Fivecomm

5G-enabled AGVs for NPN Production Lines in Manufacturing

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EUCNC 2021
Workshop on 5G Private Networks

EUCNC 2021 June 8-11
European Conference on Networks and Communications | Porto, Portugal

5G INDUCE

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 101016941

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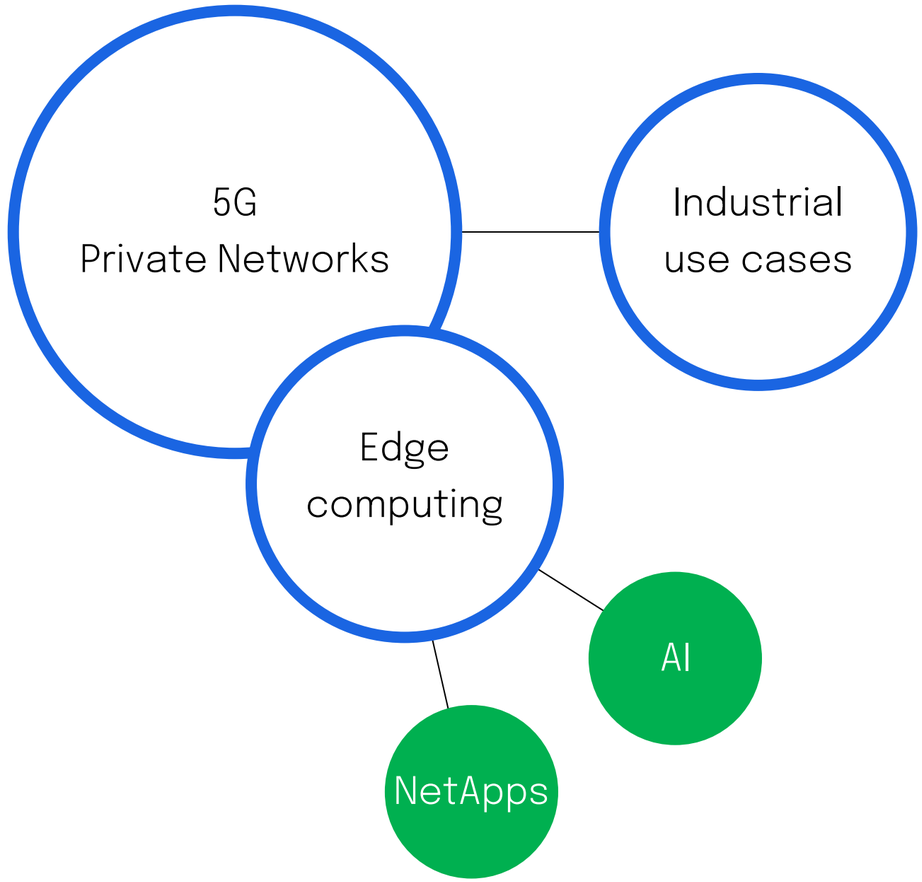
1. Introduction

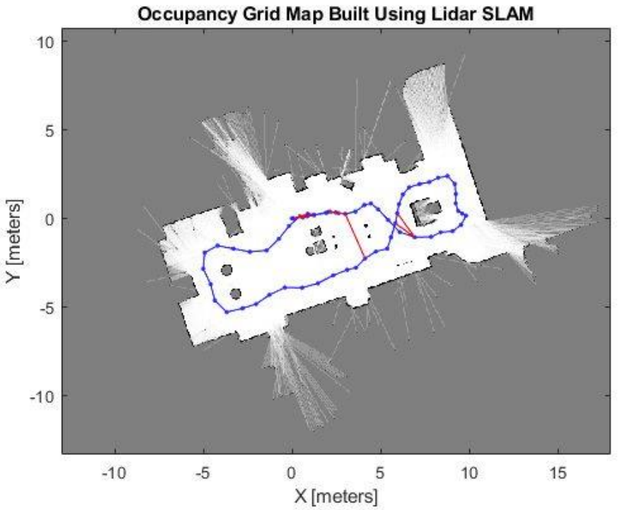
- Nowadays, industrial communications are mostly based on wired industrial Local Area Networks (LAN), a configuration that is inflexible and complex.
- In our vision, components on the industry floor such as controllers or automated guided vehicles (AGVs) will be wirelessly connected.

- From the current alternatives, 5G Private Networks come as a unique enabler to meet the strict networking requirements set in the Industry 4.0.
  - ✓ It offers ultra-reliable and low-latency connectivity, as well as ultra-high bandwidth.
- Edge computing is key to ensure this low-latency close to the user.
  - ✓ Smooth and costless porting of network application (NetApps).
  - ✓ Artificial Intelligence at the edge is also key.



1. Introduction

- AGVs are portable robots, usually used in industrial environments and applications, that transport heavy materials in a large industrial building or its surroundings.
- AGVs can be controlled remotely.
- They can be autonomous either using lines/wires on the floor or by using vision cameras, lasers, or navigation algorithms such as SLAM (*Visual Simultaneous Localization And Mapping*).
- Some examples of SLAM algorithms:
  - Visual SLAM uses images acquired from cameras and other image sensors.
  - LiDAR SLAM uses a laser/distance sensor that provides more precision.



Reference: MathWorks, "What Is SLAM? 3 things you need to know".

- Some examples of AGVs:

indoor

outdoor

Reference: https://www.astimobilerobotics.com/

2. The 5G-INDUCE Project

- 5G-INDUCE: enabling open and cooperative 5G network platforms for the showcasing and evaluation of advanced network applications (NetApps) in the Industry 4.0.
- **Goal**:

> *To provide realistic experimentation facilities for the seamless deployment of network functions, forming the building blocks of industrial NetApps*

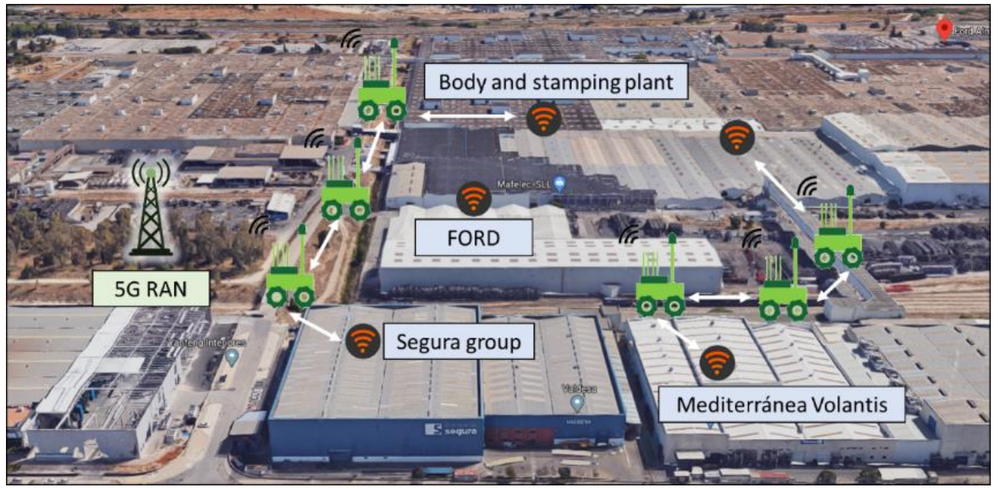
- Development of a 5G platform for the verification of NetApps targeting the broader emerging Industry 4.0 sector.
- The project will perform a wide set of advanced 5G trials of various scales over a set of Industry 4.0 sector use cases.
- 3 factories of the future:

Ford	**Heavy manufacturing and AGV control**	**Spain** ⇦
Whirlpool	Electronics and devices supply chain	Italy
PPC	Power production and distribution	Greece

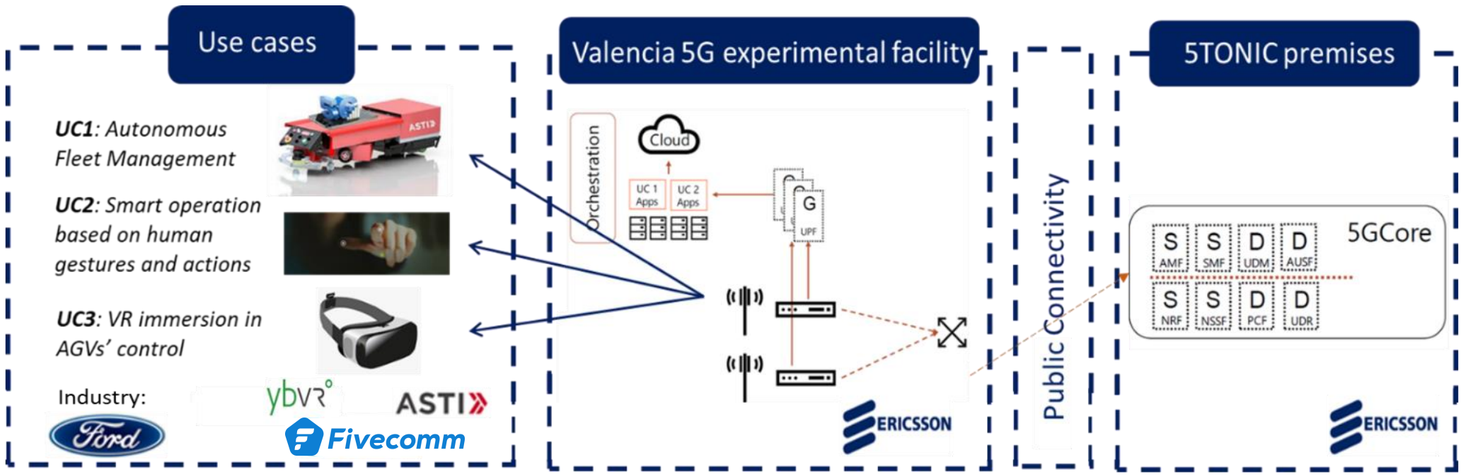
3. Experimentation facility

- We actively participate in *Valencia 5G experimental facility.*
  - ✓ Built on top of the 5TONIC co-creation laboratory.

- It will use an end-to-end 5G network that allows to experiment under technical conditions.
- Network deployment:
  - ✓ 5G Core from 5TONIC, located in Madrid.
  - ✓ The rest of the network will be placed in the facility itself, located in Ford premises.

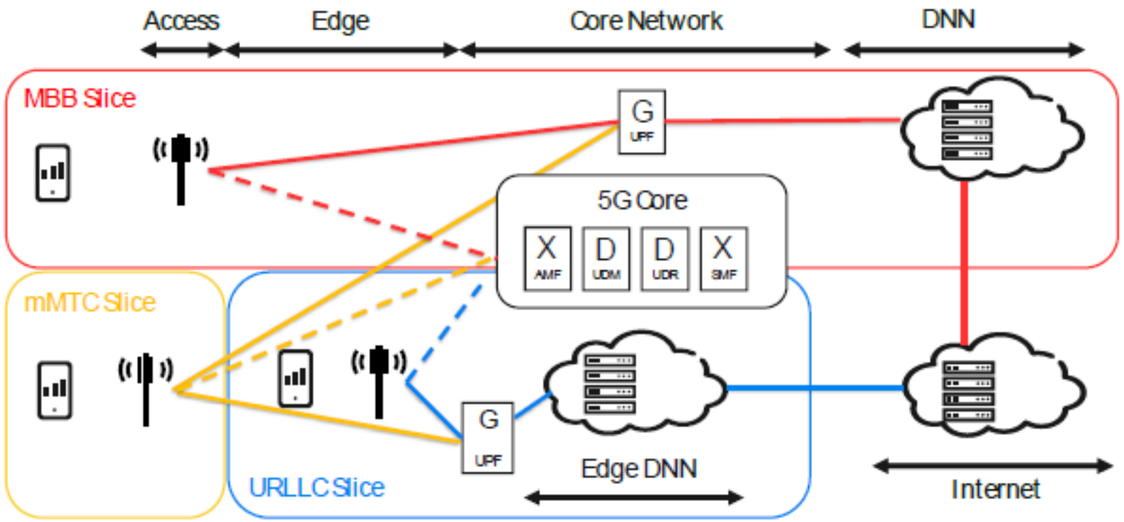


- ***Industry***
- ***Edge computing***
- ***Critical applications***

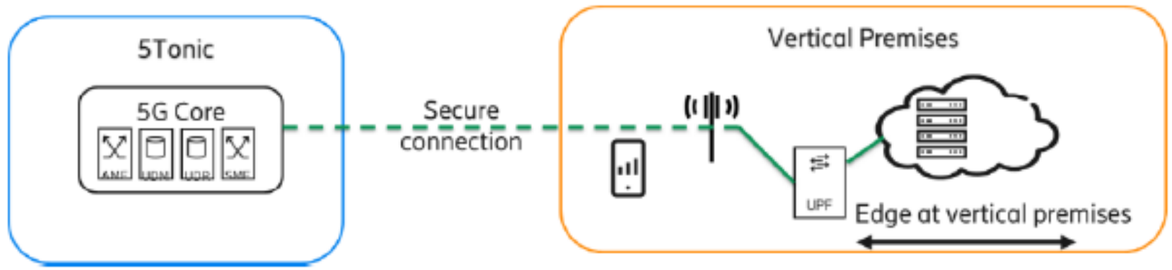


3. Experimentation facility

- The facility will be supported by Ericsson as main owner of the infrastructure.
  - + 3 high-tech SMEs specialized in the use cases: ASTI, Fivecomm and Yerba Buena VR.
- Additionally, the facility will count on Intel, UPV and Gestoos as close collaborators.
- 5TONIC provides a portable 5G network that can be used for demonstrating use cases in the vertical premises or in a specific event, in this case at Ford premises.



5G network of the 5TONIC co-creation laboratory



Remote coverage using portable network of 5TONIC

3. 5G Modem

The 5TONIC infrastructure will also use a 5G modem to connect the AGVs.

Powerful, versatile and miniaturized device designed to bring all the advantages of 5G to the industry.

Simplified its electronics to make the most of the 5G modules in the market, while minimizing the power consumption and its cost.

Main features:

5G native

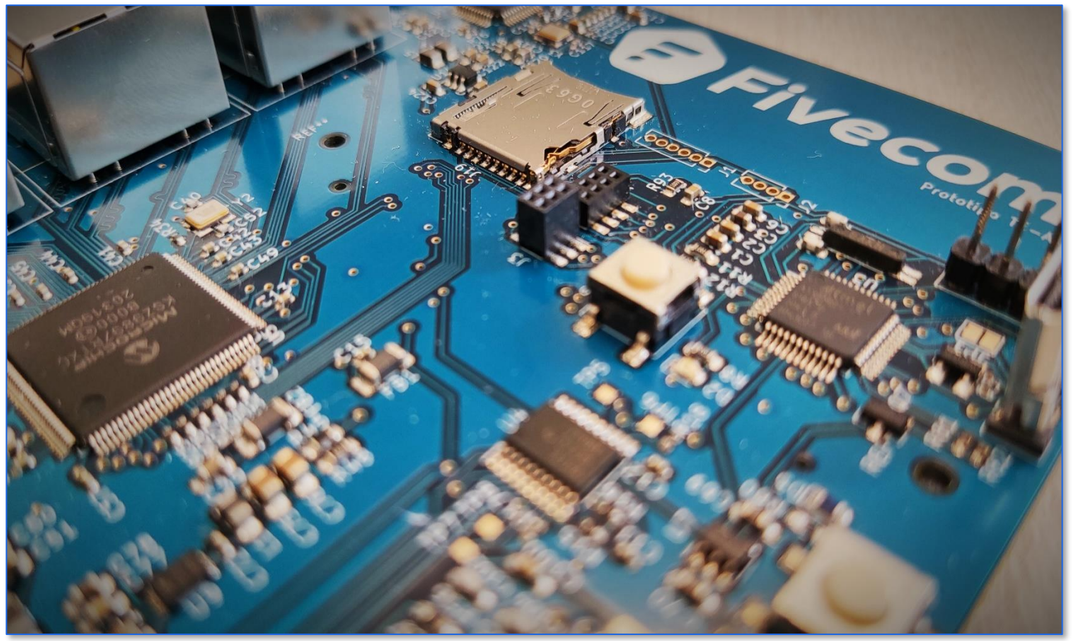
Both 5G Non-Standalone (NSA) and 5G Standalone (SA) modes are supported, in addition to 4G and 3G.

Easy deployment

Step 1: Connect to the digital connectors.
Step 2: Fix 5G device to the infrastructure.
Step 3: Press the 'ON' button.

Customizable

Different IP protection degrees are available. Up to 4 antennas to provide the best experience.



Fivecomm 5G Modem

3. Use cases
Autonomous fleet management

- Rationale: AGVs at Ford premises only perform for some indoor functions, guided through lines. Specific needs though have been identified for connectivity and modernization of the AGVs fleet.
- Objective: To manage a small fleet of AGVs with simultaneous localization and mapping (SLAM) navigation (outdoors/indoors) through 5G and edge computing capabilities.
- Scenarios:
  1. **Outdoor** transport between different outdoor Ford warehouses
  2. **Indoor** transport within a Ford plant.

- Capabilities: Ability to control AGVs movements, automate transport plants, apply safety features.
- Requirements:
  - ✓ E2E latency < 0.5 ms
  - ✓ Minimized interruption time during outdoor to indoor handovers.
- Leader: ASTI

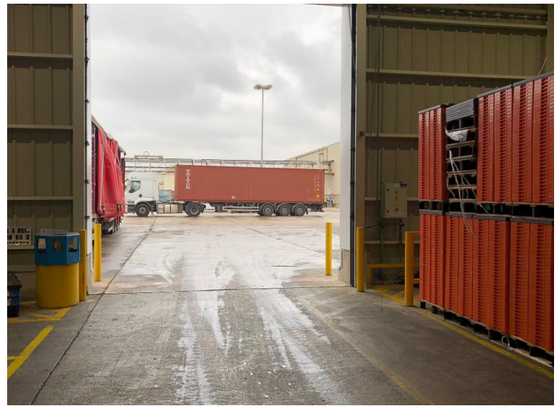
Outdoor/indoor path in Ford premises

3. Use cases
Autonomous fleet management

- The use case will demonstrate an indoor and outdoor coordination of AGVs for intelligent transport in manufacturing premises.

Source: Ford






Indoor

Change of AGV

Outdoor

Change of AGV

Source: ASTI

3. Use cases
Human gesture recognition

- Rationale: Through human gestures (hands or body), the operator will be able to give orders to the AGV in the field, thanks to the edge computing capabilities and 2 NetApps implemented for gesture recognition and AGV control.
- Objective: To control industrial operations of AGVs through human gesticulations without using any type of special equipment.
- Scenarios:
    1. **Outdoor** transport between different outdoor Ford warehouses
    2. **Indoor** transport within a Ford plant.
- Capabilities: Ability to guide industrial AGVs by human gestures and voice, permitting easy, touch-free interaction with robots.
- Requirements:
    - ✓ End-to-end latency 100 ms
    - ✓ 5G latency < 10 ms
    - ✓ Edge computing
- Leader: Fivecomm

Gesture Recognition

Gesture recognition using advanced AI algorithms with the aim to avoid special equipment, extra time and cost equipment.

Source: Gestoos

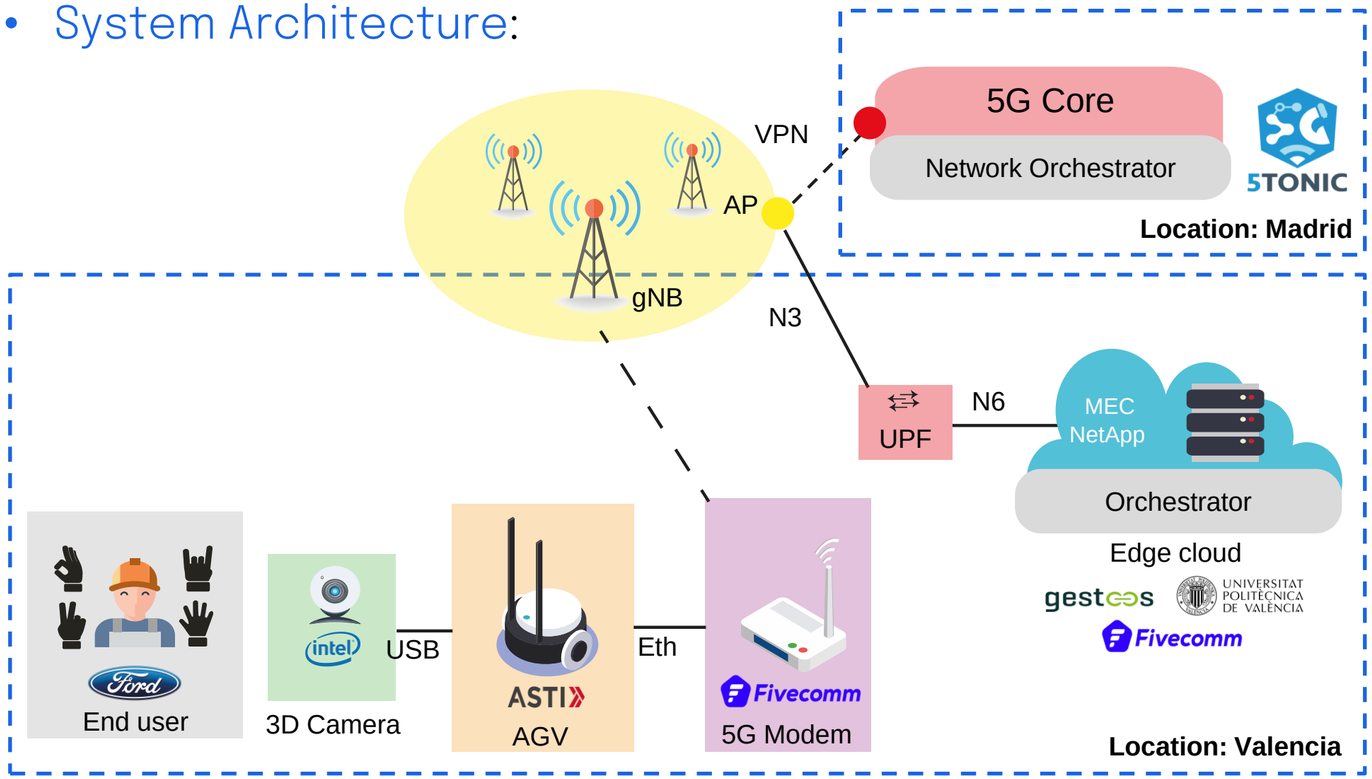
AGV Control

AGV control to do industrial operations in order to optimizing some of the processes of the logistics distribution chain.

Source: ASTI

3. Use cases
Human gesture recognition

- System Architecture:



Description:

1. The AGV, located in the ExFa of Ford, receives the RGB/depth and gesture info from the 3D camera.
2. The 5G modem, connected to ASTI's AGV will send the video/depth info to the 5G network.
3. The NetApp will get the video and gesture information, process the order and send it back to the AGV.
4. The AGV will move, stop or change its direction depending on the worker's order.

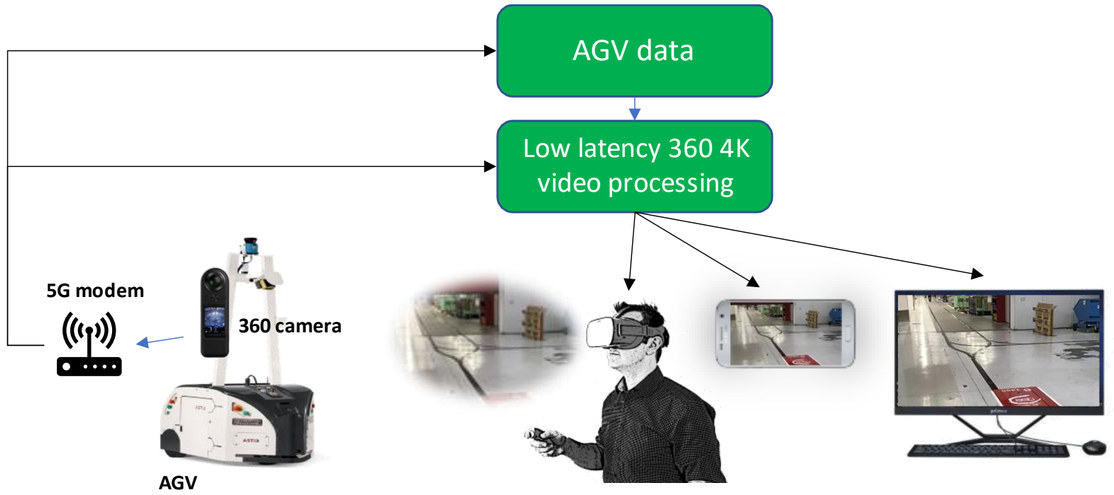
- Some available gestures:

Source: Gestoos

Hand poses | Actions | Body poses

3. Use cases
VR immersion and AGV control

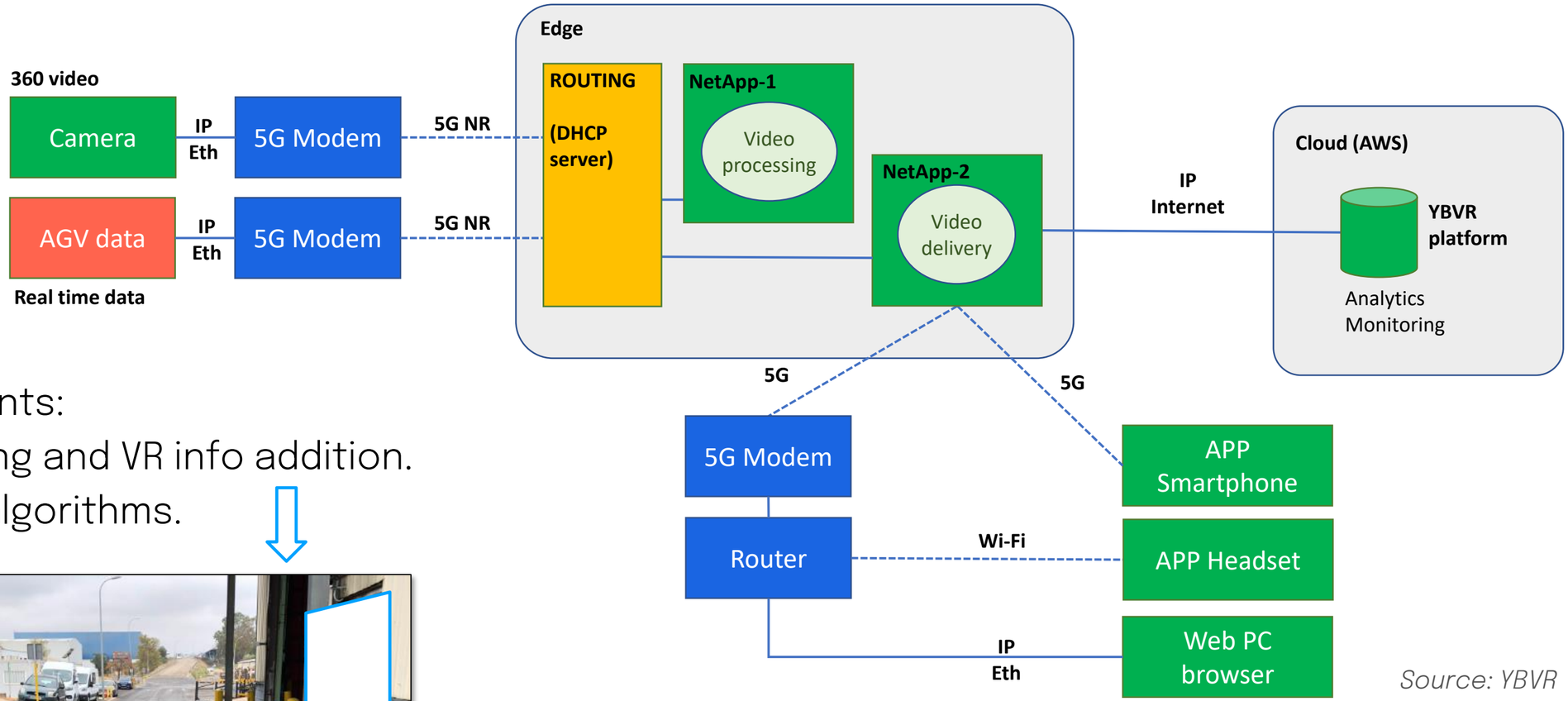
- Rationale: Through this immersed experience, the industrial operator will get a high-quality interactive view of what is happening in each AGV. This use case will additionally bring to the industry extra beneficial services such as security or person recognition.
- Objective: To explore VR and 5G capabilities to provide an immersive live 360 view from the AGV to a remote viewer.
- Scenarios:
  1. **Outdoor** transport between different outdoor Ford warehouses
  2. **Indoor** transport within a Ford plant.
- Capabilities: Supervise industrial AGVs by virtual reality immersion.
- Requirements:
  - ✓ Network latency 5ms
  - ✓ E2E latency < 5sec or < 1sec (real time)
  - ✓ Service Bit Rate 0.1Gbit/s
  - ✓ VR quality producing 8K@60fps.
- Leader: ybvr



Source: YBVR

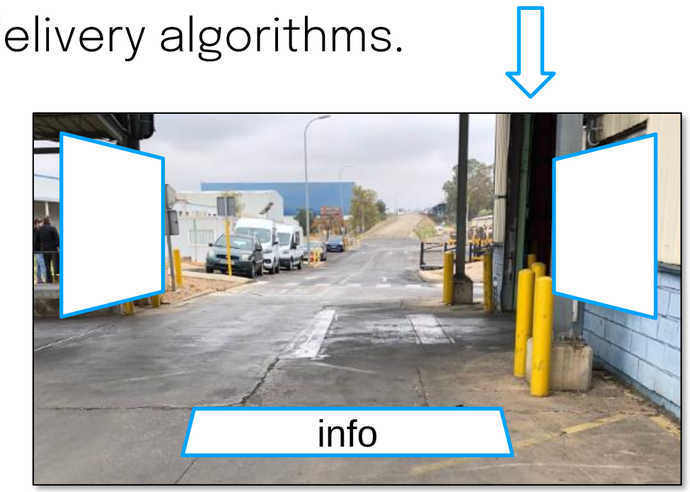
3. Use cases
VR immersion and AGV control

- Architecture:



Source: YBVR

- 2 NetApp components:
  - ✓ Video processing and VR info addition.
  - ✓ Video delivery algorithms.



This work was supported in part by the European Commission under the 5G-PPP project 5G-INDUCE (Grant number 101016941). The views expressed in this contribution are those of the authors and do not necessarily represent the project.