Bari Matera 5G

TIM FASTWEB HUAWEI

5G Italy

Roma, 5 Dicembre 2018

Infrastructure Monitoring & Monitoring through Drones

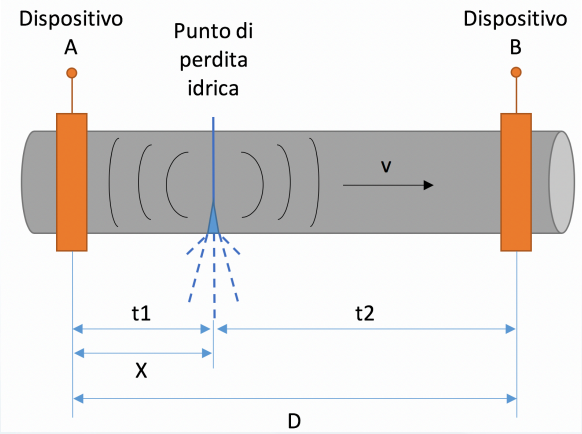
Andrea Passarella (IIT-CNR), Erina Ferro (ISTI-CNR), Marco Conti (IIT-CNR)
Ettore Stella, Roberto Marani (STIIMA-CNR), Lorenzo Molinari Tosatti (STIIMA-CNR)
Claudio Gennaro (ISTI-CNR), Giuseppe Virone (IEIIT-CNR),
Alberto Gotta (ISTI-CNR), Massimiliano Ruggeri (IMAMOTER-CNR)

INFRASTRUCTURE MONITORING:
Scenarios and needed 5G features

Bari Matera 5G

TIM FASTWEB HUAWEI

- Train infrastructure monitoring
  - Key features: obtain a detailed real-time view on the conditions of the railways
  - 5G features: high bandwidth (eMBB) + low latency (URLLC)
- Water infrastructure monitoring
  - Key features: obtain a detailed view on the underground pipes damages
  - 5G features: large-scale monitoring (mMTC)
- Common goal
  - Exploit TIM 5G network to build Digital Twins of the infra
  - To allow real-time monitoring and intervention



INFRASTRUCTURE MONITORING: Common Goals

Bari Matera 5G

TIM FASTWEB HUAWEI

- Build a Digital Twin of the physical infrastructure
  - which requires very big amount of data to be built
- Which can be updated in real time (if needed)
- Allow to dynamically configure the trade-off between local vs centralised data elaboration
  - Supporting both edge-oriented and cloud-oriented data elaboration
- Allowing remote intervention on the infrastructure
  - Which requires low delays

Train Infra Monitoring: System View

Bari Matera 5G

TIM FASTWEB HUAWEI

Sensory devices mounted on trains/special vehicles monitoring the railways

Fotogrammetria
- HD camera(s) generating
  - high-res pictures
  - @ high frame rate

Telemetria
- Point cloud acquisition
  - 1 per railway

Geometry
- Laser camera(s)
  - 1 per railway

Localisation (GPS + odometric) to localise the other three

Train Infra: Requirements

Bari Matera 5G

TIM FASTWEB HUAWEI

- Fotogrammetria
  - 5 Mpxl camera
  - 1 picture every ~25cm
  - per camera: 330 Mbps @ 50Km/h up to 2Gbps @ 300 Km/h
- Telemetria laser
  - 2x10^6 sps (samples per second)
  - per camera: 110 Mpbs @ 50Km/h up to 0.65Gbps @ 300Km/
- Geometry
  - 4 Mpxl @ 400Hz frame rate
  - Per camera: 10Mpbs @ 50 Km/h up to 600Mbps @ 300Km/h
- Localisation
  - 1.7 Mpbs @ 50 Km/h up to 10 Mpbs @ 300 Km/h

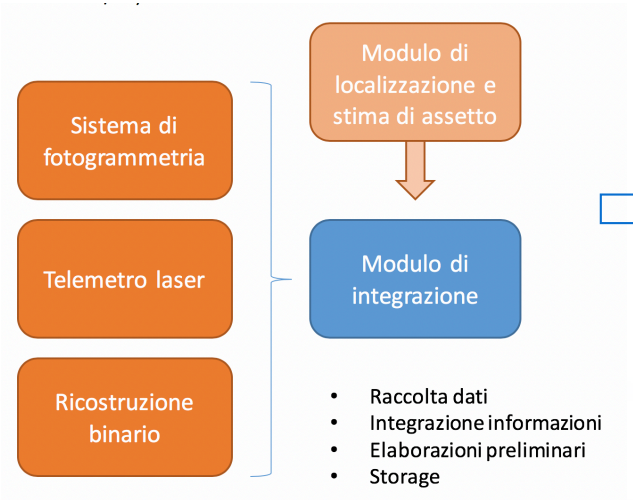
800 Mbps to 5 Gbps uplink traffic

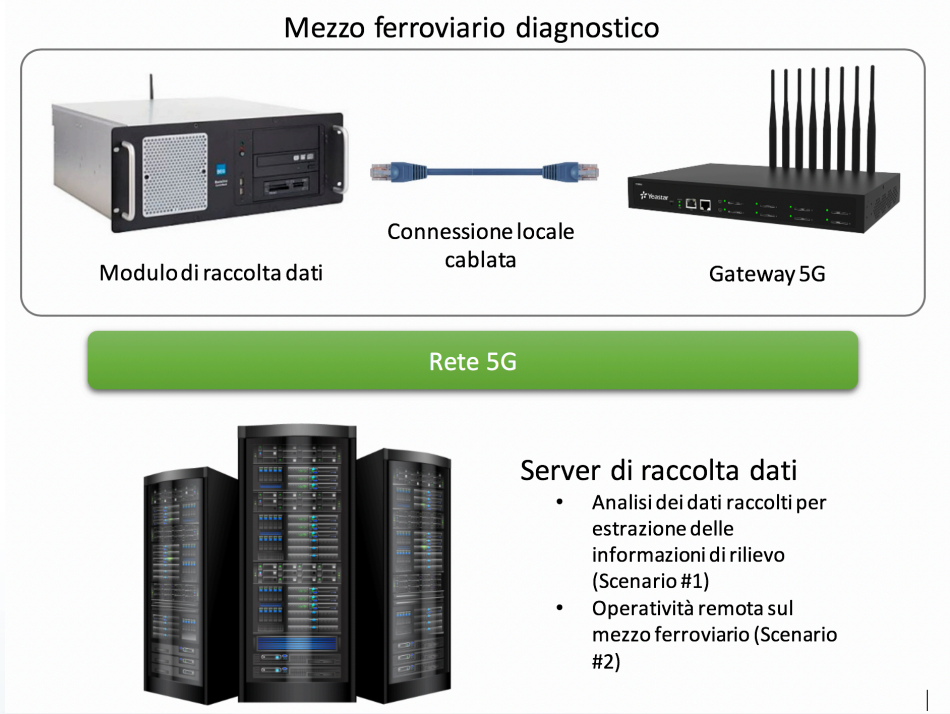
Asymptotic requirement, not tested in the experiments

Train Infra: Integration

Bari Matera 5G

TIM FASTWEB HUAWEI





a.passarella@iit.cnr.it

Train infra: Plan

Bari Matera 5G

TIM FASTWEB HUAWEI

- Emulated environment
  - Static data integration module
  - Simulated data generator
    - With realistic data rates and data sizes
  - Goal
    - Functional tests and Initial performance measures of 5G connectivity
- Real environment #1
  - Operational module mounted on monitoring devices
  - Goal
    - Real tests at low/medium speed
- Real environment #2
  - Operational module mounted on high-speed trains
  - Goal
    - Real tests at high speed (up to 300 km/h)

Train Infra: Partners & Stakeholders

Bari Matera 5G

TIM FASTWEB HUAWEI

Partners

Monitoring system integrator

Embedded devices

TIM

mermec AN ANGEL COMPANY

SITAEL

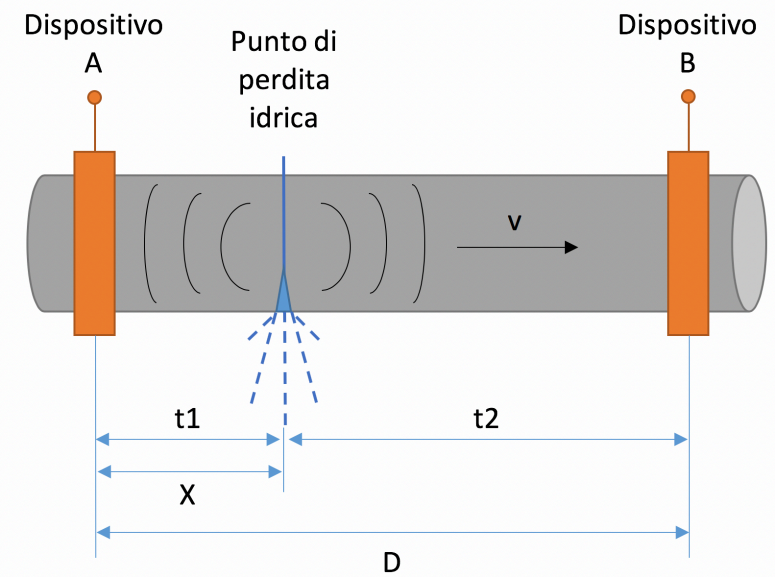
Stakeholders

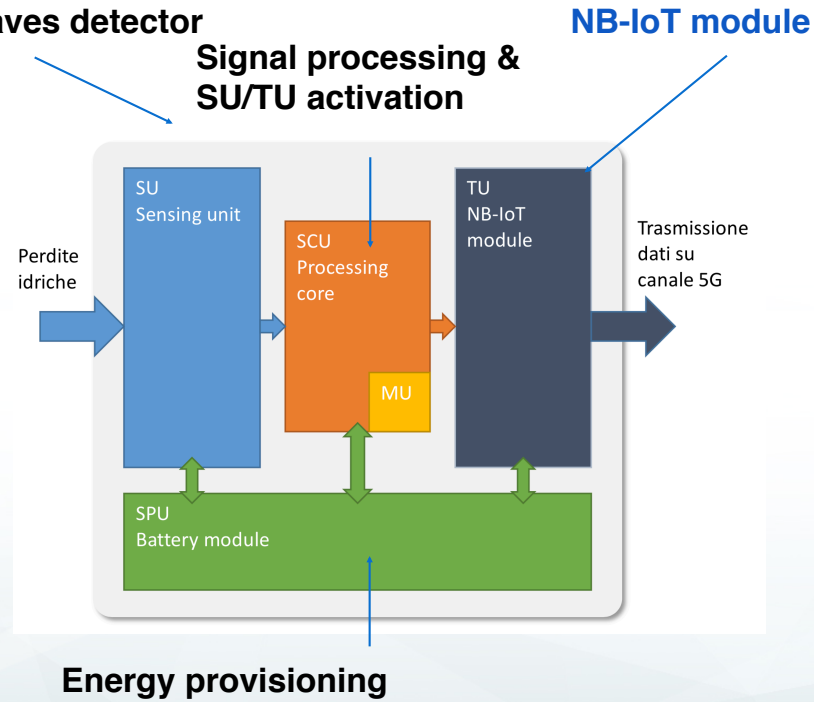
RFI RETE FERROVIARIA ITALIANA
GRUPPO FERROVIE DELLO STATO ITALIANE

Water Infra: Concept and developed sensor

Bari Matera 5G

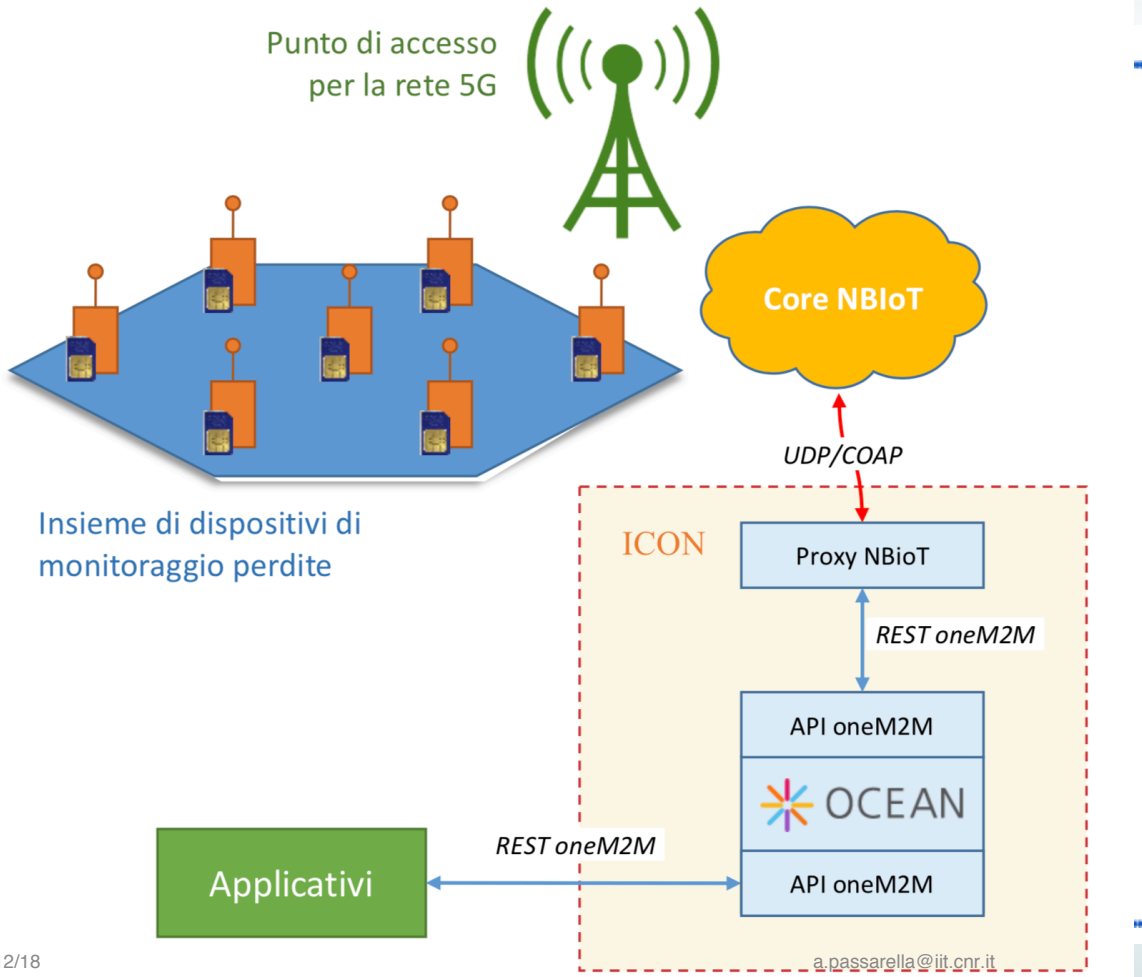
- Water spill generates specific sound signatures along the pipe
- By correlating sound signals between two endpoints the spill can be detected quite precisely





a.passarella@iit.cnr.it

Water Infra: Systems View & Requirements



Energy efficiency (0.02mAh/ device)

Low bandwidth (~150 KB/ packet)

(long-term) Low delay real-time control of repair operations

a.passarella@iit.cnr.it

Water Infra: Plan

Bari Matera 5G

TIM FASTWEB HUAWEI

- Emulated environment
  - Real integrated single device with NB-IoT module
  - Simulated data generation
  - Goal
    - Functional tests for integration with ICON
- Real environment
  - Sufficiently dense deployment in coverage area
  - Goal
    - Operational tests

Train Infra: Partners & Stakeholders

Bari Matera 5G

Partners

Stakeholders

Drones: Public security

Bari Matera 5G

TIM FASTWEB HUAWEI

5G allows quickly sending large amount of data of various kinds to the ground

Surveillance of public places through the use of high quality cameras and sensors installed on drones in order to recognize and identify in real time people, vehicles, license plates, etc. in support of public security forces.

Drones: Public security

A high-definition camera mounted on the drone captures a video stream and sends it in real time to a local server.

The drone can also activate a video stream in case of signaling coming from a specific remote location

server analyzes, the images and makes a comparison with a database of objects and faces to be identified.

Great computation power required!

deep learning algorithms run on the server

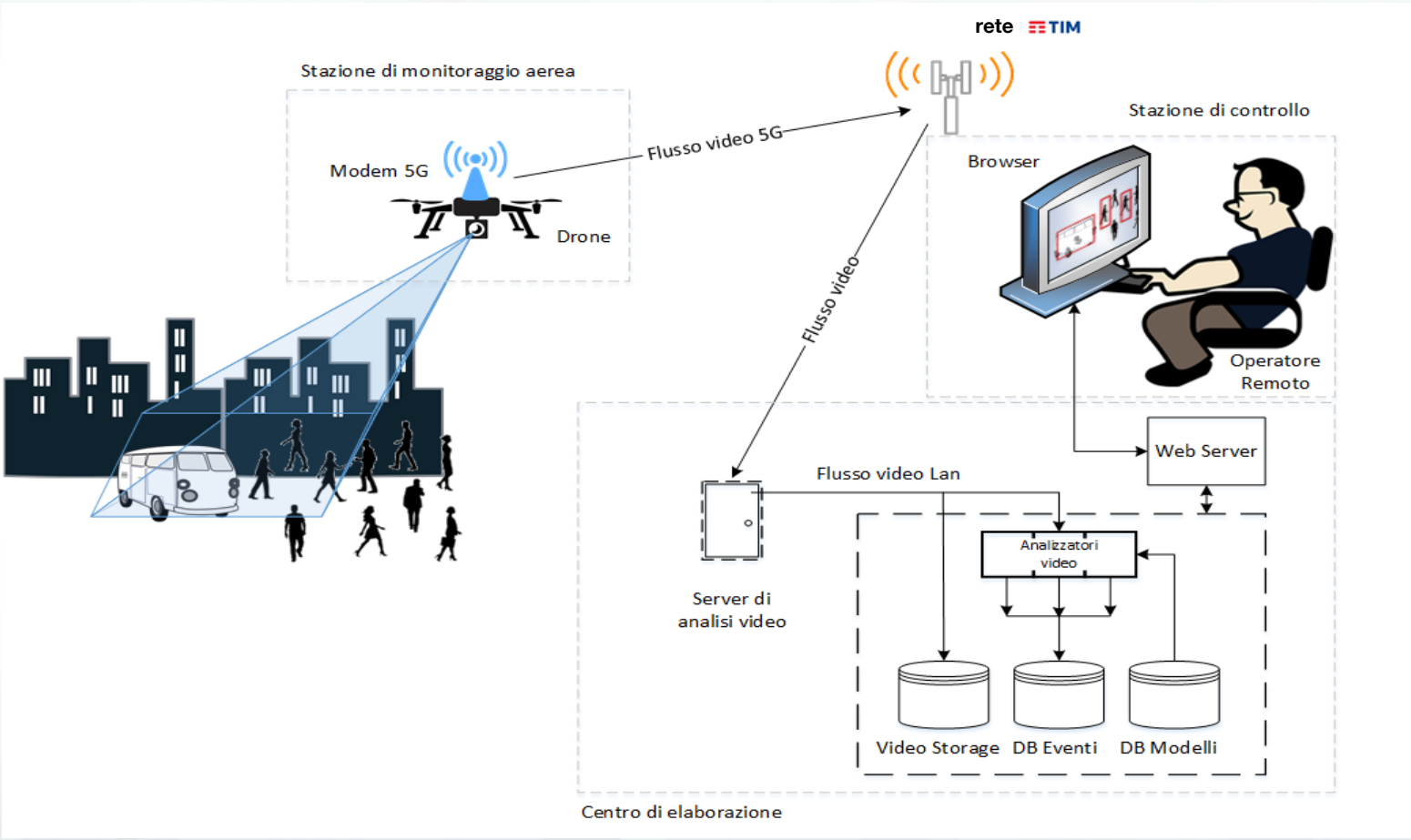
The server sends an alert to the public safety entities in case of positive matches.

Drones: Public security

- **the detection of objects based on deep learning** and in particular with the convolutional neural networks (CNN) is **extremely demanding from the computational point of view**
  - it generally requires **GPU (Graphics Processing Unit) of great power, which has a significant weight,** thus better that computation is demanded to a powerful remote server on the ground
- Independence of the object detection algorithm:
  - **the architecture is designed in such a way that at any time it is possible to change the objects and their models to be detected and recognized.**
  - This is a requirement because the operational scenario can vary, for example, from an urban context (pedestrians, cars and so on) to a rural environment (crops, roads, rivers)
- Integration details
  - Client-server architecture
  - Web user interface
  - Independence of the UAV platform
  - Data persistence

Drones: Public security

Bari Matera 5G



Drone: Jammer detection

Bari Matera 5G

TIM FASTWEB HUAWEI

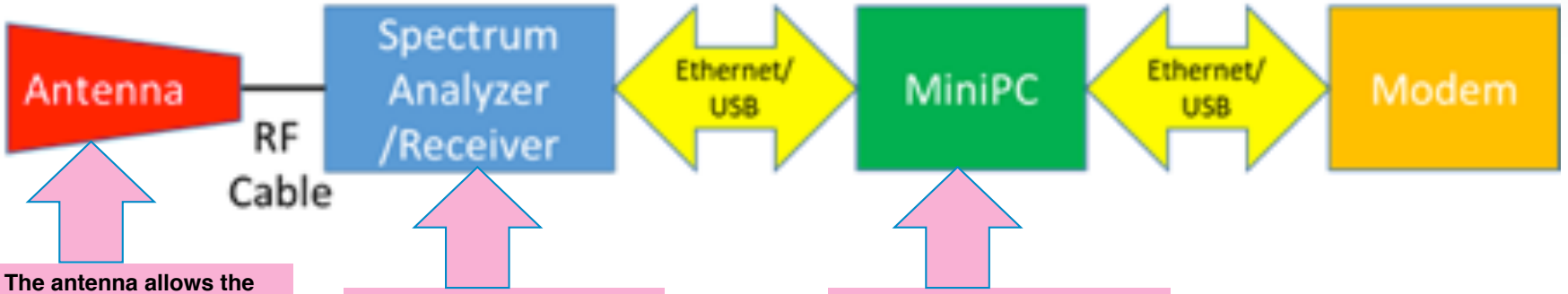
- To detect the presence of malicious devices, by integrating suitable radiofrequency receivers on board of drones
- Drones can adopt more efficient detection strategies than the operator on the ground, equipped only with handheld instruments or installed on board of motor vehicles.
  - Drones can reach high heights, set the angle of the antenna in azimuth (and elevation through any gimbal system) and move independently from obstacles on the ground (crowds, vehicles, homes, etc ...).
- Drones can use different telemetry channels (including 4G and 5G) to transmit data to the operator on the ground or directly to the cloud, allowing completely remote operation.
  - The large bandwidth of 5G can allow the streaming of high resolution IQ data that can be used to study/ demodulate the Jammer signal.
- Using the same channels, the operator can change the flight plan of the drone according to the data received.

This scenario will be implemented as a proof-of-concept by developing a dedicated payload, any necessary instrumentation on the ground and related research strategies that can be achieved with the drone

Drones: Payload block diagram

Bari Matera 5G

TIM FASTWEB HUAWEI



The antenna allows the signals coming from the surrounding space to be conveyed on the radio-frequency (RF) cable.
Both broadband characteristics (since the frequency or more generally the spectral distribution of the interferer
is not known) and directivity characteristics (to identify the direction the origin of the interferents by rotating the drone on its axis) are necessary.

Basically a receiver with a relatively narrow band (from 10 KHz to 10 MHz) tunable on a very wide frequency spectrum (from tens of MHz to 6 GHz for the most common compact devices)

the payload requires a miniPC to configure the spectrum analyzer and download the data. At a minimal level, the miniPC could operate as a data logger to save the data acquired on mass storage.
Fom the point of view of the 5G experimentation, it would be interesting to send the IQ flow at maximum speed to a 5G modem, which in turn will transfer data to the cloud using the network infrastructure installed by TIM in Bari-Matera.
(IQ data show the amplitude and phase changes of a sine wave)

Drones: electromagnetic field Monitoring

Bari Matera 5G

TIM FASTWEB HUAWEI

- To create a system able to efficiently generate three-dimensional maps of the electromagnetic field emitted by 5G stations and other transmitting stations, in order to provide information on the quality of service and verify the margins of exposure of citizens.
- It was decided to concentrate the activities o the basic 5G station characterization (4G as a backup) under operating conditions.
  - With respect to the jammer scenario, we use an antenna with a narrower band and with an optimized radiation pattern to guarantee high accuracy of data, regardless of the errors related to the orientation of the drone and in the presence of conductive parts on board.
- Hardware and communication protocols = jammer scenario
  - On the other hand, as regards the scanning strategies, unlike the jammer case, it will be possible to completely define the flight plan before take-off.
- The Real Time Kinematic Global Navigation Satellite System technology will be exploited, offering accuracy of centimeter positioning in real time.

Drones: Precision Farming with Autonomous Vehicles

Bari Matera 5G

TIM FASTWEB HUAWEI

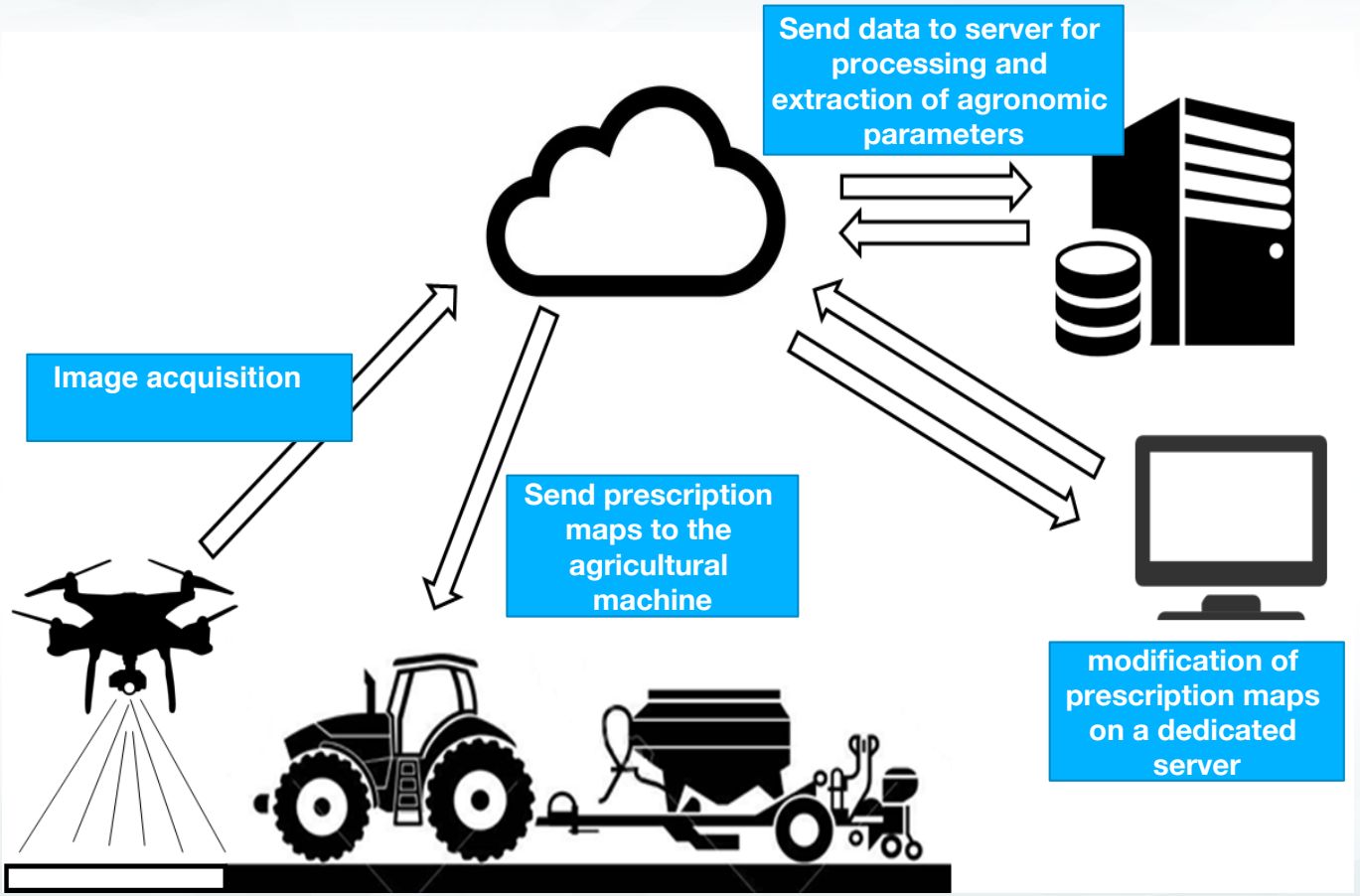
- Creation of a platform able to support the command and control of manned / unmanned vehicles for precision agriculture

One or more aerial drones proceed to the acquisition of multispectral terrain images in order to update / enrich the prescription maps used by terrestrial drones in real time.

Drones: Precision Farming with Autonomous Vehicles

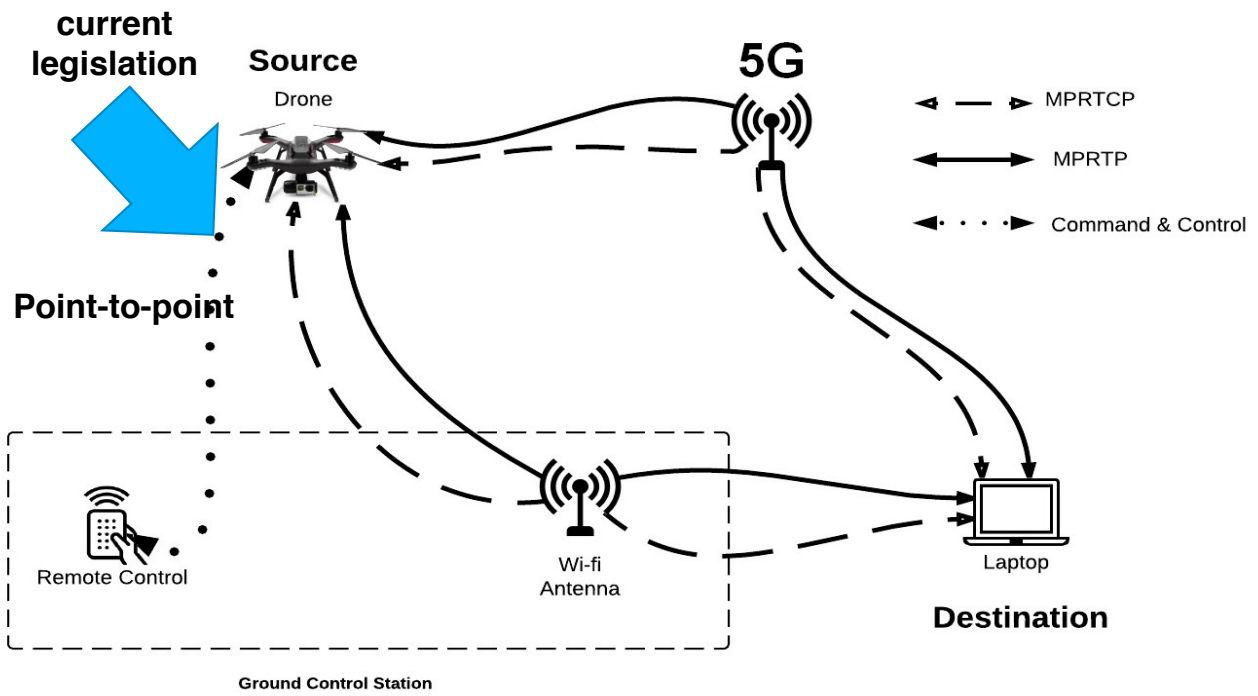
Great computation power is required

Terrestrial drones are assumed to be equipped with Variable Rate Treatments and ISOBUS systems that support the real time modification of the prescription maps.



Drones: Precision Farming with Autonomous Vehicles

Bari Matera 5G



Transmission of multimedia data takes place from an aerial drone to the ground, simultaneously using two paths: a 5G connection and a WiFi connection.

real-time transfer of images in the visible, multispectral, and hyperspectral fields, for multiple purposes:
- **verification of the presence of sudden obstacles on the ground**
- **data collection through the sensors on board the aerial drone**
- **coordination of multiple terrestrial vehicles and their synchronization**

MULTIPATH SYSTEM based on MP-RTCP protocol (MultiPath-Real-Time Control Protocol)

Bari Matera 5G

TIM FASTWEB HUAWEI

5G Italy

Roma, 5 Dicembre 2018

Grazie

Infrastructure Monitoring & Monitoring through Drones

Andrea Passarella (IIT-CNR), Erina Ferro (ISTI-CNR), Marco Conti (IIT-CNR)
Ettore Stella, Roberto Marani (STIIMA-CNR), Lorenzo Molinari Tosatti (STIIMA-CNR)
Claudio Gennaro (ISTI-CNR), Giuseppe Virone (IEIIT-CNR),
Alberto Gotta (ISTI-CNR), Massimiliano Ruggeri (IMAMOTER-CNR)