AI for Industrial 5G

– Challenges and Opportunities –

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Why 5G for Industry?

Factory of the Past

Rather static and highly optimized for one particular product

Image: Bosch

Factory of the Future

Highly flexible and support of high degree of customization
→ walls, roof and factory floor as only fixed components
→ ubiquitous wireless connectivity for plug-and-play + mobility

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The Factory of the Future

5G will become the central nervous system of the Factory of the Future

- Edge Computing
- Wireless Connectivity
- Device Positioning
- QoS Differentiation

QoS: Quality of Service
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Value to be Unlocked by 5G in Different Vertical Domains

Source: KPMG, "Unlocking the benefits of 5G for enterprise customers", 2019
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Key Success Factors for 5G in Industry

- Industrial-Grade Performance
- Time-Sensitive Communication
- Costs
- Integrated Positioning
- Private 5G Factory Networks
What is a Private 5G Network?

- 3GPP inside
- A Standard-Compliant 5G Network
- Only for a Restricted Set of Users
- Local Deployment
- Using Managed / Dedicated Spectrum
Why Private 5G Networks?

Security  Performance  Business  Independence  Liability
Why AI?
Why AI for Industrial 5G?

1. Optimize performance to satisfy demanding industrial requirements
2. Simplify & automate planning & operation of private 5G networks
3. Make network data available to applications for joint optimization
4. Provide higher security on different levels

Real-time and offline optimizations possible for all aspects
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How AI may enhance Industrial 5G

Network Planning
- Placement & dimensioning of antennas & nodes

Network Reconfiguration
- In case of changes of the environment and/or applications

Security
- Detect anomalies & jammers and react in a smart way

Network Installation
- Fine-tune initial planning based on few measurements

SON\(^1\) Features
- Self-healing, self-configuration, self-monitoring, etc.

Performance Optimization
- QoS\(^2\) prediction and proactive network mgmt

AI-Enhanced Applications
- Joint optimization of application and 5G network

\(^1\)Self-Organizing Networks \(^2\)Quality-of-Service
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Example 1: QoS Prediction

Controller → Actuators → Process

Closed-Loop Control System

Cyclic traffic + common AGV\(^1\) routes for accurate interference / QoS\(^2\) prediction
Example 2: Potential (Transfer) Learning Opportunities

**Reconfiguration of Production Lines**
- Change of individual modules or part of the structure of the production line
  - Can we leverage existing knowledge?
  - How frequent may these changes occur?

**Transfer of Production Lines**
- Change of building architecture & material, co-located production lines & machinery, regulatory constraints, etc.
- But: Still the same production line + many similarities
  - Can we leverage existing knowledge?
### Opportunities

- **Access to plenty of (high-quality) data**, including relevant context information beyond communication system
- Many **polycyclic and repetitive processes** → “easy” to be learned
- Rather **controlled environments** for optimizing the overall system beyond the communication system
- **Localized problem** → latencies, amount of data, processing power easier to deal with than in public networks
- **Data sovereignty challenge** easier to be addressed as whole system may be under control of factory owner

### Challenges

- Very **complex environments** with challenging propagation conditions, diverse traffic characteristics & requirements and (still) high heterogeneity → but this may eventually also motivate the usage of AI 😊
- **Suitable interfaces** for making connectivity data available to production systems and/or vice versa still widely missing
- **Where to process the data** and who owns and can access the data, esp. if network is not operated by factory owner himself? → data-to-the-Cloud vs. AI-to-the-data (on premise)
- **How much training** is needed? → Training durations > reconfiguration cycles?
- Potential high damage in case of errors → **high confidence levels & traceability** required
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Planned German National Research Project KICK

KICK = Artificial Intelligence for Campus Communication

Major Objectives

(1) AI-supported network management incl. suitable interfaces between production system and network management system
(2) Consideration of short and medium time scales + transfer learning
(3) Development & evaluation of hybrid approaches
(4) Validation and experimental evaluation in real-world factory environment
(5) Identification of standardization gaps

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Key Facts

- Jan 2020 – Dec 2022 (expected)
- Funding body: BMBF
- Total volume: ~9.5 Mio. € (costs)