5GANG SUMMIT

PARTNER PRESENTATION
BOSCH

GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung

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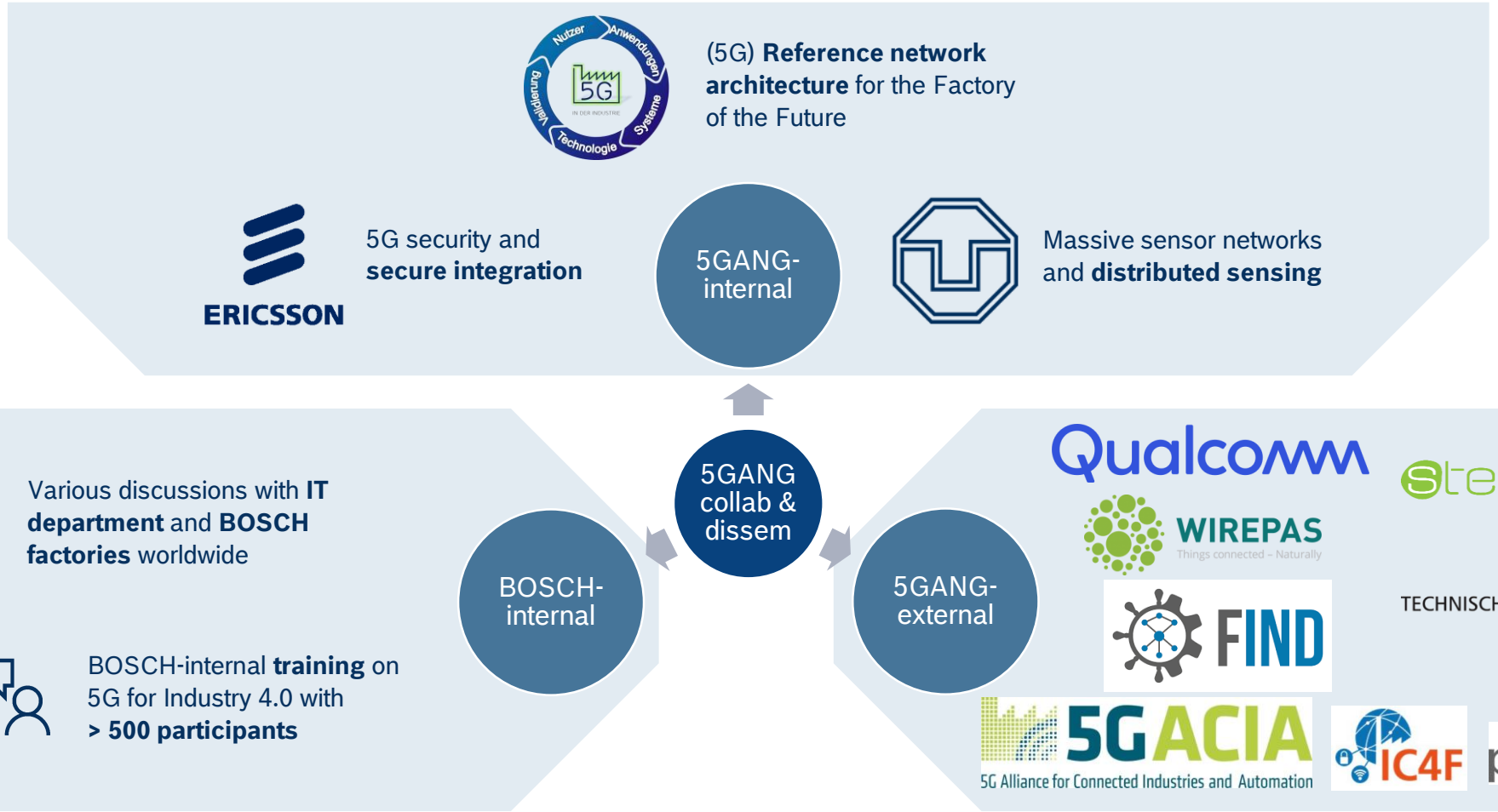
BOSCH‘s 5GANG Collaboration and Dissemination Activities



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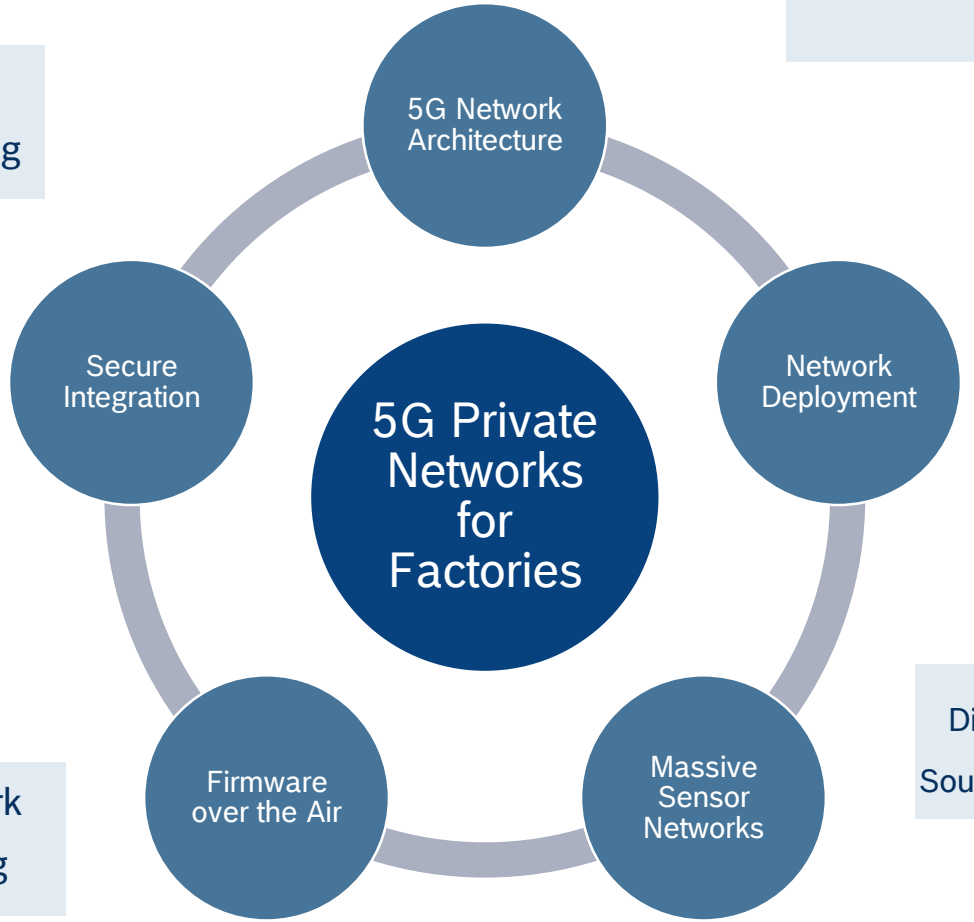
BOSCH‘s 5GANG Engagements



Virtualization

Edge computing

Operation models

5G Security Architecture

BOSCH XDK

RAN deployment

Compressed Sensing

5G network management

Distributed Source Coding

Network coding

Mesh Networks

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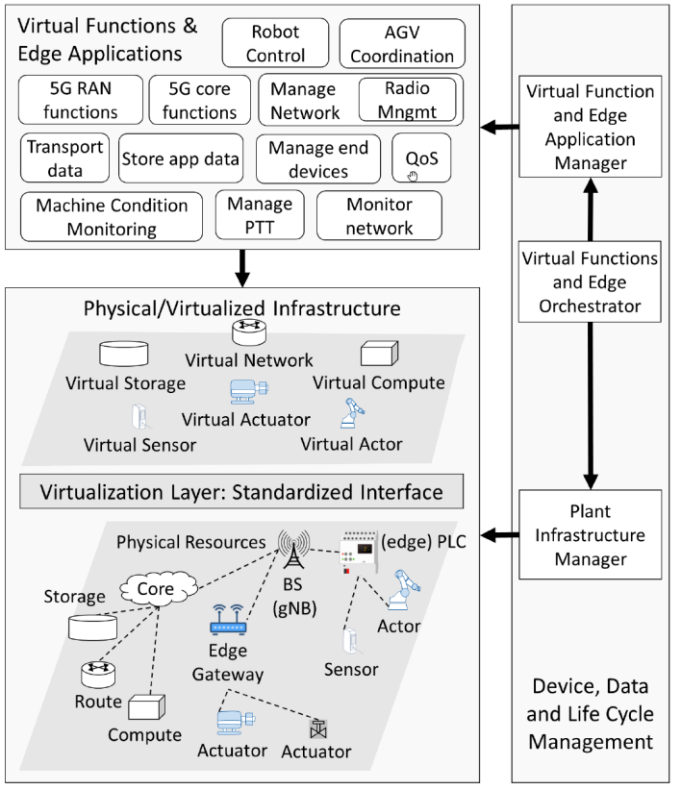
Reference Network Architecture for the Factory of the Future



- 5GANG 5G Architecture analyzed from multiple perspectives
- Virtualization and orchestration of all assets incl. 5G is important
- Lifecycle of a private 5G network must be end user friendly (factory personnel)

	Application	Compute & store stack on device	Network rules: access, data flow, firewall	Control/Machine/ Network device
Setup	• Install/configure application • Enable capabilities • Enroll users	• Install/configure compute & store environment • Set up access rules • Offer capabilities	• Install network stack • Set up access rules • Set up data flows • Set up firewall rules	• Enroll and secure device • Set up access onto device
Execute	• Monitor application • Remote diagnosis • Troubleshoot/remote access • Reconfig. application, user rights • Backup/recovery application/data	• Monitor stack • Remote diagnosis • Troubleshoot/remote access • Reconfigure stack • Backup/recovery rules	• Monitor network • Remote diagnosis • Troubleshoot/remote access • Reconfig. rules, exclude devices • Backup/recovery rules	• Monitor device • Remote diagnosis • Troubleshoot/remote access • Reconfigure device • Update drivers & OS • Backup/recovery
Shutdown	• Shutdown application • Disenroll users	• Shutdown compute & store environment	• Shutdown network	• Disenroll and shutdown • Wipe device • Exclude device

Virtualization of 5G Network and Applications on a Flexible (Edge) Compute Platform is Key

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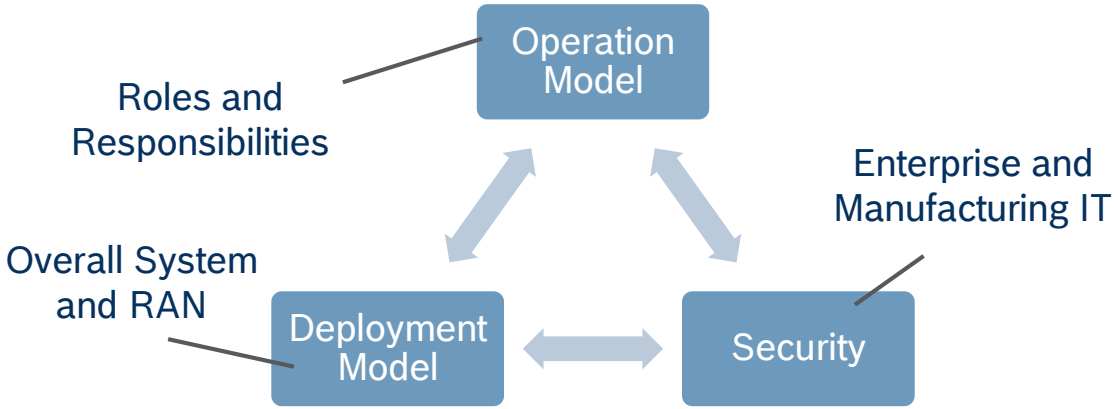
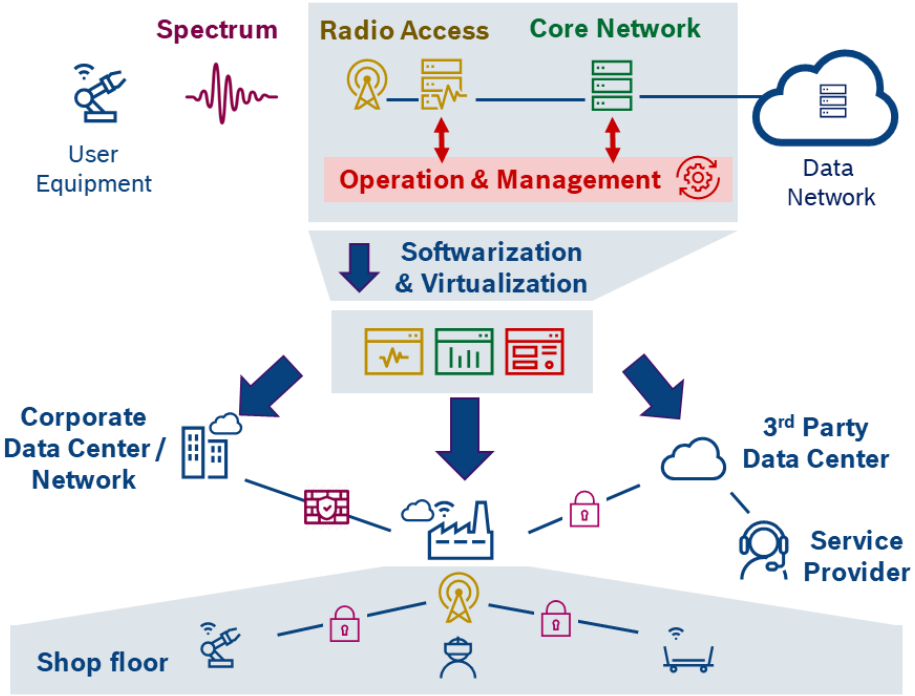
5G Deployment Models



- RAN deployments have different features
- Performance implications on shop floor



There is a Large Variety of Deployment Models – All Having their own Implications!

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Secure Integration | Requirements, Solution Space & Challenges

	Enterprise IT	Manufacturing IT
	▶ Dictated by enterprise-specific regulations, concerns, and many other conditions	▶ Dictated by security principles in the manufacturing domain, e.g. IEC 62443
	▶ Deployment and operation models ▶ 5G- and non-5G-specific security mechanisms	▶ 5G Security Architecture and 5G security features
	▶ Extremely large solution space ▶ Dependence on third parties	▶ Flexible usage of 5G security principles and plant-specific implementation

Secure Integration is Complex and Goes Beyond 5G Security. No Security, no 5G Network!

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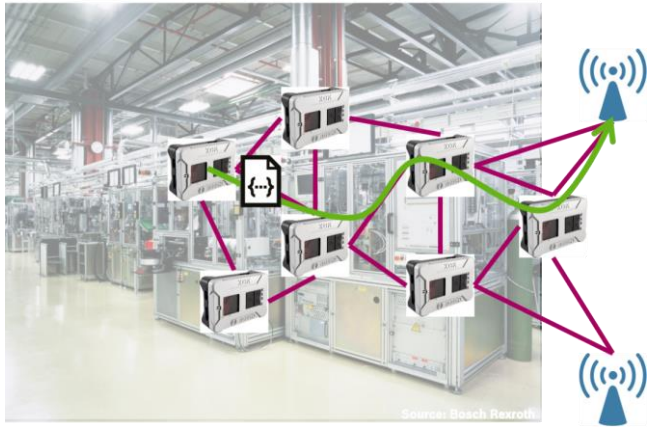
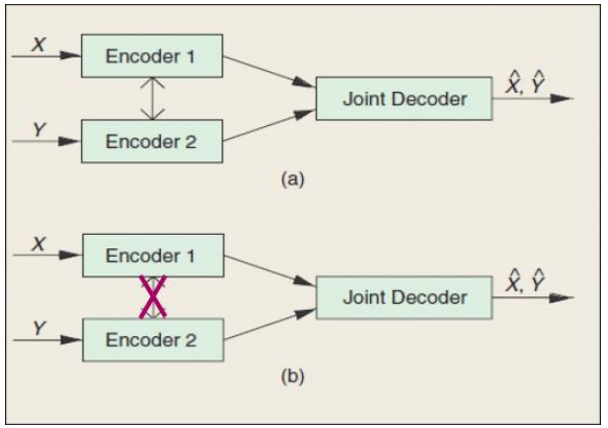
Massive Sensor Networks (1)



- Overall idea: data traffic reduction with low encoding effort at sensor node
- Compressed Sensing: Sample below Nyquist sample rate
  - Several improvements on reconstruction quality; temporal-spatial reconstruction (matrix completion); determining sparse transform; anomaly detection using compressed sensing data
  - Real-world: low-pass signals with known max. frequency
    → MMSE reconstruction performs better; maybe even perform Fourier transform on sensor
- Distributed Source Coding – Low-effort joint data compression among multiple sources/sensor nodes without communication with each other
  → Developed two new *practical* schemes for a large number of sources
  - compressing multi-level or continuous values
  - with an arbitrary split of the transmit data rates between the sources
  - with an easy construction
  - which can adapt to changing degrees of correlation between the sources
  - and is optimal in terms of Information Theory



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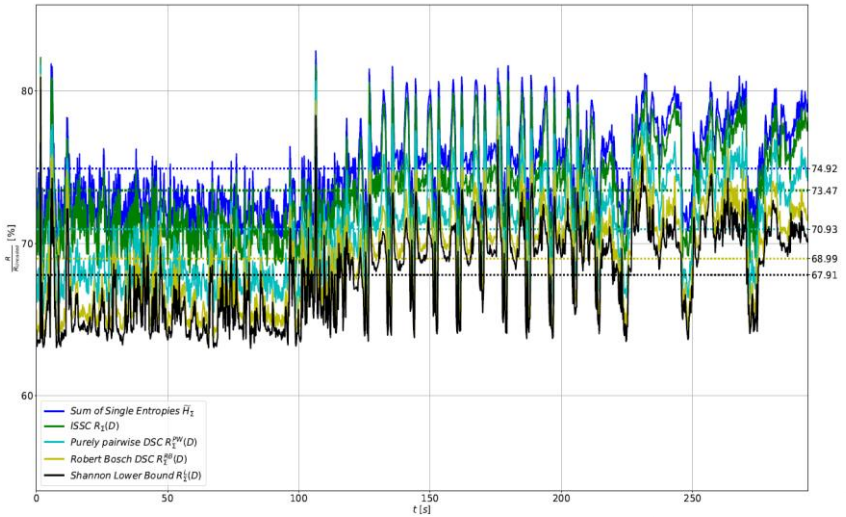
Massive Sensor Networks (2)

- Audio Measurements in Bosch plants Feuerbach + Bamberg) of spatial correlation with 20 microphones on a rack
  - Results: only little spatial correlation (<50%)
    → insignificant compression gain (data reduction by 5%)
  - Use distributed source coding scheme for temporal compression (data reduction by ~30%) with low effort
- Mesh Networks in order to cope with massive number of devices (self-organizing, build small clusters)
  - Bluetooth – bad performance for large sensor networks
  - Wirepas – proprietary with many auto-setup features
  - IEEE 802.15.4e – has good performance, but steep learning
- Network Coding
  - Compared network coding schemes and rateless codes
  - Network coding and rateless paket erasure correction codes are beneficial for firmware updates over the air (FOTA) → Demo



THANK YOU

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