A radiation tolerant wireless Internet of Things (IoT) platform for on-field sensor data acquisition

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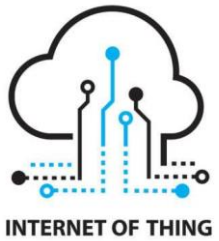
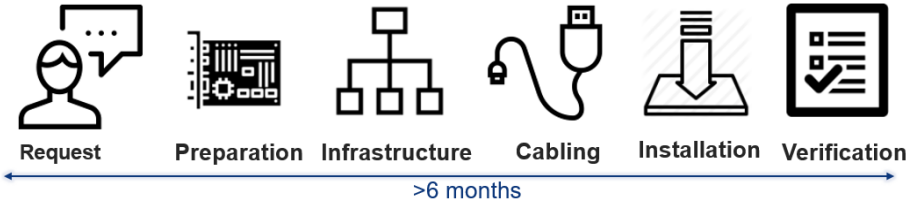
Title break down

- **A radiation tolerant**
  - In the accelerator tunnels and experiments there is a radiation field that affects all the electronics installed
  - The electronic systems should be “qualified” to be installed in the LHC tunnel and in the injectors
  - The same happen for the electronics in the Space and in the Nuclear power plants
- **Wireless**
  - Communication without cables
  - Possibility to have only batteries as main source of power
- **Internet of Things**
  - The Internet of things (IoT) describes the digital connection of objects to the Internet in order to achieve total CONTROL and MONITOR such objects.
  - Summarizing: Making the objects SMART and CONNECTED
- **platform for on-field sensor data acquisition**
  - Standardized Hardware board that can be used as base system for sensors acquisition
  - Can host several applications and it is not application-specific

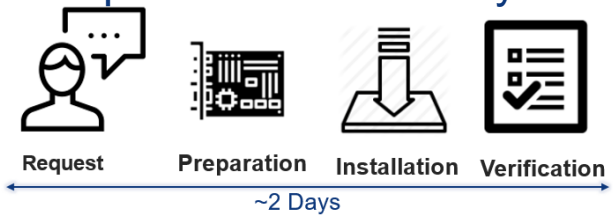


The origin

- Key idea is born around a CERN development called RadMon: Radiation Monitor for CERN electronics
  - RadMon is a radiation tolerant device based on commercial components well qualified under irradiation
  - RadMon is a system of cabled devices with a well defined infrastructure inside the CERN (device management, gateways, logging etc..)
  - More than 500 devices are installed currently in the LHC



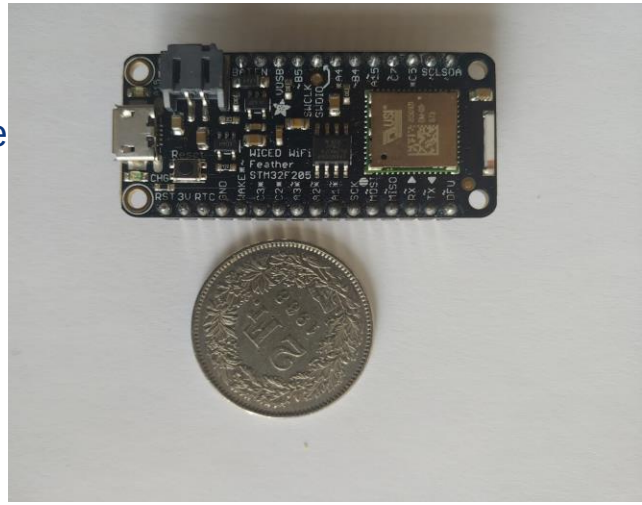
- What happen if one user want to monitor the radiation level in a place where RadMon are not available?
  - We have mainly only the technical stop (few days) for the installation
  - Usually the requests arrive few days before the access…



The BatMon and the proposal

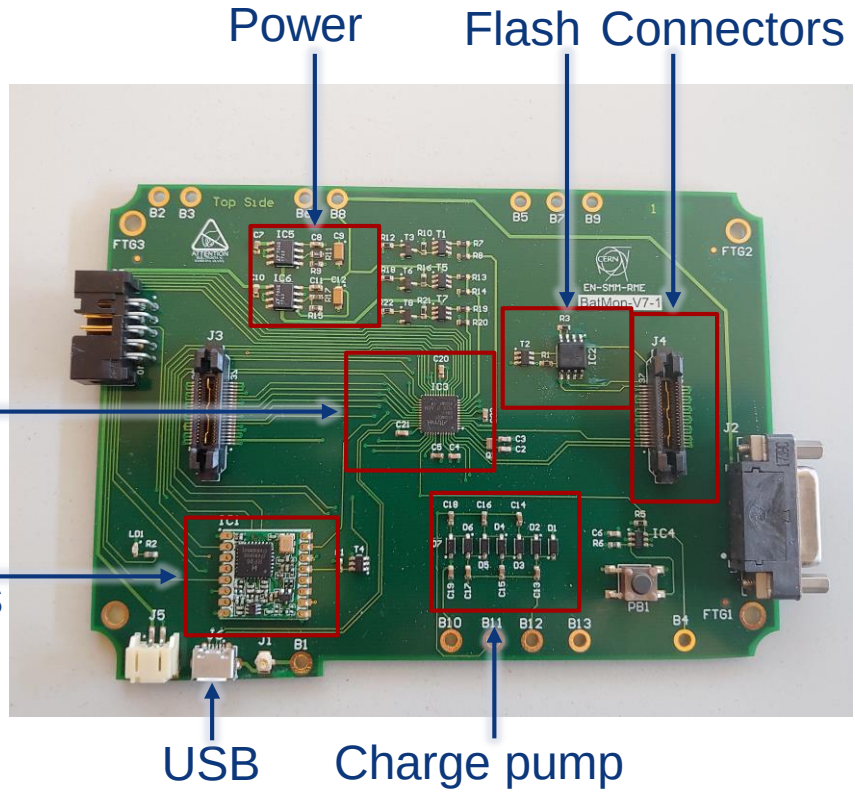
- The BatMon: a BATttery radiation MONitor
  - Monitor and control radiation sensors
  - Modular
  - Battery powered
  - Reliable under radiation
  - Wireless communication over km range
  - Well known standard for IoT (LORAWAN selected)
    - Strong collaboration with IT/CS for the choice of the supported link
  - Same form factor as the actual RadMon to reduce the cost
  - The first wireless radiation tolerant CERN development

- **Proposal :** The radiation tolerant wireless Internet of Things (IoT) platform for on-field sensor data acquisition
  - Inherit all the features of the BatMon
  - Remove the sensor part and keep only the intelligent wireless core
  - Provide to the users/companies a platform independent from any application
  - Make it multipurpose
  - Make it configurable
  - Easy of installation
  - Support other wireless standard such as the ZigBee but also WiFi
    - Allowing mesh network sensor and high speed data communication
  - Make it miniaturized to make it embeddable in any other system



Specification and possibilities

- Based on commercial components
  - Low cost
- Low power development
- Tested under irradiation
  - Components have been selected for radiation hardness and low power
- Availability of several on-board peripherals
  - Very large Flash Storage system 128Mbit
  - Analog to Digital Converter (ADC)
  - Digital to Analog Converter (DAC)
  - Serial Peripherals Interface (SPI)
  - Inter-Integrated Circuit communication (I2C)
  - LORA wireless communication
  - Multi supply voltage +5V and +3.3V
  - Charge Pump capable of generating up to +20V
- Just few examples of sensors immediately adaptable:
  - Light sensor via ADC
  - Temperature via SPI, I2C, ADC
  - Voltage/Current monitor via ADC, SPI
  - Humidity via ADC
  - Position via ADC,SPI,
  - Motor/actuator via DAC




Humidity


Position

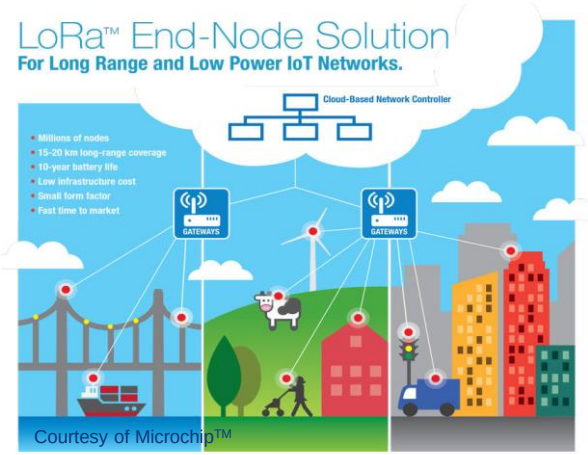

Motors

Radiation tests and performances

- All the components used has been tested in a proton facility to verify their suitability
- Mitigation strategies to reduce the radiation effects have been implemented in both hardware and software
- Performance tests are carried out directly in a controlled radiation environment
- CHARM irradiation facility as testbench
- Currently testing three devices
- After one week of irradiation all the device all still functional
- They have cumulated the amount of dose expected in 10 years in most of the LHC regions where electronics is installed
- More than 20 mt of effective concrete shielding between the gateway and the devices!
- We can communicate easily between building 18 and R2.

Possibilities outside CERN

- The platform if can work under radiation can work even more reliably in standard conditions.
  - In this case the applications are very wide
- In nuclear power plants it can be used for several application also close to the reactor due to its radiation tolerance
  - Leak detection
  - Water flow
  - Etc..
- For Space applications
  - Low power feature can be very attractive
  - Radiation tolerance is mandatory
  - Being low cost can be a big advantage
  - Target is sensors placed far away from each other -> no need of cabling
  - ESA is searching for technologies suitable for this kind of application: link



Conclusions

- The radiation tolerant wireless IoT platform inherits all the features and strategies applied on a CERN development to make it robust in a very harsh environment allowing kilometres range communication
- It is reliable under radiation, thus reliable in a standard environment for any kind of application
- It is not application specific and very easy to adapt to any scope.
- The next important steps are:
  - Miniaturization
  - Checking new wireless protocol to be implemented: i.e WiFi and ZigBee
- IoT is an essential driver of innovation
- Will allow to gather more data and being more effective
- We can say we are currently moving towards a “SMART IoT Accelerator”
- **Let’s think already beyond this scope**

Thank you