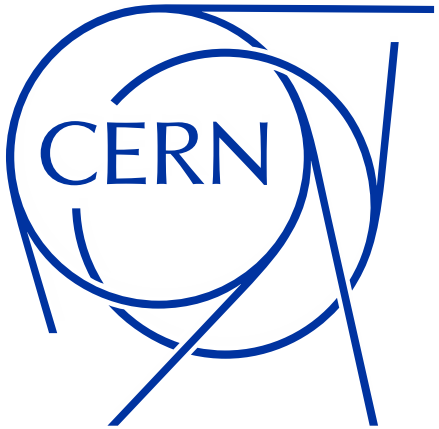

Monitoring particle accelerators with wireless IoT

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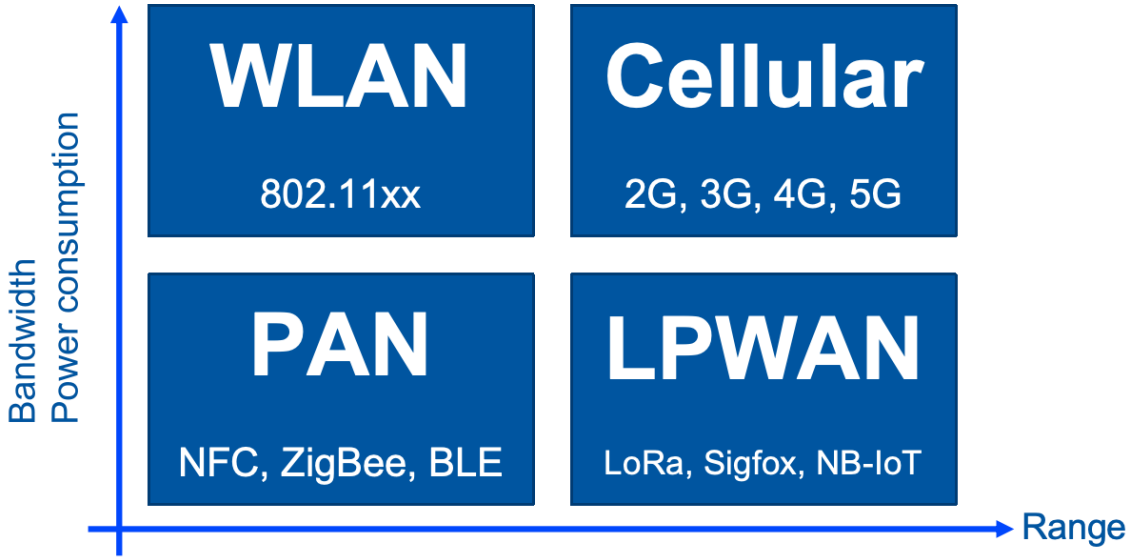
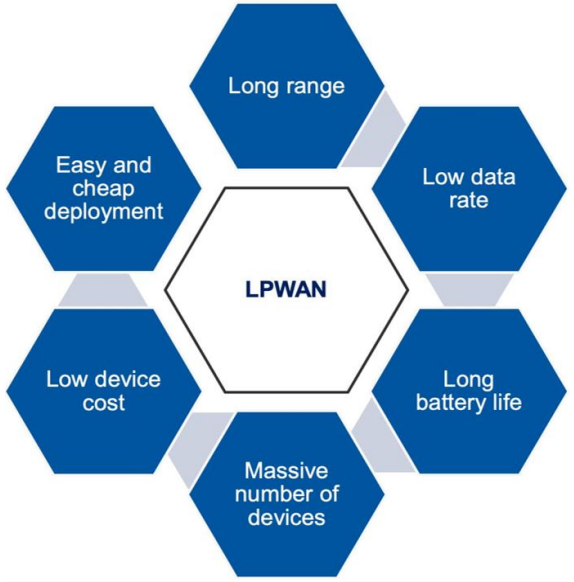
21/10/2024

The IoT service

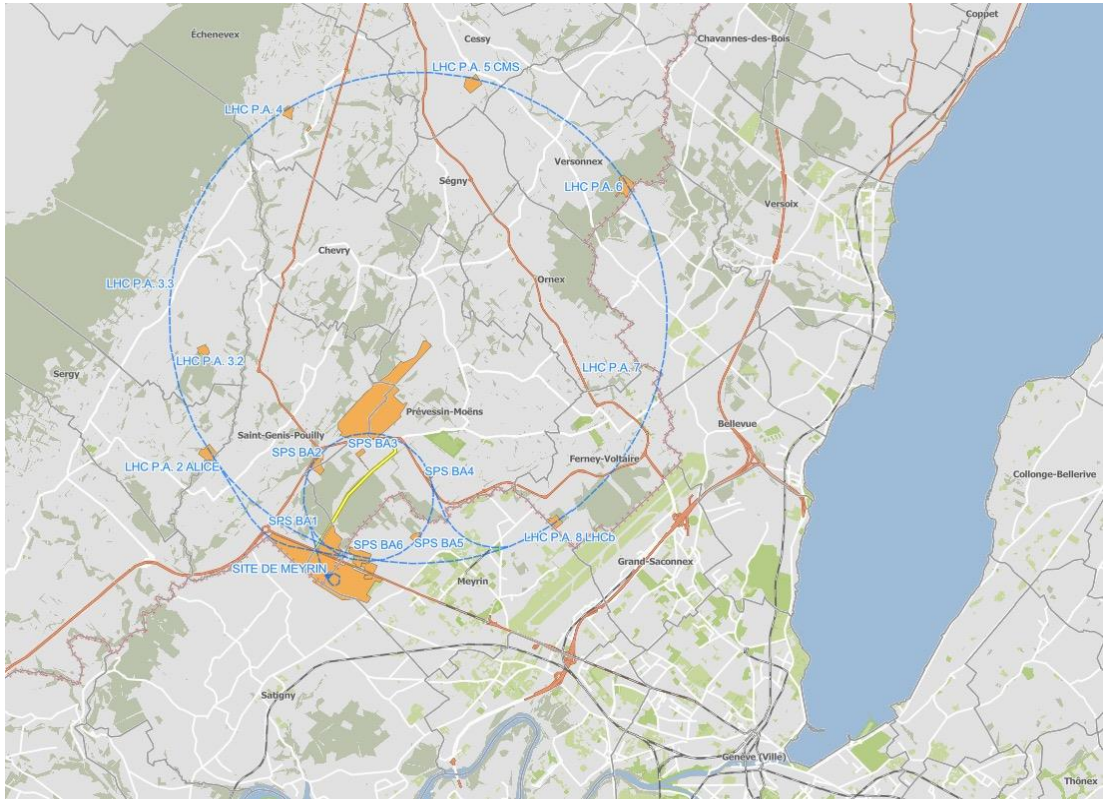
- **CERN used to use Wi-Fi, cellular and local PAN networks**
- **But we were missing a solution for LPWAN (Low Power Wide Access Network)**
- **In 2019, we chose and deployed LoRaWAN as our LPWAN solution**





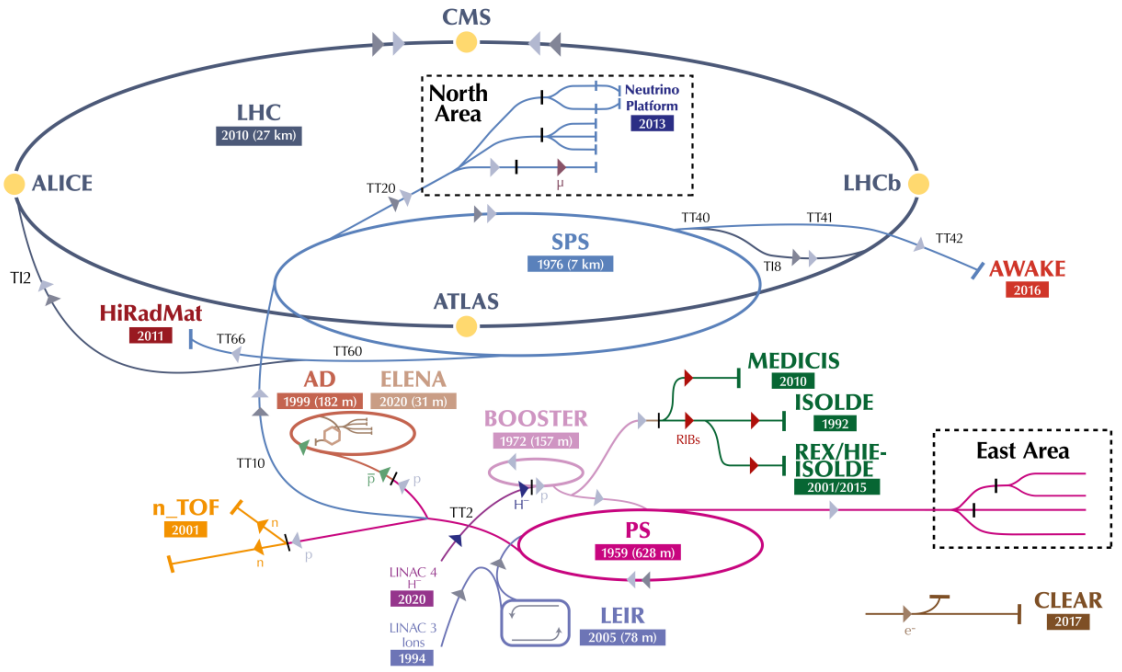
Our particular case

- ~60km^2 campus at the franco-swiss border
- ~700 buildings, including several industrial facilities
- 35 outdoor gateways to cover the campus
- ~18km of galleries and 65km of tunnel



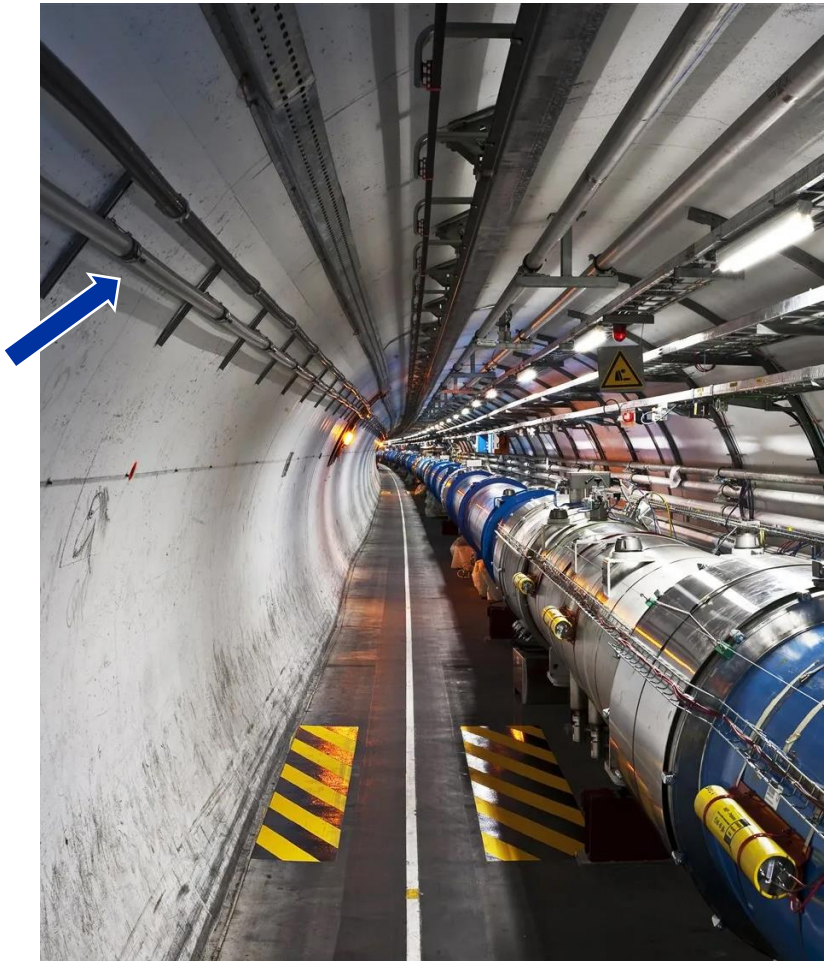
The challenge in underground aeras

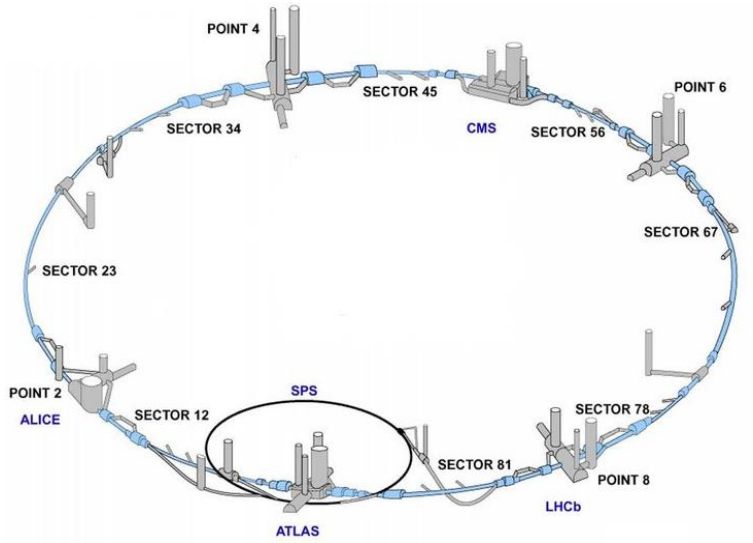
- Radiation is present in accelerators and detectors
- Electronic devices are impaired by radiation
- We cannot place complex devices inside the radiating areas, including radio emitters
- Radiation-safe areas are limited



Network solution

- **Underground coverage in the whole acceleration chain:**
  - Radiation-safe areas distanced up to 1.5 km (emitters)
  - Coverage provided by a radiating cable (~60km)
  - 45 LoRa dedicated gateways for accelerators/experiments
  - LoRa shares the radiating cable with cellular network and TETRA

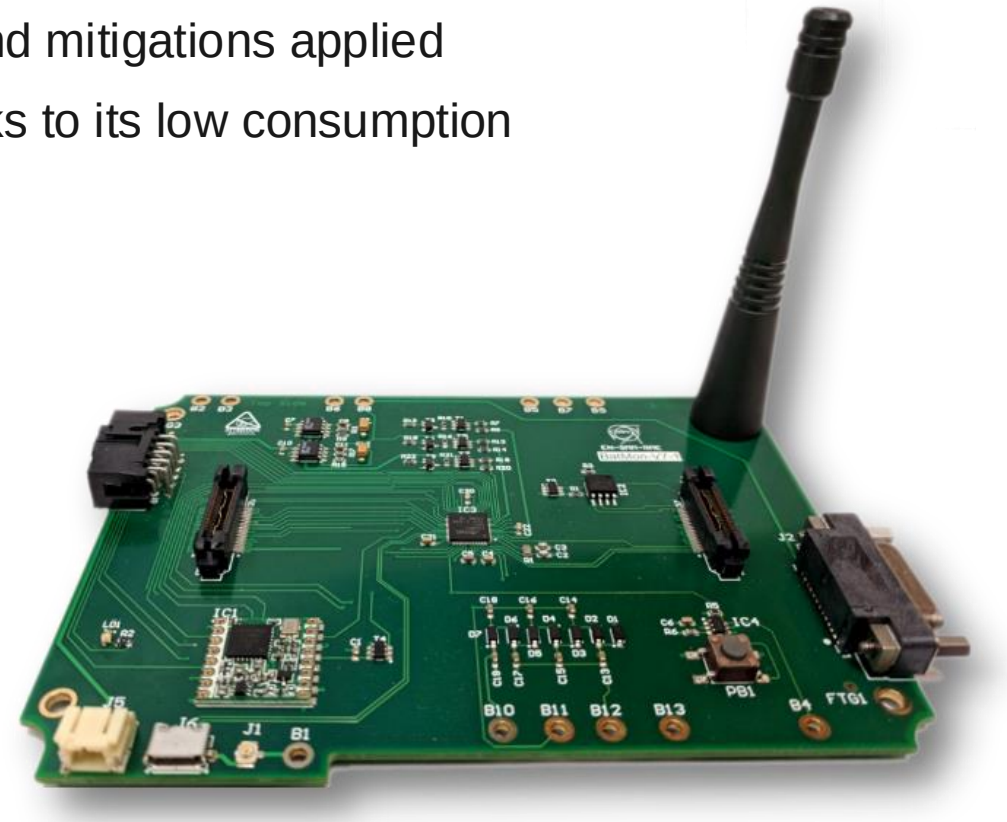




Radiation proof devices

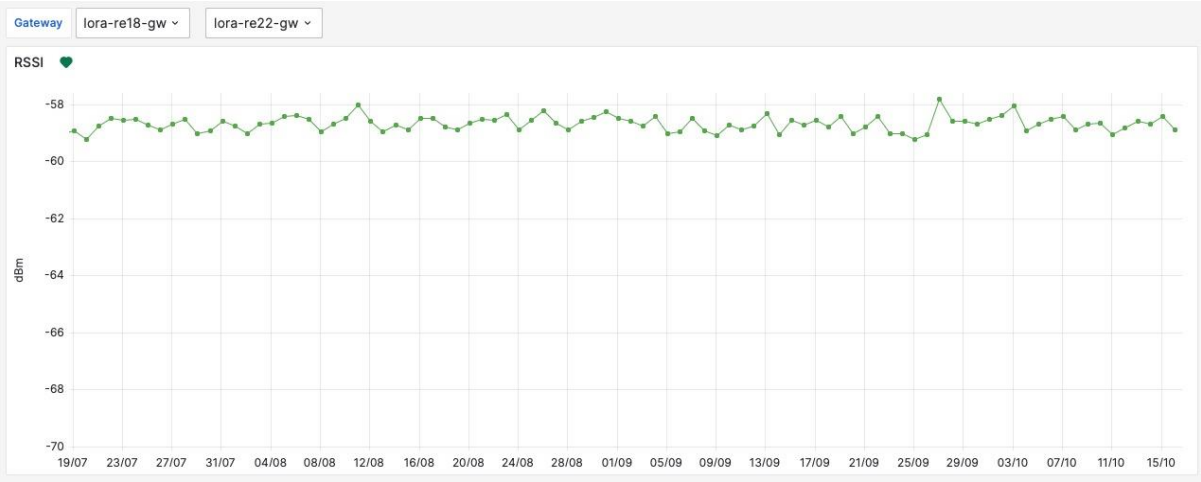
- **CERN developed a custom radiation-tolerant LoRaWAN platform**
  - LoRaWAN electronics were tested under radiation and mitigations applied
  - LoRaWAN is ideal for battery-powered sensors thanks to its low consumption
  - Modular architecture for several types of sensors

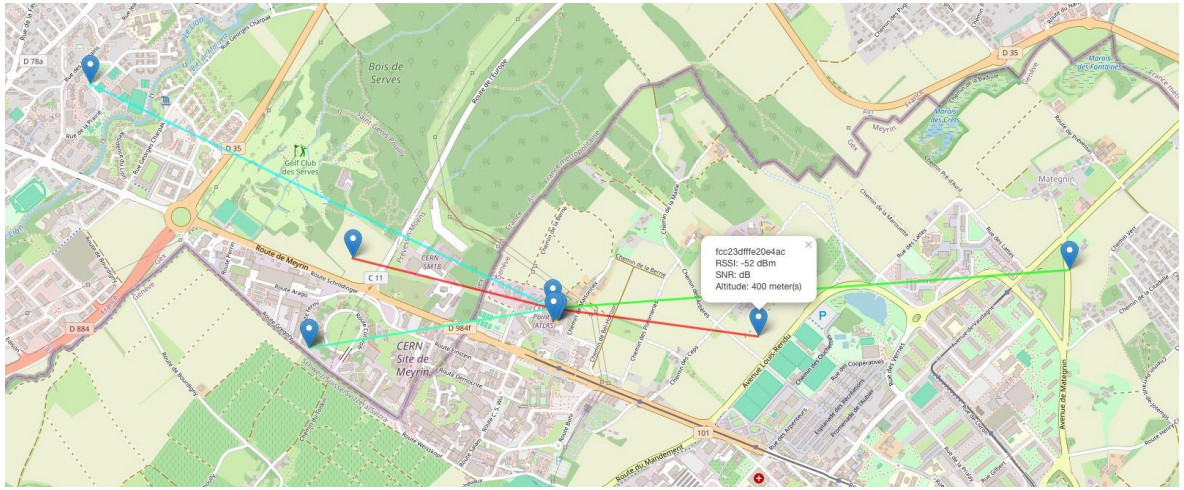
	Cost	Real-time
Fieldbus system	✗	✓
Offline sensor	✓	✗
LoRaWAN	✓	✓



Monitoring LoRaWAN service in the underground facilities

- **Signal monitoring between 2 gateways or between the device and the gateway:**
  - Status of the LoRa service
  - Status of the radiating cable
  - Data correlation with cellular and TETRA emitters to assess all radio services underground
- **Allows us to track the damages in the cable or degradation due to the radiation**

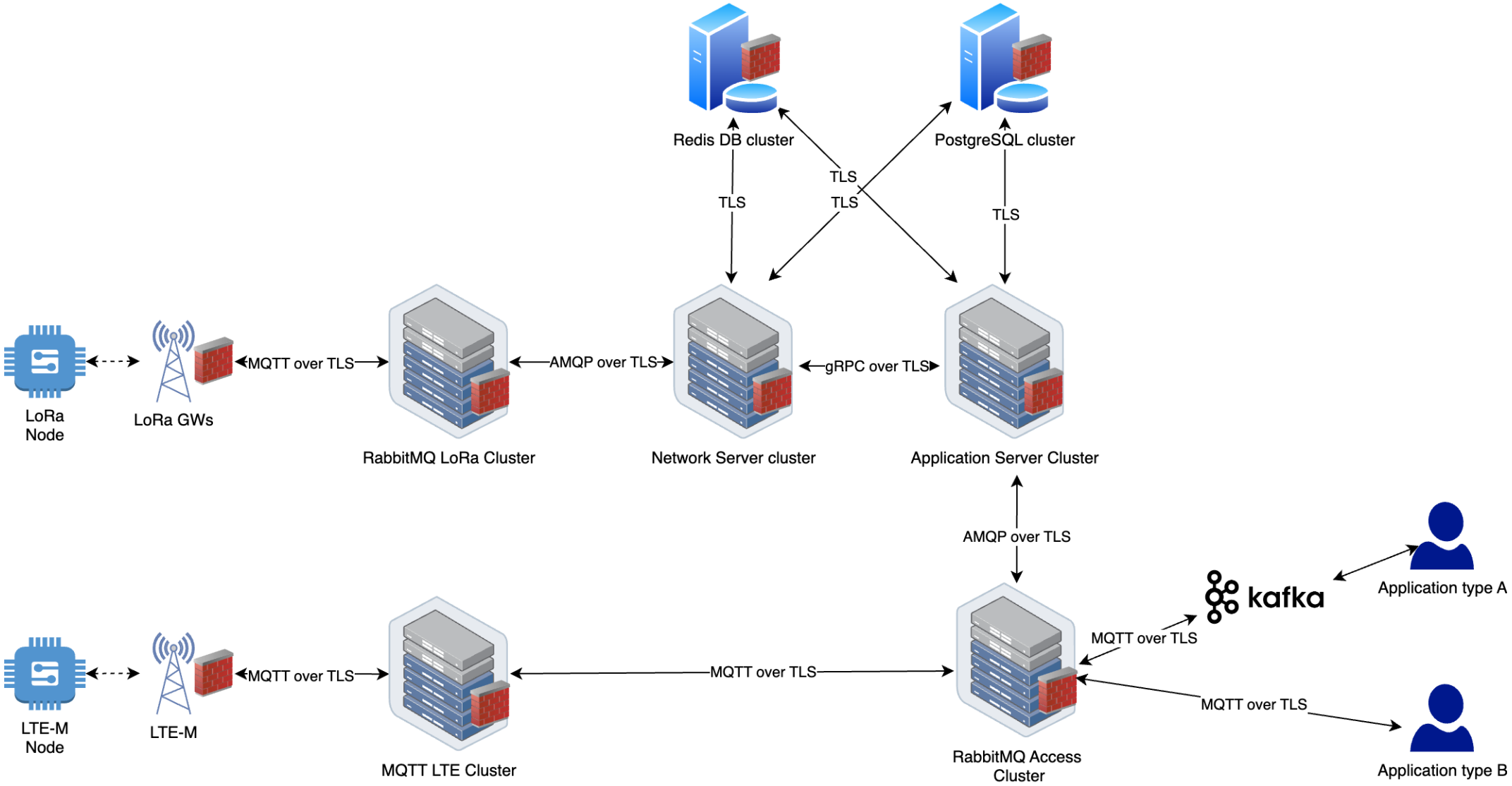




Use cases

- **Industrial use cases:**
  - Temperature and humidity
  - Access control
  - Assets and vehicles tracking
  - Cranes usage monitoring
- **Underground uses cases:**
  - Measure radiation levels
    - Installation and cost reduced drastically
    - Number of monitored areas can grow
  - Tunnel displacement and cracks monitoring
    - Allows us to avoid manual campaigns
  - Vibration and electromagnetic field monitoring

Architecture

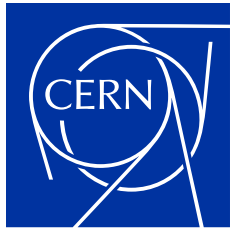


Technologies

- Based on open source software
- Standard IT components
- Designed for high availability
- Secure and encrypted communication
- Automatized server and gateway provisioning

Conclusion

- **CERN has completed its communication offer by adding and consolidating LoRaWAN for wide-area communication where no cabling or power is available.**
- **We used standard IT components.**
- **Thanks to the new radiation-tolerant hardware and the use of the radiating cable, we were able to expand the use cases to our underground facilities.**
- **The new service has allowed CERN users to simplify operation and reduce costs.**



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