

APPLICATION SCENARIOS FOR 5G IN THE INDUSTRIAL ENVIRONMENT

2. 5G-INDUSTRIE SUMMIT – DR.-ING. DANIEL KNOPP

GÖTTING

The logo for Götting is rendered in a bold, dark blue, sans-serif font. The 'ö' is represented by two teal dots above the 'o'. A teal horizontal line runs across the bottom of the text, ending in a stylized graphic element on the right side that resembles a folded corner or a bracket.

SCENARIO OVERVIEW

- COMPETENCE CENTER



ROBDEKON

- RESEARCH PROJECT



- PRACTICAL IMPLEMENTATION



COMPETENCE CENTER ROBDEKON

- **ROBOTERSYSTEME FÜR DIE DEKONTAMINATION IN MENSCHENFEINDLICHEN UMGEBUNGEN**



- **CONSORTIUM**



- **RESEARCH AND DEVELOPMENT OF NOVEL ROBOTIC SYSTEMS FOR DEKONTAMINATION TASKS**

- **RELEVANT APPLICATION AREAS:**

- Remediation of landfills and contaminated sites
- Dismantling of nuclear facilities
- Decontamination of plant components

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REMEDIATION OF LANDFILLS AND CONTAMINATED SITES

INITIAL SITUATION:

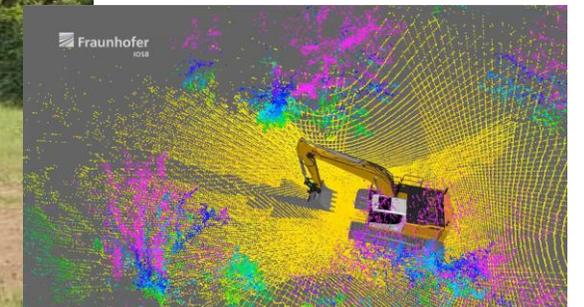
INSUFFICIENTLY DOCUMENTED STORAGE OF VARIOUS CHEMICAL HAZARDOUS MATERIALS (FLAMMABLE, TOXIC, HARMFUL TO THE ENVIRONMENT) IN OLD LANDFILLS AND ILLEGAL DUMPS



Source: ICP mbH

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RESEARCH APPROACH: FULLY AUTOMATED PROCESS



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POTENTIAL OF 5G IN THIS APPLICATION

- IDEA: SHARING OF SENSOR DATA BETWEEN MOBLIE MACHINES
- THIS ALLOWS
 - Advanced obstacle perception
 - Advanced motion planning
 - Advanced action handling
- REQUIREMENTS:
 - High bandwidth for extensive sensor measurement data
 - Low latency for real-time decisions while the machines are moving

DISMANTLING OF NUCLEAR FACILITIES

INITIAL SITUATION:

ENORMOUS MANUAL EFFORT BY HIGHLY QUALIFIED AND TIME LIMITED SPECIALISTS



1 and 2: Manual milling work on radioactive surfaces

3: Filling of contaminated material into barrels

Source: ICP mbH

RESEARCH APPROACH: TELEOPERATION



View forward and backwards:
1280x1024px, 25fps

Fisheye cameras left/right:
1024x1024px, 25fps

Video:
MJPEG-stream, latency < 200ms

Radio:
WLAN 802.11ac
(2,4 GHz + 5 GHz), 50 m range



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POTENTIAL OF 5G IN THIS APPLICATION

- THE CONTROL CYCLE
(VIDEO CAPTURE → OPERATOR COMMAND → VEHICLE REACTION)
IS SHORTENED BY LOWER LATENCIES – THIS ENABLES HIGHER OPERATION SPEEDS
- HIGHER BANDWIDTHS ALLOW BETTER IMAGE QUALITY AND / OR MULTIPLE VEHICLES
IN THE SAME OPERATIONAL ENVIRONMENT
- HIGHER RADIO RANGES ENABLE GREATER DISTANCES TO THE OPERATION SITE –
THAT MEANS MORE SAFETY FOR THE OPERATOR.

RESEARCH PROJECT TACNET 4.0

- OVERALL GOAL: UNIFIED INDUSTRIAL 5G COMMUNICATION SYSTEM THAT INTEGRATES 5G NETWORKS AND INDUSTRIAL COMMUNICATION NETWORKS



- CONSORTIUM:



- SPECIFIC USE CASE:
INTERACTION OF AN AGV WITH A STATIONARY ROBOT IN WHICH THE RADIO SYSTEM TO BE EXAMINED IS PART OF THE CONTROL LOOP

DEMONSTRATOR CONCEPT

- TRANSPORTCONTROL (AGV MANAGEMENT) CYCLICALLY SENDS JOB INFORMATION TO THE AGV AND ROBOT PARTICIPANTS
- THE AGV REPLIES CYCLICALLY WITH ITS CURRENT POSITION VIA LTE
- THE POSITIONS ARE TRANSMITTED FROM THE RADIO NETWORK TO THE HOST COMPUTER
- TRANSPORTCONTROL TRANSFERS THESE POSITIONS TO THE ROBOT
- THE ROBOT USES THIS TO ADAPT THE POSITION OF THE LOAD TO THE MOVEMENT OF THE AGV
- THE LOAD IS TRANSFERRED TO THE MOVING AGV

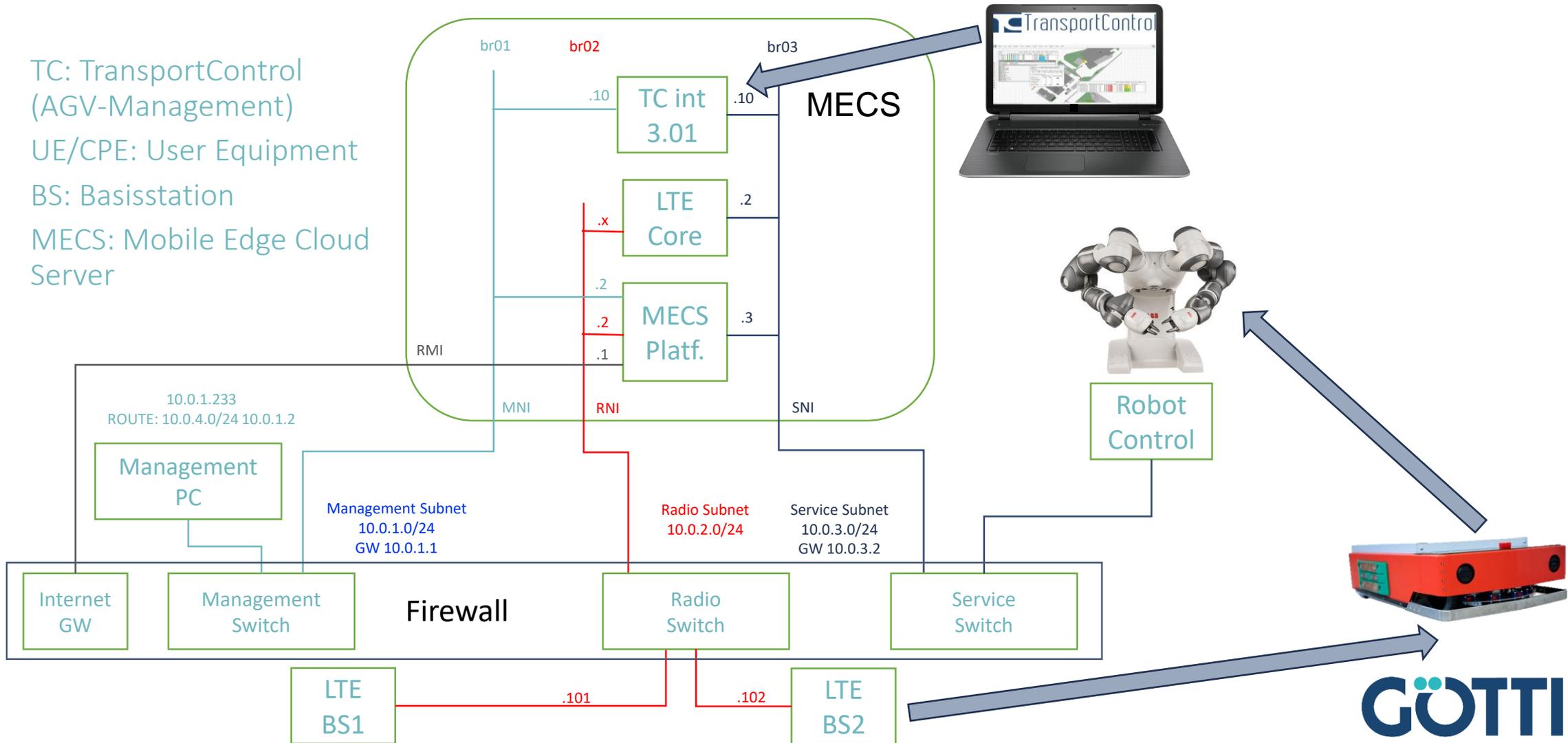


WHAT IS NEW?

- STANDARD RADIO SYSTEMS (WLAN, BLUETOOTH) THAT ARE CURRENTLY USED NOT ONLY IN OFFICE ENVIRONMENTS BUT ALSO IN INDUSTRIAL APPLICATIONS DO NOT ALLOW REAL-TIME-CAPABLE CONTROLS IN WHICH THE RADIO LINK IS PART OF THE CONTROL LOOP.
- THE REASON IS THE UNPREDICTABLE LATENCY DUE TO THE MEDIUM ACCESS PROCEDURE (E.G. LBT) TO THE SHARED RESOURCE RADIO SPECTRUM (SHARED MEDIUM). ISM RADIO FREQUENCIES ARE UNLICENSED AND ARE OPEN TO BE USED WITHIN ITS LIMITATIONS (BANDWIDTH AND TRANSMITTER POWER).
- REPLACEMENT OF WLAN BY A 4G/LTE OR 5G PRIVATE CAMPUS NETWORK WITH OWN PACKET CORE ON A MECS IN A LICENSED SPECTRUM WILL RESULT IN MORE PREDICTABLE BEHAVIOR

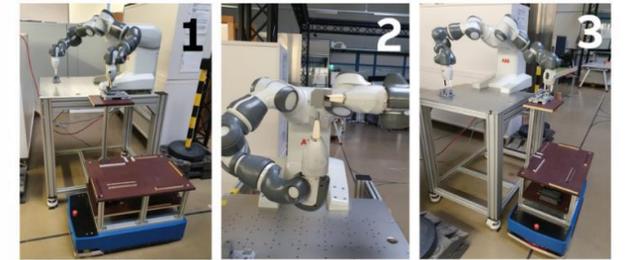
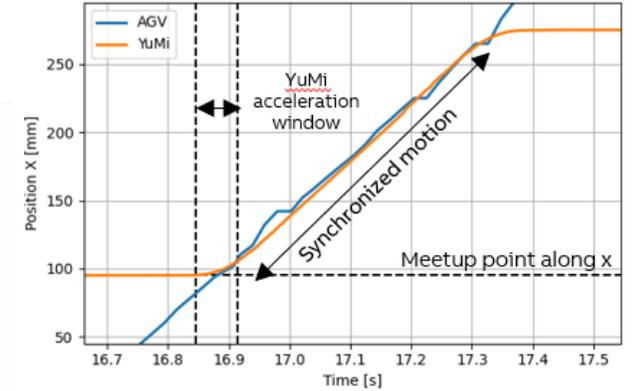
STRUCTURE OF 4G (LTE) PRIVATE CAMPUS NETWORK

TC: TransportControl
(AGV-Management)
UE/CPE: User Equipment
BS: Basisstation
MECS: Mobile Edge Cloud
Server



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DEMONSTRATOR VIDEO



RESULTS OF THE DEMO SCENARIO

IMPORTANT FOR THIS APPLICATION IS ONLY THE LATENCY OF THE UPLINK, BECAUSE

- UPLINK LATENCY DETERMINES THE AGE OF THE MEASURED POSITION
- AGE OF POSITION IS NECESSARY TO LET THE ROBOT CONTROL EXTRAPOLATE THE AGV POSITION
- ROBOT CONTROL ASSUMES CONSTANT E2E-LATENCIES TO FILTER OUT UNWANTED PACKETS

POTENTIAL OF 5G IN THIS APPLICATION

- 5G URLLC WILL LEAD TO SMALLER RTT AND THUS SMALLER LATENCIES AND VARIATIONS → RELIABILITY AND PERFORMANCE OF THE SYSTEM ARE INCREASED



BASF AGV



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BASF-OPERATED PRIVATE LTE CAMPUS NETWORK

REQUIREMENTS BY THE AGV SYSTEM:

- UPLOAD OF 5 VIDEO STREAMS 1080P30 PLUS AUDIO AND STATUS DATA = 15 MBIT/s
- DOWNLOAD OF CONTROL COMMANDS < 500 KBIT/s
- LATENCY < 50 MS – MONITORED BY GPS TIME STAMP COMPARISON
- COMPLETE RADIO COVERAGE OF BASF, LUDWIGSHAFEN, = 10 KM²



Source: BASF SE

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CONCLUSION

- NEW APPLICATION SCENARIOS FOR MOBILE ROBOTS USING WLAN AND LTE ARE DEMONSTRATED BY GÖTTING KG
- IN EVERY SCENARIO, RANGE, BANDWIDTH AND LATENCY TURN OUT TO BE KEY PARAMETERS FOR SUCCESS
- 5G IS PROMISSING SIGNIFICANT IMPROVEMENTS FOR EACH OF THESE PARAMETERS
- THEREFORE, THE AVAILABILITY OF 5G IN THE INDUSTRY AND A WIDESPREAD ROLL-OUT OF THE APPLICATION SCENARIOS SHOWN ARE DIRECTLY RELATED