Clear5G

Communication for the Factories of the Future

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Project Vision:

“to provide technical solutions that enable future 5G networks to act as dependable communications backbone for the Factories of the Future”

Project Brief

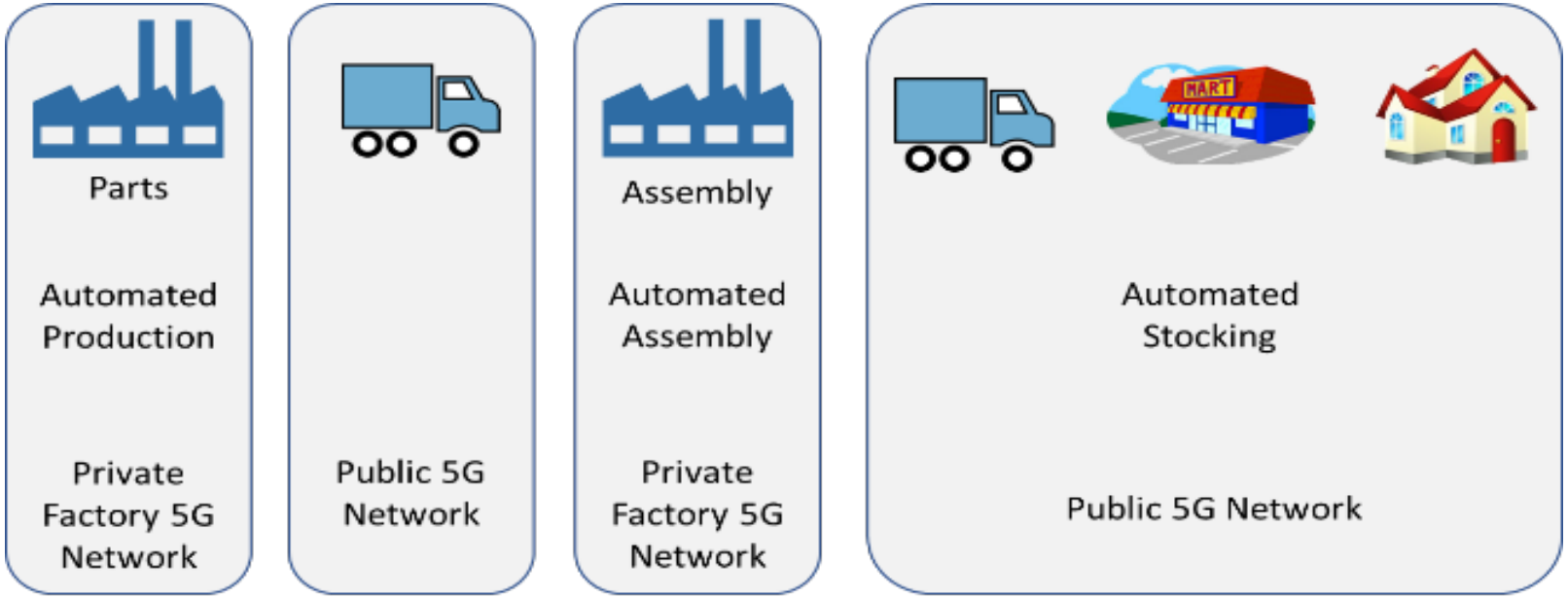
- **Clear5G-C**onverged wire**le**ss **a**ccess for **r**eliable **5G** MTC for factories of the future (FoF)

- Horizon2020 EU-TW collaboration
- Sept. 2017 – Feb. 2020
- Focus on 5G radio network for FoF (PHY, MAC, NET)
- Coordinator: University of Surrey
- Coordinator TW: Institute for Information Industry
- Technical Manager: TNO

- Objectives: to design, develop, validate, and demonstrate an integrated convergent wireless network for Machine Type and Mission Critical Communication (MTC/MCC) services for Factories of the Future (FoF)

Clear5G network view

- While parts of the underlying communications infrastructure will be **public** networks, within factories there will be **private** (physically or virtually) factory wide 5G networks tailored to the particular needs of the individual site
- **Continuous monitoring** while products or parts are within the logistics section of the production chain
- **Spectrum** regulation and management plays a significant role



Challenges and Clear5G KPI's

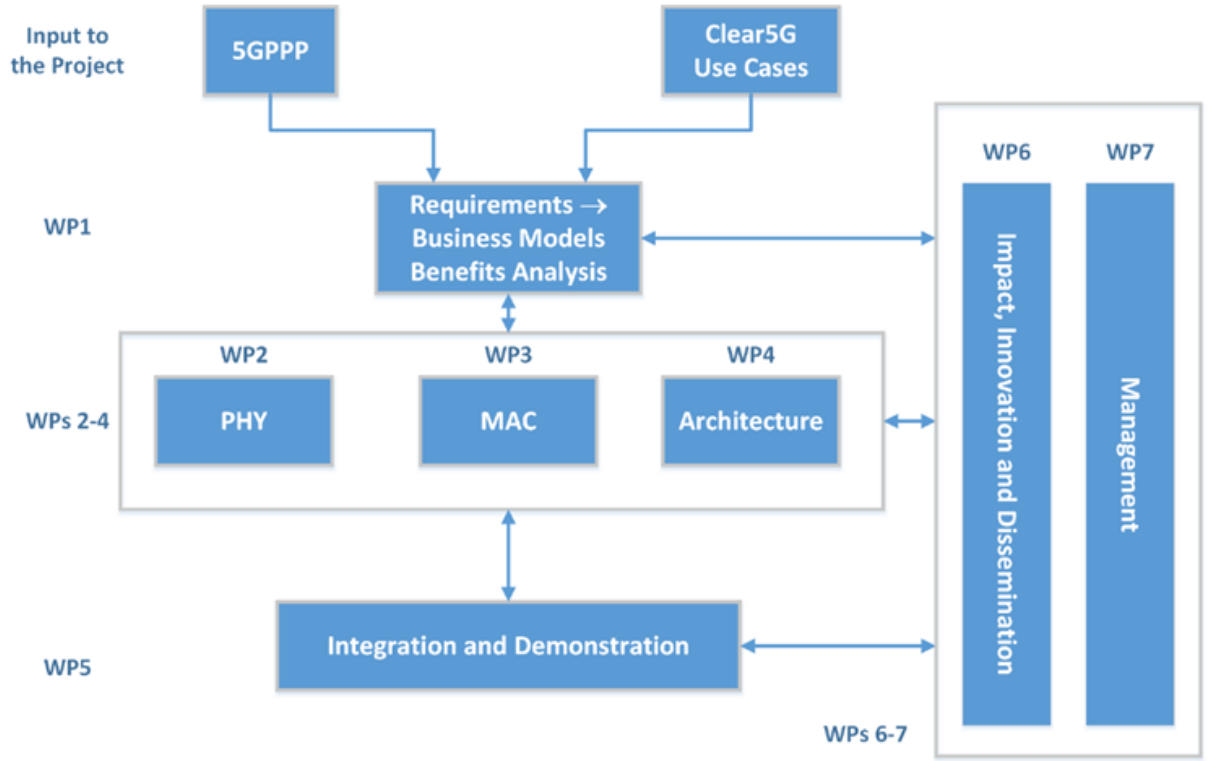
Clear 5G KPI	Targeted value
Latency (end-to-end)	Down to 1 ms
Reliability	Up to 99.999%
Connection density	Up to 100 nodes per 1 m3
Security	PHY framework
Heterogeneity (convergent air interfaces)	Coexistence of various radio interfaces, and various FoF use cases
Energy efficiency (Device battery life)	>15 year battery life

The Industrial environment is challenging for wireless connectivity, e.g. both large- and small-scale fading (predictable?)

- Massive connectivity
- Coverage, reliability and latency
- Heterogeneity (private and public network, different radio technologies)

How are we getting there?
The technology components

- PHY (WP2)
  - Adaptive frame structure
  - New waveform
  - Non-coherent modulation
  - NOMA
  - Physical-layer security
- MAC (WP3)
  - Random access enhancement
  - (Adaptive) Contention-based or –free MAC
  - Joint PHY and MAY optimization
  - Heterogeneous Radio Access
- Networking (WP4)
  - RAN architecture
  - RAN Slicing
  - Multiple connectivity, (UE) relaying
  - Public and private network integration



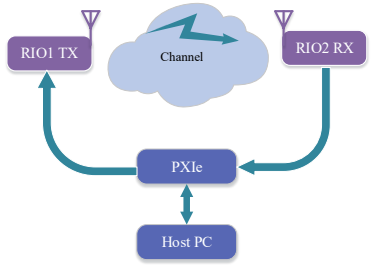
Example: Hardware prototyping of sparse code multiple access (SCMA) for massive connectivity in FoF

SCMA: A code-domain NOMA which can support massive connectivity by efficiently exploiting the sparsity of codebook using message passing algorithm.

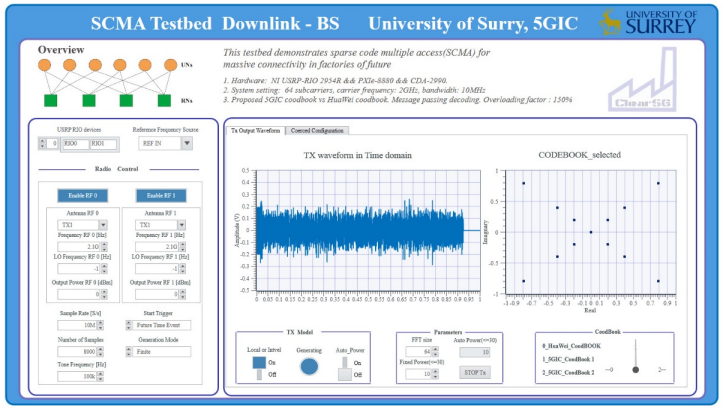
Objective: To implement and demonstrate SCMA system over USRP testbeds.

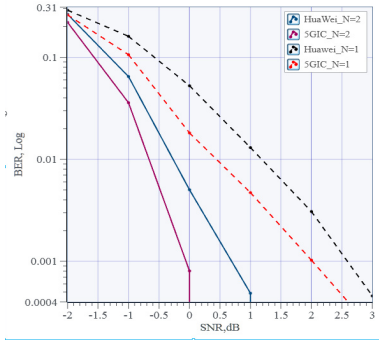
Testbed hardware & software

- One NI-PXIe
- Two USRP RIO-2943R
- One CDA-2900 (10 MHz frequency clock)
- LabVIEW Communication System Design



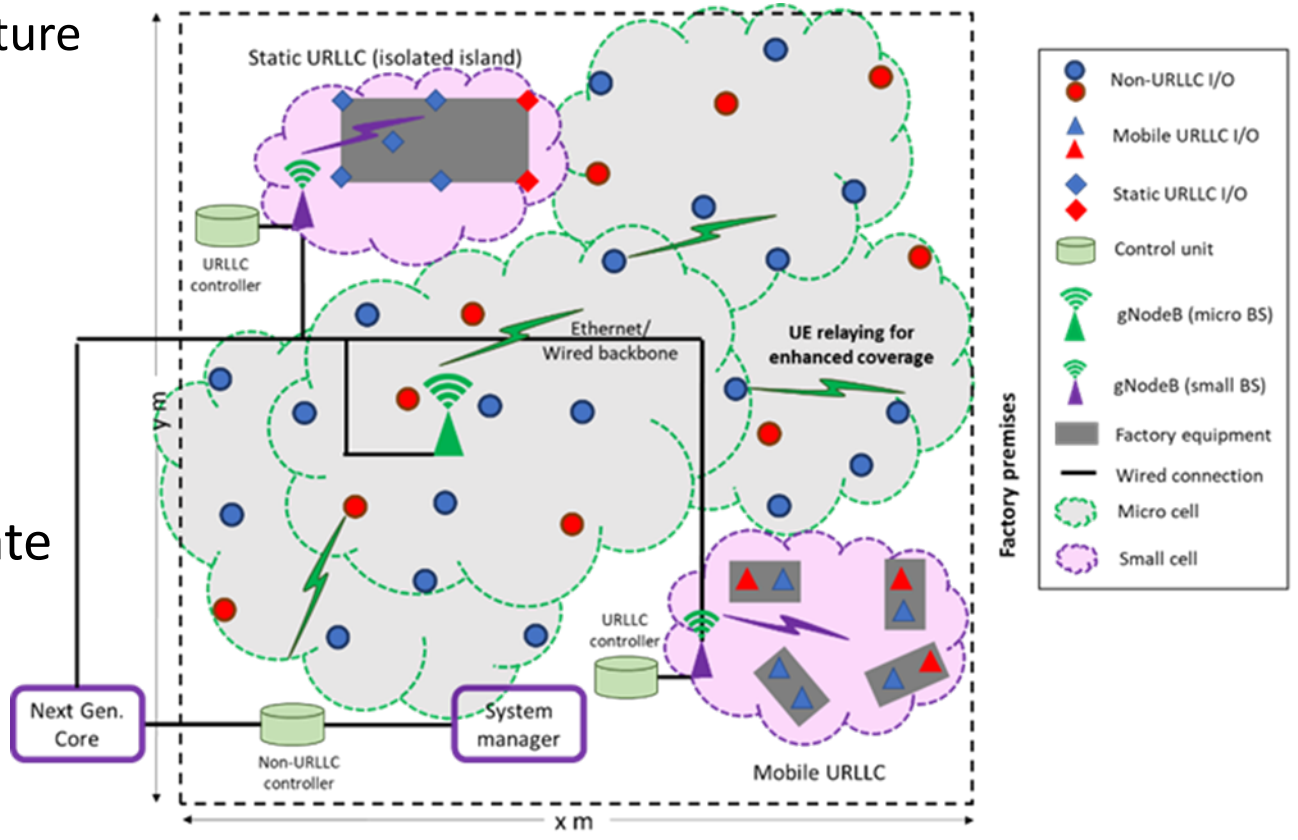
System parameters	Values
Center frequency	2 GHz
Bandwidth	10MHz
FFT length	64
CP length	8
# of RB per frame	200
# of samples per frame	12000





Example: Network slicing in a factory network

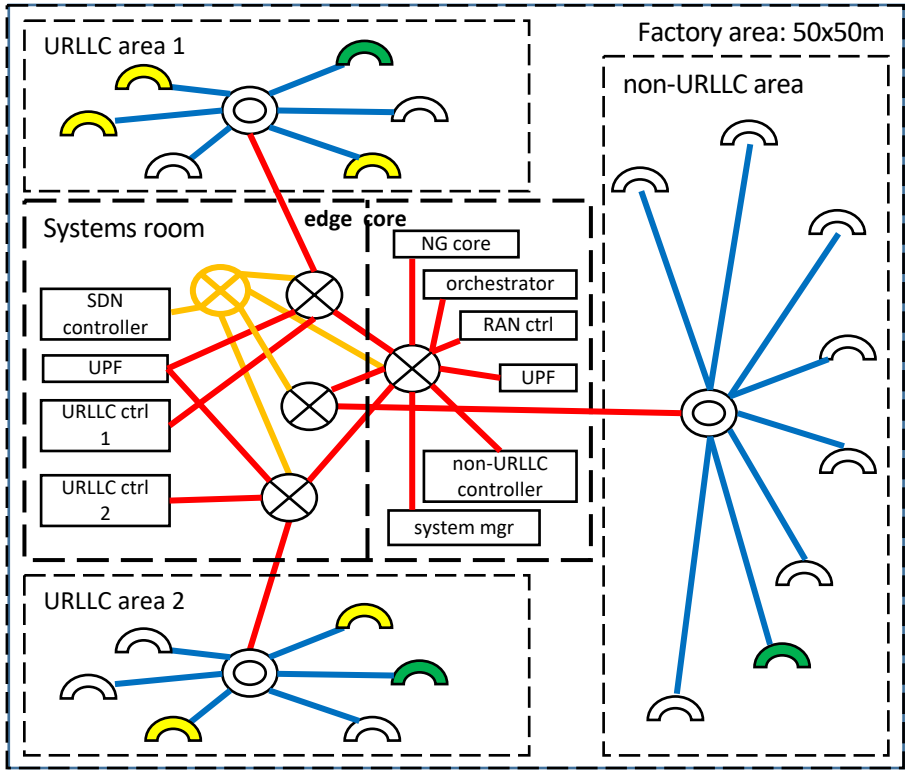
- Slicing enables operators to support different network instances on the same infrastructure
- FoF as one of the slices, or
- Different FoF use cases (e.g. URLLC, non-URLLC) may be served by different slices
  - URLLC: local controller
  - Non-URLLC: controller in the cloud
- FoF slices may be provided by a public network operator, or a physically private network.



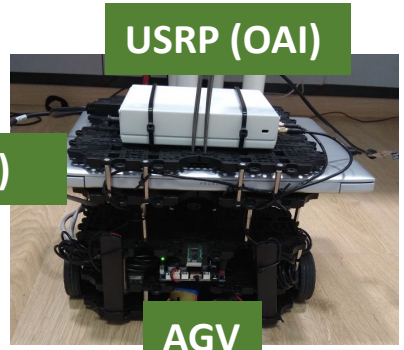
… leading to Traffic Abstraction and Analytics

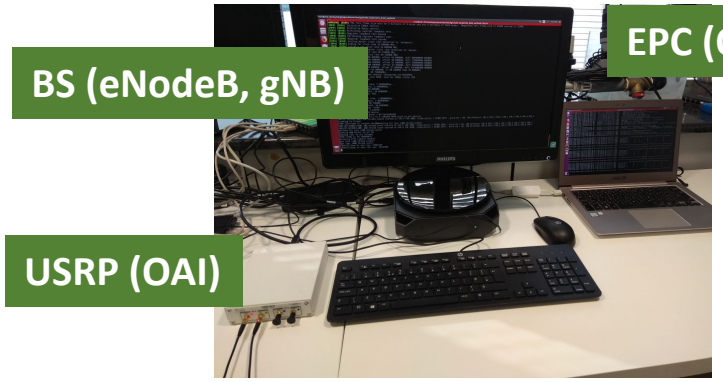
Showcase managing wired FoF network wrt specific requirements and analysing traffic statistics gathered from the network
Steps to follow:

- ✓ Define multiple traffic classes in wired network
- ✓ Create and install a set of wired paths for each traffic-class – road network
- ✓ Mix traffic classes so as to achieve a fair distribution between different traffic classes
- ✓ Collect traffic statistics and analyse them



Example: Closed-loop control of industrial AGV with UE relaying support



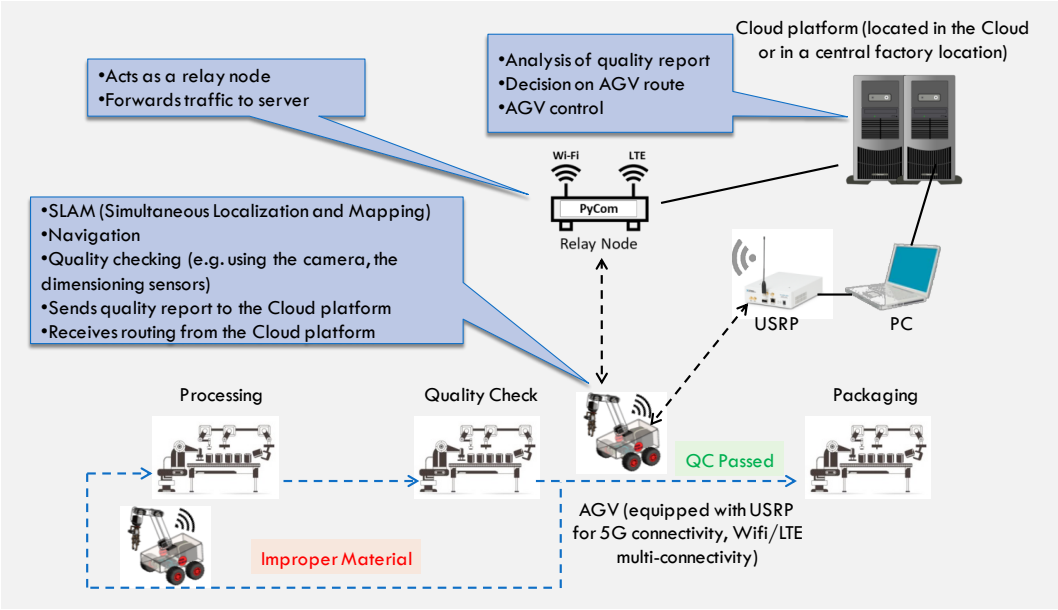


Objectives

- Demonstrates that 5G technologies can fulfil the strict requirements of a close-loop controlled Automated Guided Vehicle (AGV) moving in a factory.
- Support low latency exchange of data in monitoring and analysis services such that the AGV can be remotely guided based on product quality results.
- Showcases UE relaying in a factory environment as a mean to improve reliability.
- If the default communication link of the AGV is unavailable, the AGV will use nearby UE(s) as relay node(s) in order to reach the destination node.

Technical Benefits

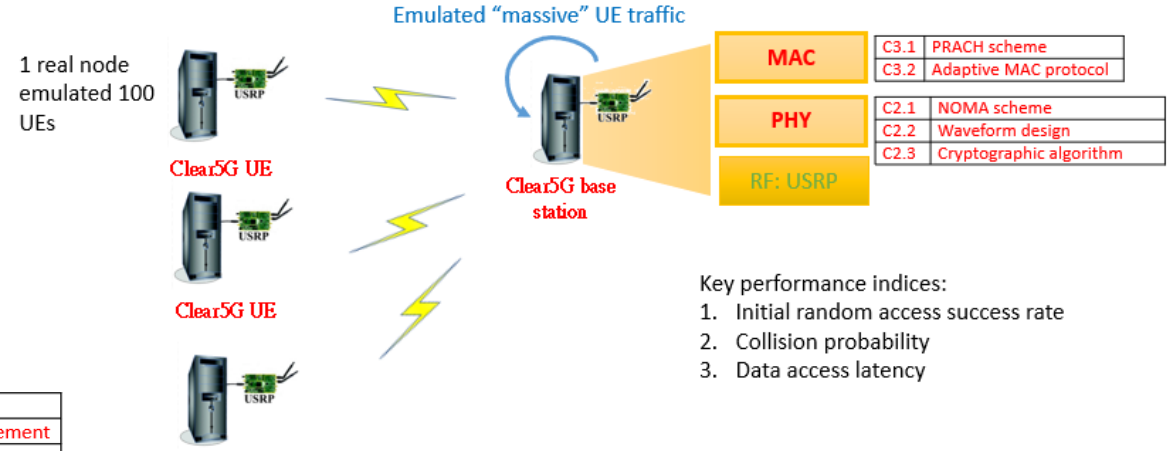
- Low latency exchange of data between the industrial devices (e.g. AGV, factory server)
- Improvement in reliability by using multiple connectivity options
- Improvement in radio coverage by using UE relaying
- Improve the level of industrial automation



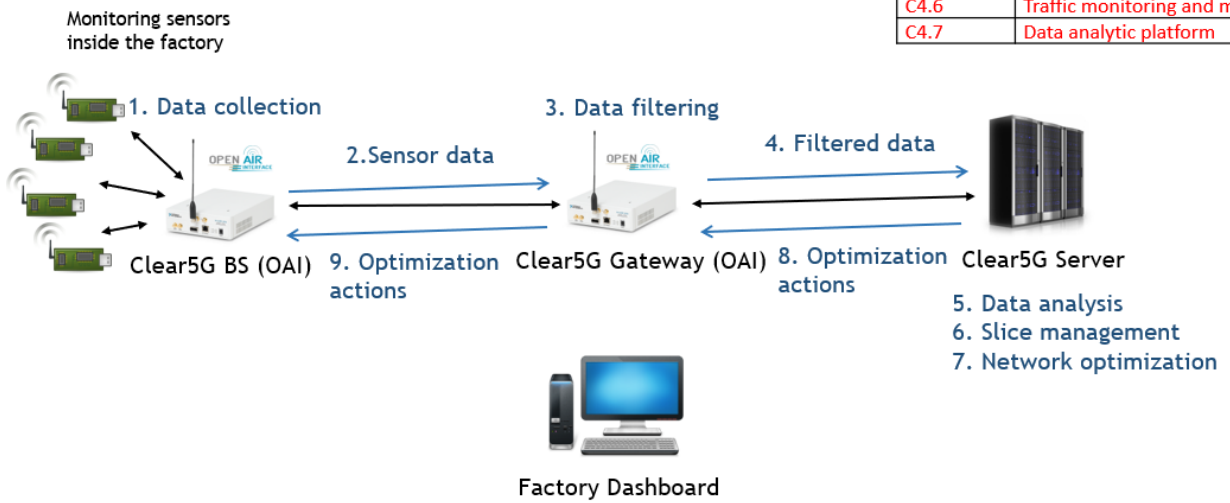
For more details, visit the Clear5G booth in the exhibition area!

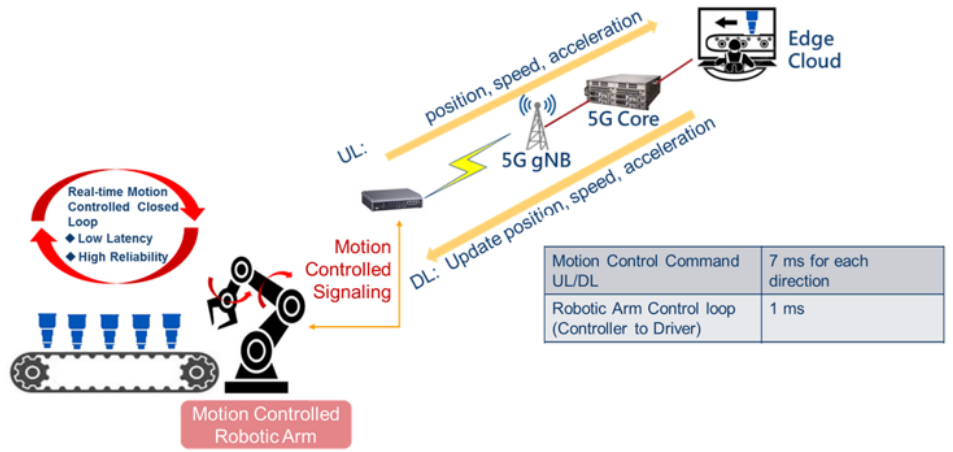
Beyond simulations: the trial scenarios

- Massive sensor data collection in FoF
- Monitoring & Closed Loop Control in FoF
- Seamless Interoperability and Mobility (private FoF and public networks)

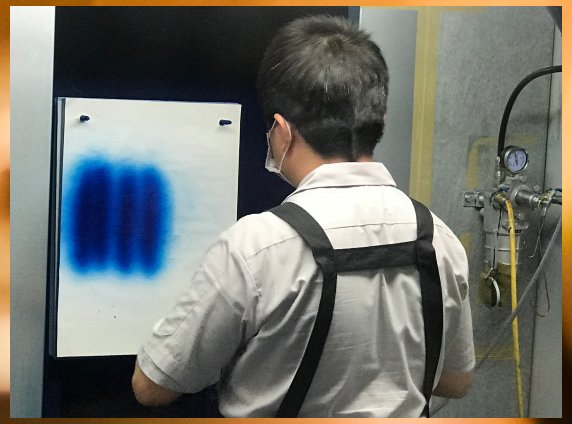


C4.1	Network slicing
C4.6	Traffic monitoring and management
C4.7	Data analytic platform





Putting the Clear5G solutions on the factory floor



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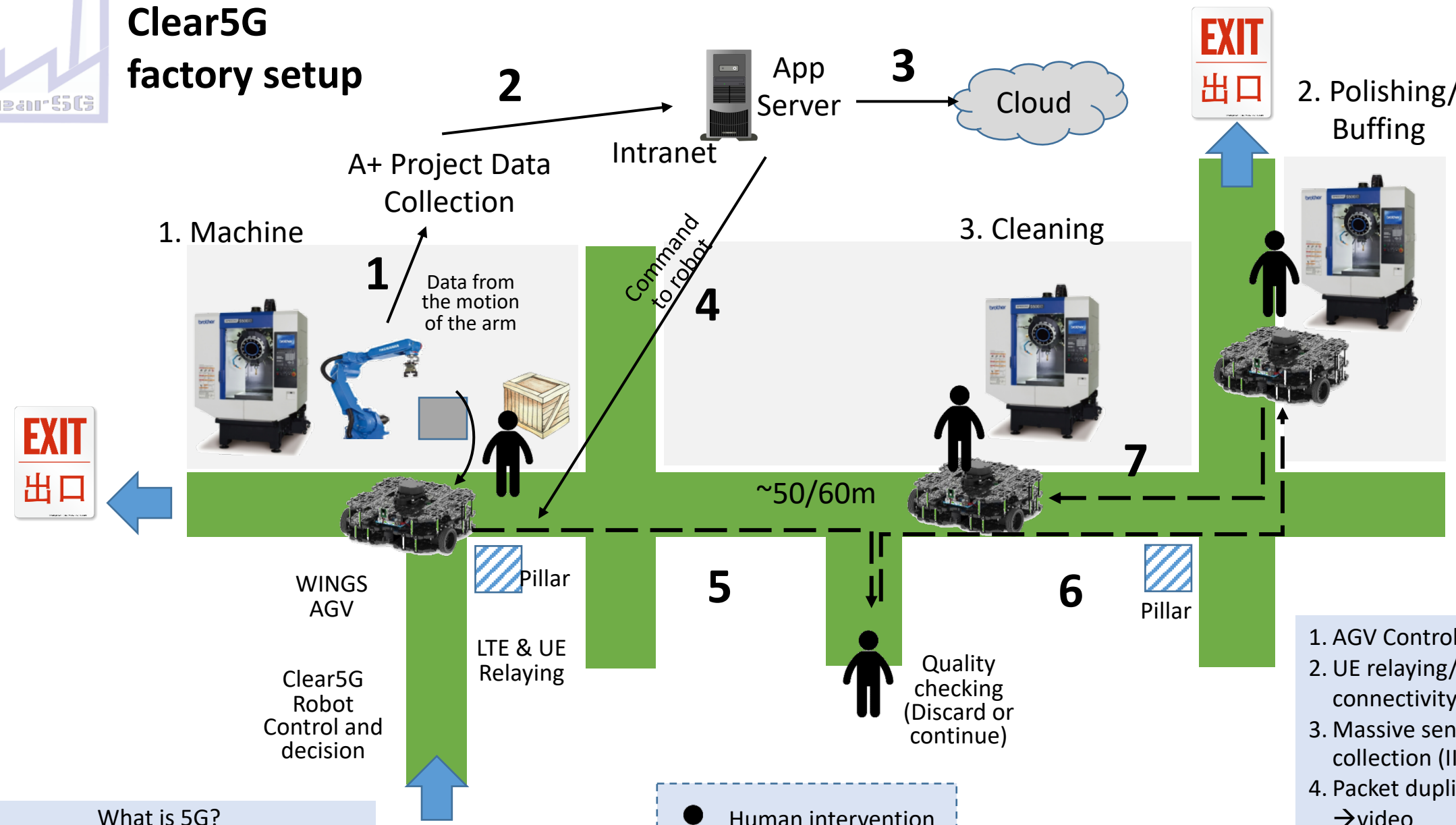
Clear5G factory setup



What is 5G?

- UE Relaying and RAT Selection
- Communications with AGV (~40ms)
- Slicing

Human intervention (e.g. loading/ unloading from AGV)

1. AGV Control (WINGS) ok
2. UE relaying/multi-connectivity (TNO) ok
3. Massive sensor data collection (III) ok (A+)
4. Packet duplication (UNIS) →video
5. LORA/LPWA (CEA) ok
6. Slicing (ARG/TT) ok

More info: http://www.clear5g.eu or follow Clear5G on twitter. @Clear5G

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Visit the Clear5G booth in the exhibition area!