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# An educational distributed Cosmic Ray detector network based on ArduSiPM using microcontrollers as data acquisition node NTP protocol as time distribution and IoT technology for data aggregation.

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The advent of microcontrollers with enough CPU power and with analog and digital peripherals give the possibility to design a complete acquisition system in one chip. The existence of an world wide data infrastructure as internet allows to think at distributed network of detectors capable to elaborate and send data or respond to settings commands.
The internet infrastructure allow us to do things unthinkable a few years ago, like to distribute the absolute time with tens of milliseconds precision to simple devices far apart from a few meters to thousands of kilometers and to create a Crowdsourcing experiment platform using simple detectors.
The terms of IoT (Internet of Things) define a set of data communication protocols and the capability of single embedded electronics objects to communicate using the internet .
The MQTT ( Message Queue Telemetry Transport ) is one of the main protocol used in IoT device for data transmission over TCP/IP, the client version can run easily in nowadays microcontrollers, the MQTT broker (the server version) can run also in credit card–sized single-board computers as well in big server.
The ArduSiPM (1) is an easy hand-held battery operated data acquisition system based with an Arduino board, which is used to detect cosmic rays and nuclear radiation.
The ArduSiPM uses an Arduino DUE (an open Software/Hardware board based on an ARM Cortex-M3 microcontroller) as processor board and a piggyback custom designed board (Shield), these are controlled by custom developed software and interface. The Shield contains different electronics features both to monitor, to set and to acquire the SiPM signals using the microcontroller board. The SiPM photon counting detector can be coupled to a cheap plastic scintillator to realize a cosmic ray detector (mainly muon particles). An ArduSiPM channel give informations about rate of events, arrival time and number of photons produced by muons, it contains all the feature from controls to data acquisition typical of High Energy Physics channel at a cost affordable for single user or school. The ArduSiPM send data over serial protocol instead of use ethernet interface to the network we use a sort of a network processor.In the market comes up SoCs (System on Chip) like the Espressif ESP8266 a low-cost Wi-Fi chip with full TCP/IP stack and a 32-bit RISC CPU running at 80 MHz. ESP8266 can be used to manage MQTT packets and to retrieve using Network Time Protocol (NTP) the absolute time from the network, with a precision of tens milliseconds. The network time can be used from a cloud of ArduSiPMs to detect offline coincidence events linked to Ultra High Energy Cosmic Ray to realize an educational distributed detector with a centralized MQTT broker that concentrate data.

(1) The ArduSiPM a compact trasportable Software/Hardware Data Acquisition system for SiPM detector.
V. Bocci et al.
2014 IEEE NSS/MIC 2014
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