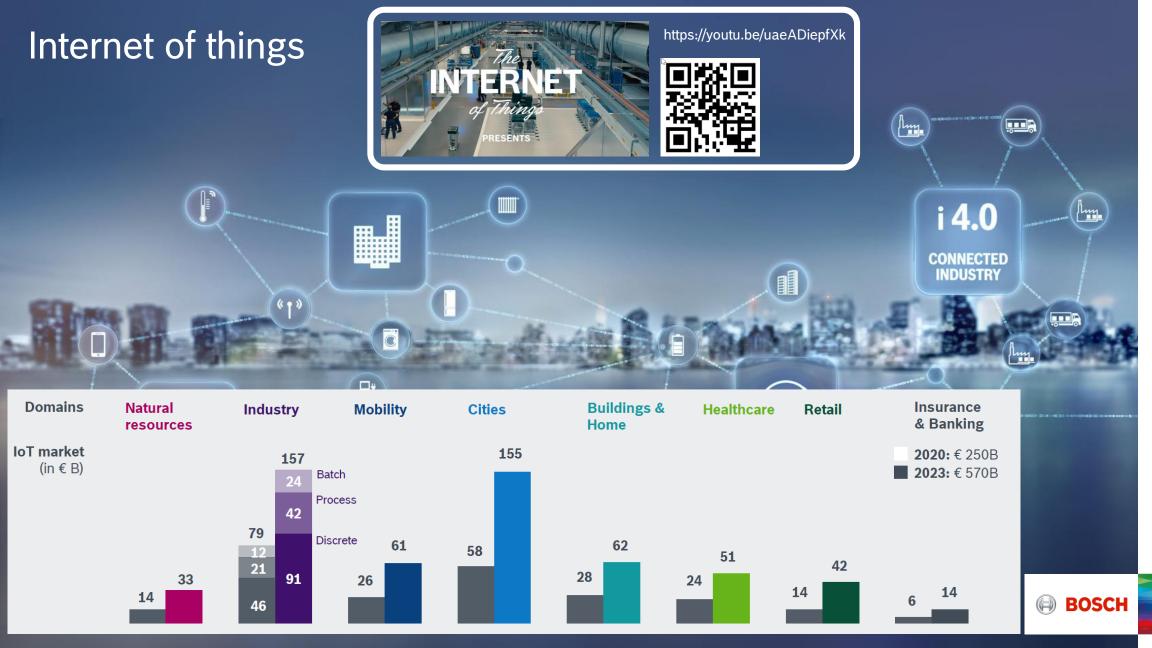




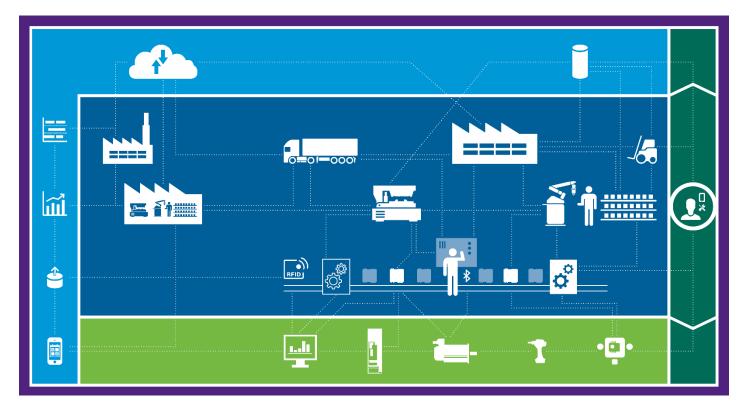
#### Important changes in recent years







#### 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.

**Key enablers for IIoT:** 

Cyber-physical systems

Edge computing

WLAN, RFID

Mobile technologies: 5G/B5G

Big data

3D printing

Advanced robotics

**Cloud computing** 

# Agenda

Smart Factories: TODAY

Smart Factories: <u>TOMORROW</u>

Smart Factories: THE DAY AFTER TOMORROW

# SMART FACTORIES: TODAY











(Wireless) Sensor Networks



Novel
Assistance Systems

#### **Advances**

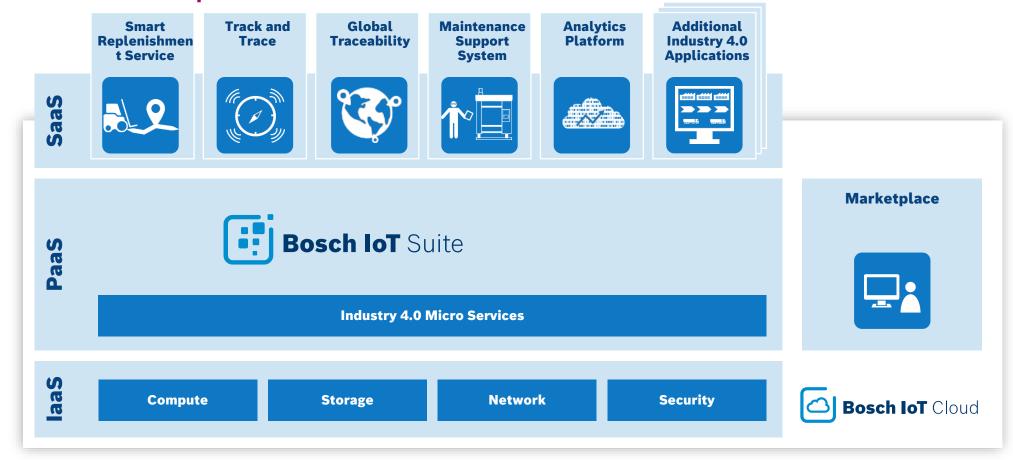
- Virtualization (control, compute, network)
- Highly connected (mostly wired)
- Big data
- Novel wireless technologies (4G/5G, WiFi5, RFID, BLE, etc.)
- Edge/Fog/Cloud computing
- Introduction of AI/ML

#### Challenges

- Fixed production lines, solitary products & solutions
- Poor support of safety concepts in novel technologies
- Integration in multi-tier cloud architecture / interplay with cloud
- Automated provisioning/partitioning of apps
- Interface between private & public infrastructure
- > Shift from technology- to customer-centric approach



#### **IIoT Cloud Example**



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



# Logistics with RFID



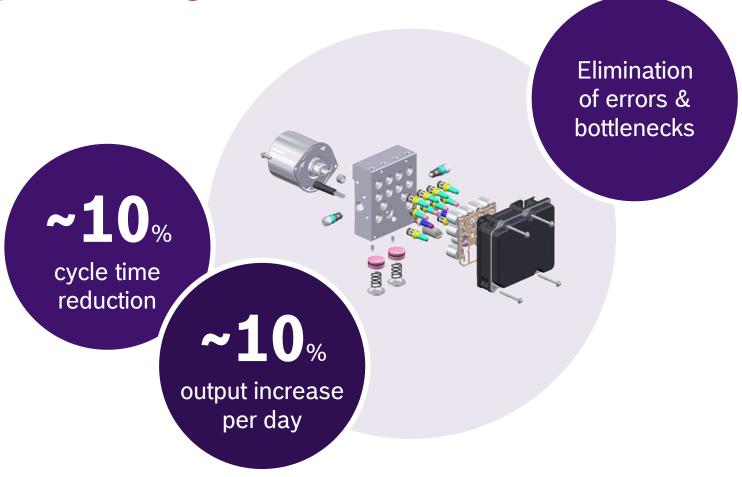




Production quality: Smart tightening

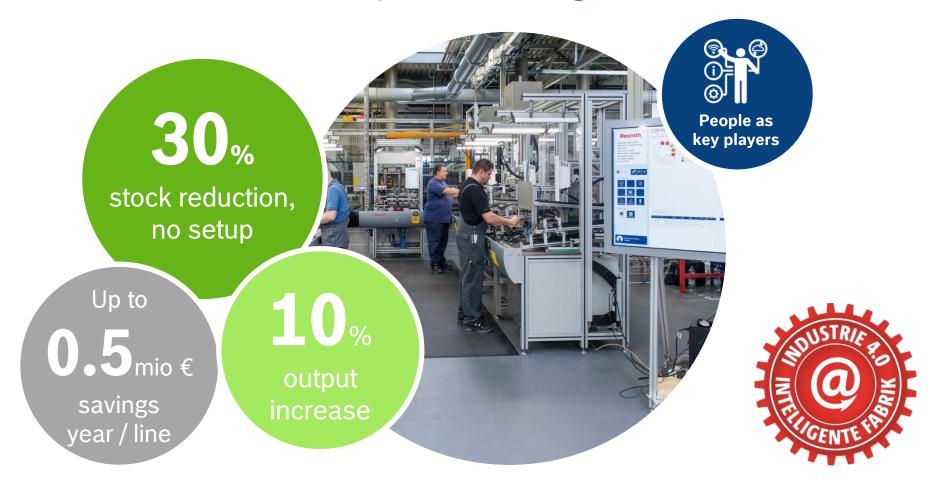


**Smart Adaptive Testing** 



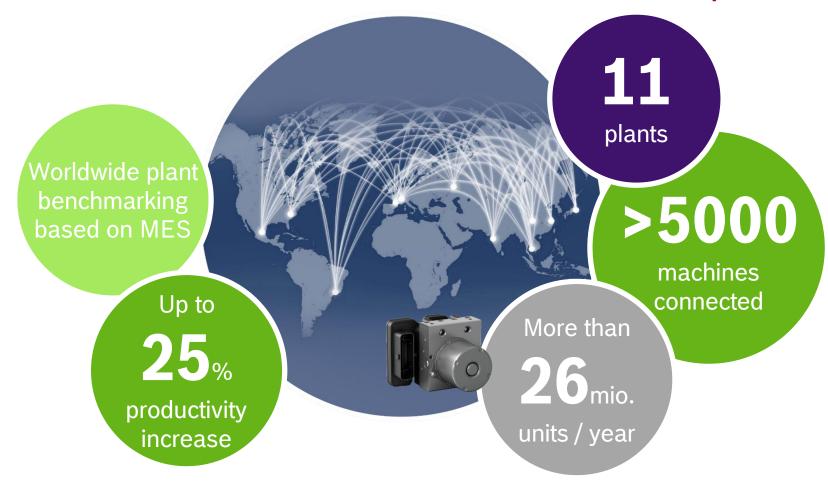


# i4.0 in an entire line – example Homburg





# i4.0 in an International Production Network - example ABS / ESP

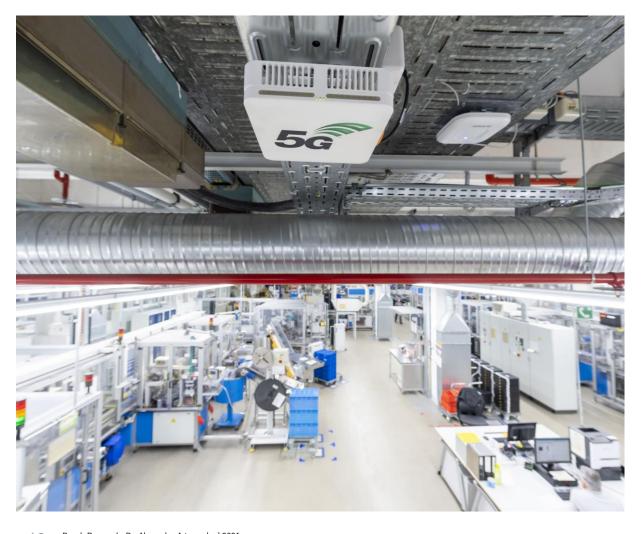




# SMART FACTORIES: TOMORROW







#### **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



# Video Offloading to Zero-Downtime Edge Cloud

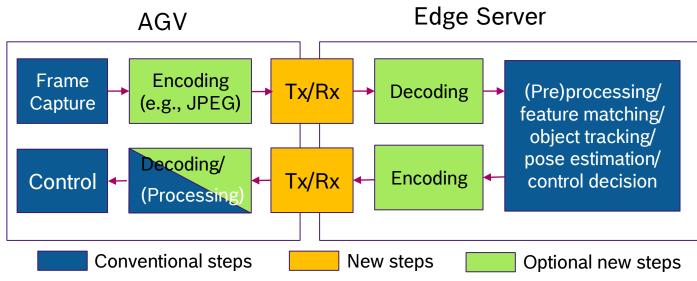


#### Requirements

- 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:**

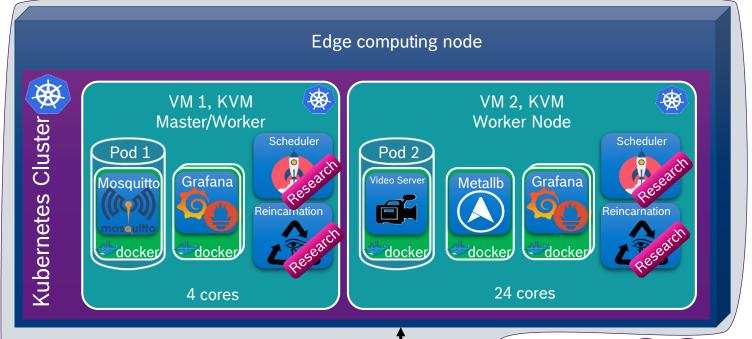
- Offloading enabling complex video processing for resource-constrained devices
- Video processing as a service
- Server-side rendering of complex3D models
- Enabler for collaborative and context-sensitive video processing



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



#### Video Offloading to Zero-Downtime Edge Cloud



Client 1

Signode B

Internal Switch/Router

Local Network

Cloud

MS Asure, VM

Harbor

Harbor

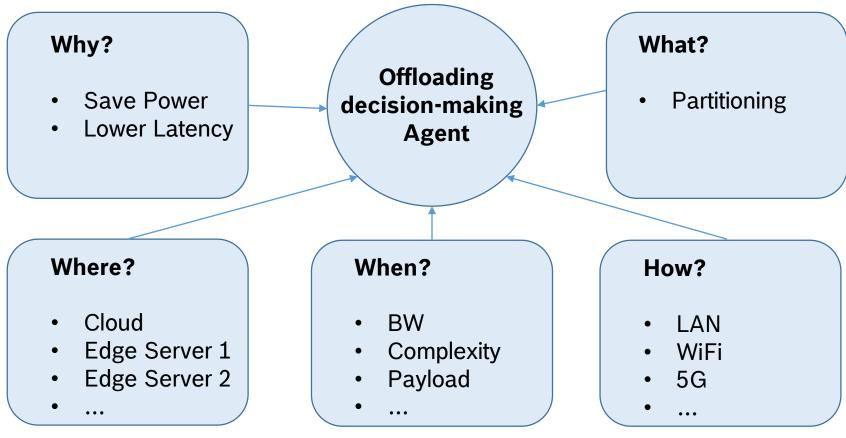
MS Asure, VM

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

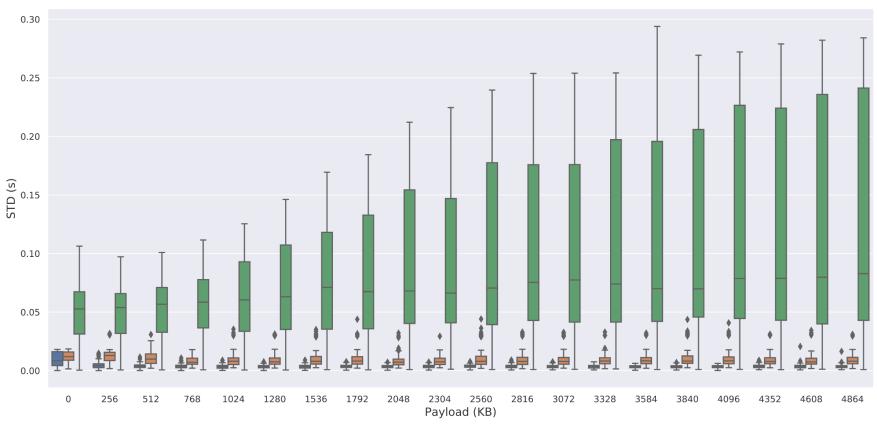
# Al-based Offloading Decision Making





# Al-based Offloading Decision Making

#### Standard Deviation from the mean, all complexities







### 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 km <sup>2</sup>
	Video-operated remote control	>99.9999%	10 – 100 ms	15 – 150 kbytes	100	< 1 km <sup>2</sup>
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 km²	

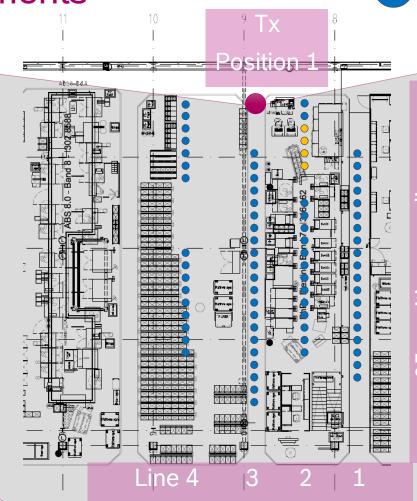
Source: 5G-ACIA www.5g-acia.org



#### **Channel Measurements**







Rx positions



Tx position



#### Measured resources:

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

BW: 6.75 GHz (x1, x5, x9)



# SMART FACTORIES: THE DAY AFTER TOMORROW

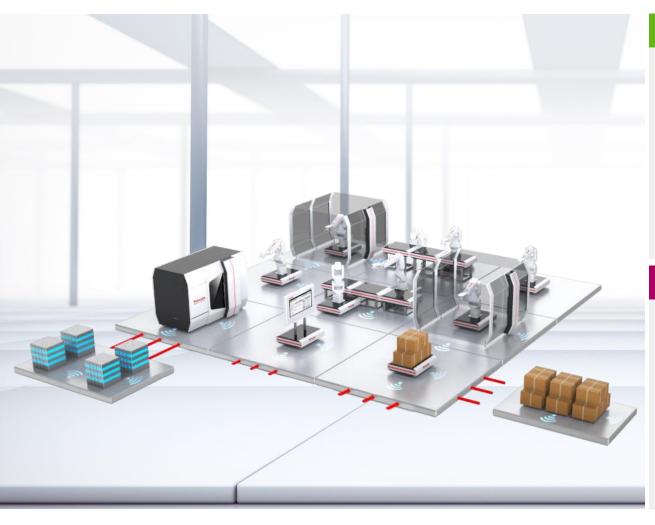


https://youtu.be/ISk64bJ35yM





#### Smart Factories: 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 iitter
- Highly volatile requirements on communication and compute infrastructures



#### Smart Factories: THE DAY AFTER TOMORROW

#### AloT – Al-enabled IoT

#### Key enablers



**Data ownership & policies** 



**Data architecture** 



**Digital twin** 



**Data quality** 



**Data lifecycle** 

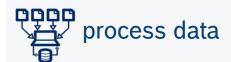


Al development

#### Key tasks

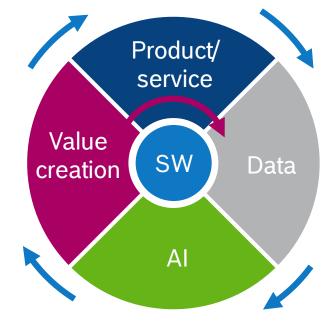








#### AloT value creation cycle



Quick continuous improvement through data-driven, agile feedback 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.
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