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ELECTRICAL AND COMPUTER ENGINEERING

Towards a Flexible Architecture for Industrial Networking

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Background: 5Gang project

- BMBF funded R&D project within the call "5G: Industrielles Internet"
- The 5Gang project considers different use cases of future industrial production principles and their requirements on the communication network.
- The project scope does not only cover local production sites but as well the opportunities arising from adding inter-site connections.

- Duration: February 1st, 2017 – January 31st, 2020
- Project Coordinator: Henning Buhr, Ericsson
- Webpage: https://5gangprojekt.com/
- Consortium:

  5Gang is a consortium of eight partners from industry and academia who bring in experience covering technical, business and production process aspects.

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5G in production

- ITU-R addresses three main capabilities to define the requirements for 5G systems [1]:
  1. Enhanced Mobile Broadband (eMBB)

     eMBB will provide up to 20 Gbit of data towards the end-users (100 Mbit/s per user) and 10 Gigabit (50 Mbit/s per user) from the end-users towards the network. User plane latency shall be below 4 ms.
  2. Ultra-reliable and low-latency communications (URLLC)

     Sometimes referred to as critical Machine Type Communication (cMTC), it requires a user plane latency of less than 1 ms.
  3. Massive Machine Type Communications (mMTC)

     mMTC will allow to connect up to 1,000,000 devices per km^2 with the given Quality of Service.

[1] Minimum requirements related to technical performance for IMT 2020 radio interface(s), https://www.itu.int/md/R15-SG05-C-0040/en

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5G in production

- Further advantages of 5G networks (not complete):
  - *Virtualization of network resources:* The same physical network can be used for many use cases. There is no need to set up and maintain different networks. Mobile phones of the factory employees can be connected as well.
  - *Support for mobility:* Moving workpiece carriers can not only be controlled or tracked inside the factory but as well on their way between different production sites.
  - *Long battery life*: It will be possible to connect battery powered devices in an energy efficient manner allowing operating times of 10 years, in extreme cases even 15 years.
  - *Privacy:* It will be possible to install mobile network equipment in a cost-efficient manner inside the factory. This will prevent the risk of production parameters or other data leaving the factory site.
  - *Security:* The usage of SIM cards provides a secure way to manage devices and restrict network access.
  - *Economy of scale:* The big 5G ecosystem will increase the volume of the radio modems leading to cheaper equipment, which will not be possible if every production solution will lead to extra specialized hardware.

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5Gang use-cases and requirements

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Use-Case	Continuous Quality Control/ Tracking of Logistics Chain	Synchronized Mapping / Distributed Indoor SLAM	Distributed Sensing	Pipeline Flow Measurements
Number of logical links	10.000 tracking units per production facility 1.000 Units per truck; 100.000+ trucks	< 100	Number of sensors: 100 (..10.000)	1 – 20 (per cell
Payload length	< 1kBit	Video frames / laser scanner information (++ Mbyte/Packet) Maps (++ kB/Packet)	According to buffer size (< 100ms) 12 Bit * 44 kHz Sampling rate over 100 ms -> 53 kbit per sensor (raw)	< 1 kB
Transmission interval	1 s, possibly event based for standard deviations or release of the station 5 s, possibly event-based	Based on the AGV's speed, < 10 ms	According to buffer size, e.g. 100 ms	1s
Transmission Time	Irrelevant	s. Transmission Interval	Irrelevant	s. Transmission Interval
Update Time		10 ms	Continuous	
Real-time requirement	No	yes	No	yes

mMTC (Continuous Quality Control/ Tracking of Logistics Chain) · eMBB (Synchronized Mapping / Distributed Indoor SLAM) · mMTC (Distributed Sensing) · URLLC (Synchronized Mapping / Distributed Indoor SLAM) · URLLC (Pipeline Flow Measurements)

Four use-case classes:

1. Smart Production
2. Automated Guided Driving
3. Condition Monitoring
4. Infrastructure Retrofit

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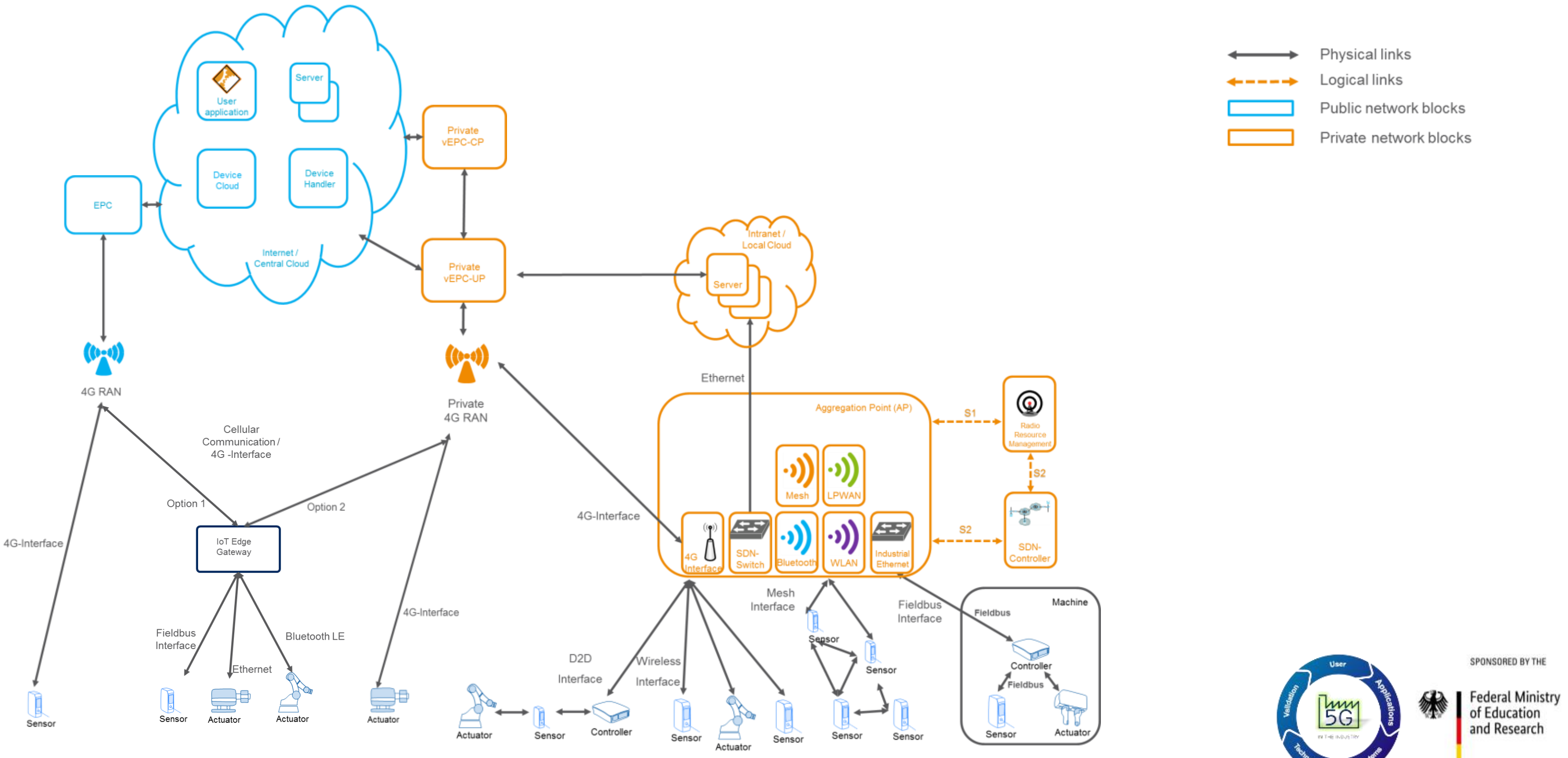
Communication Architecture



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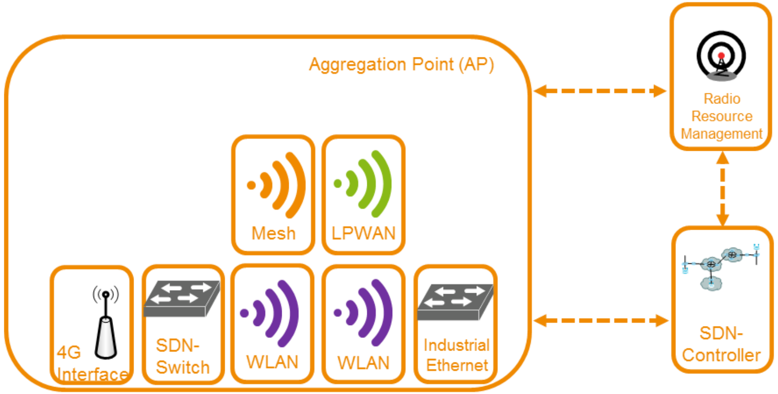
Aggregation Point (AP)



- Is primarily responsible for providing connectivity with large number of sensors, controllers and actuators, all of which could be using different wireless/wired technologies
- Located at the edge of the network
- Comprises of an SDN capable switch (Open vSwitch) to facilitate the traffic management
- Radio Resource Management manages a large number of connected wireless nodes, while implementing self-organization network techniques

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Multipathing

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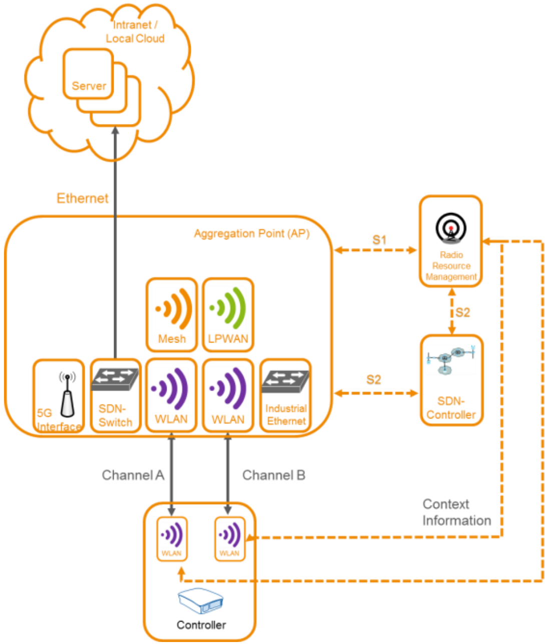

- Hardware: Two Raspberry Pis containing two wifi adapters each
  - Forming two ad-hoc networks with possibly:
    - Two different frequency bands
    - Two different channels
    - Different channel widths
- Software:
  - OVS on both raspberrys
    - Seamless switching of links possible
  - Multipath TCP
    - Enabling redundancy or increased bandwidth
  - Parallel Redundancy Protocol (PRP)
    - Enabling redundancy on layer 2

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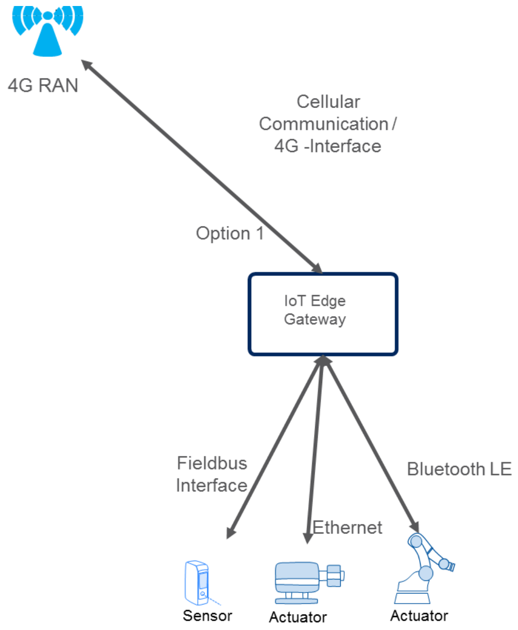
IoT edge-gateway



- Is to be installed on the edge of a network near the data provider
- Collects, edits and reduces the data available
- Numerous inputs available: classic 4-20mA/0-10V connection technology, Bluetooth low energy, Ethernet-based fieldbus (PROFINET, CAN, Modbus, etc.), Ethernet
- Data is transmitted to a central cloud service using RESTful interface

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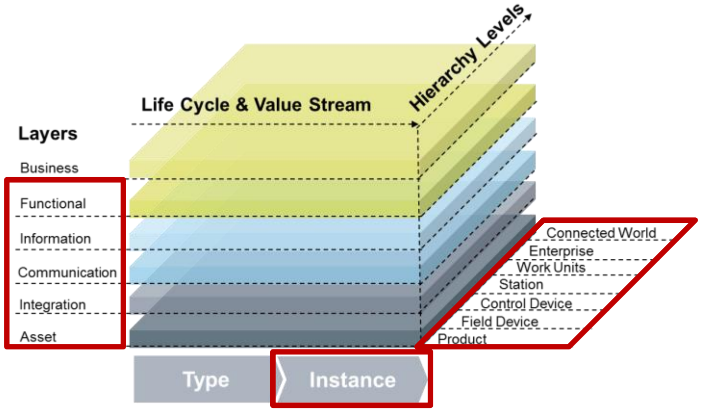
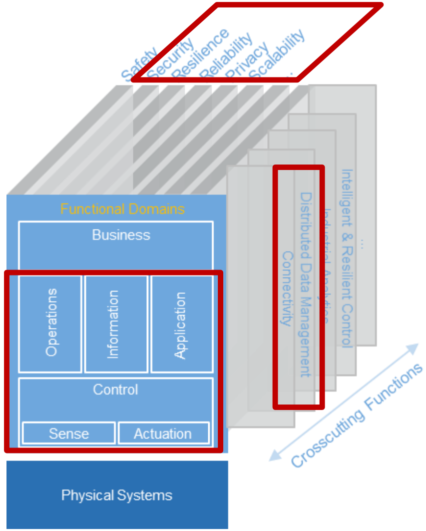
Reference architectures

RAMI 4.0



[2] ADOLPHS, Peter: RAMI 4.0–An architectural model for Industrie 4.0. In: Platform Industrie 4 (2015)

IIRA



[3] LIN, Shi-Wan ; MILLER, B ; DURAND, J ; JOSHI, R ; DIDIER, P ; CHIGANI, A ; TORENBEEK, R ; DUGGAL, D ; MARTIN, R ; BLEAKLEY, G u. a.: Industrial internet reference architecture. In: Industrial Internet Consortium (IIC), Tech. Rep (2015)

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Thank you!
Any Questions?

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