

# EEG Brain-Computer Interfaces for Internet of Everything (IoE)

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# INTRODUCTION

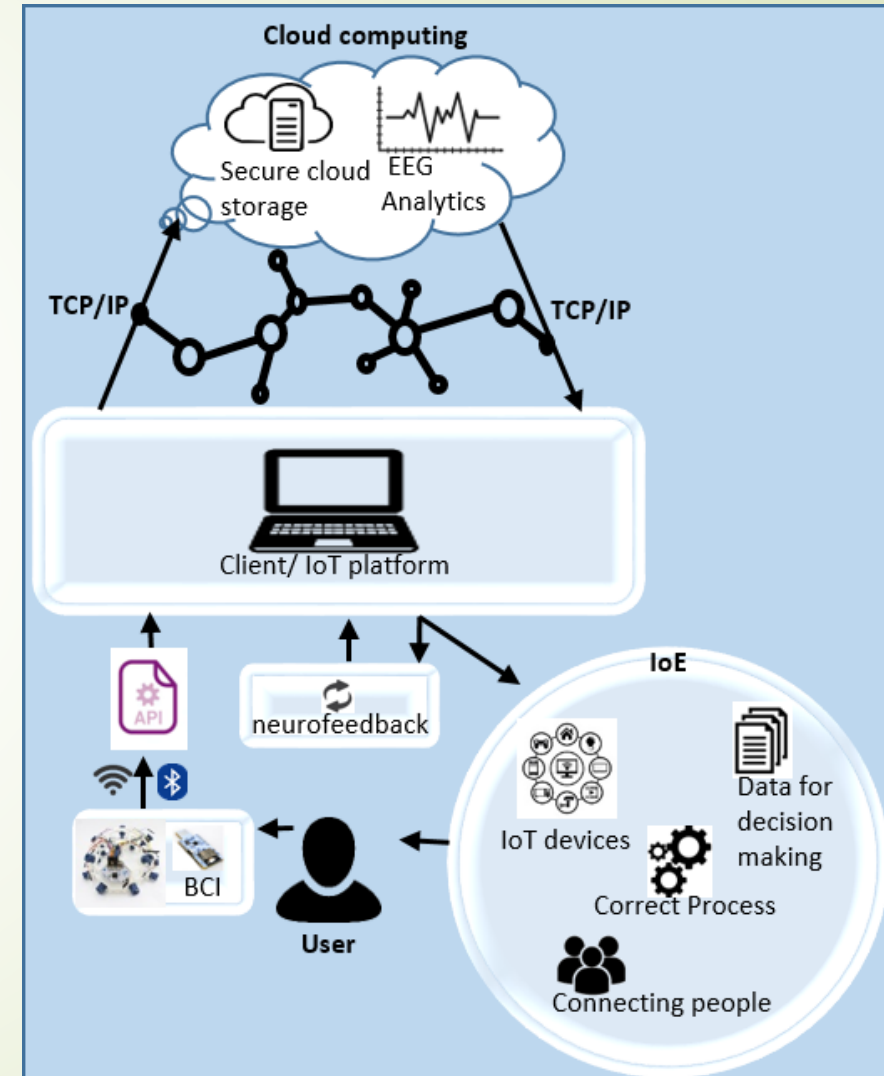
We propose a more general model for creating BCI applications to record, compute and make connections with different IoE devices and IoE services in the web or cloud.

- ▶ EEG-based Brain-Computer Interface (BCI) - measures the human scalp electrical potentials resulting from ionic currents in the brain neurons
- ▶ Cloud computing - bridge between the Internet of Things (IoT) platform and big data
- ▶ Internet of Everything (IoE) - IoT emphasizes on communication machine-to-machine (M2M), while IoE is a system that includes also data, people and processes. The cloud is not necessary for IoE, the data can be processed in the Internet, however cloud computing proposes scalability and low costs of operations.

There exist some works using the BCI concept in the cloud or in the Internet of Things, but they all use specific protocols and devices

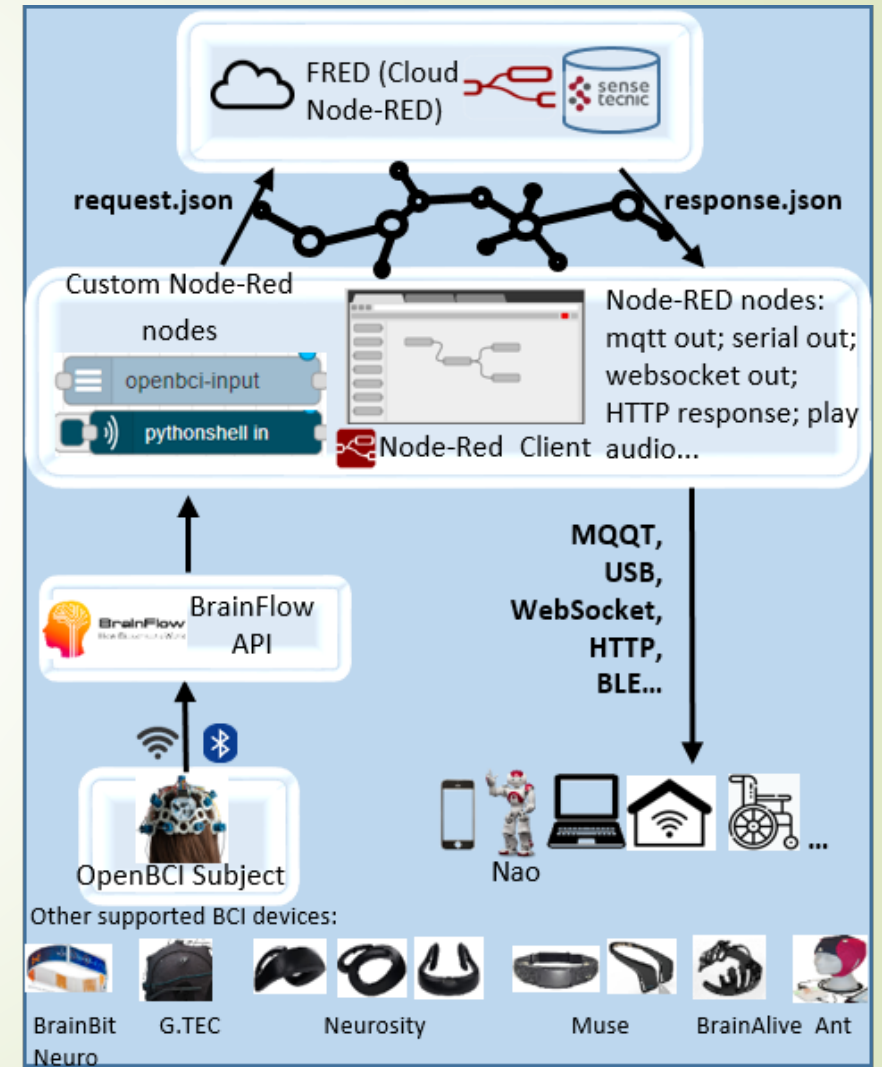
# A conceptual BCI model for IoE

- ▶ Describes the main components for managing and controlling the IoT connectivity between BCI device and everything.
- ▶ The BCI device should be transformed into *thing* in order to connect and transmit data in the web or cloud for storage, computations, Analytics and connections to other IoE devices or services.
- ▶ An IoT platform in the model provides a gateway to the IoE and acts as a message broker that can deal with the heterogeneity of IoE devices and scale with their number and the data dimensions.



# System architecture for the BCI model

- ▶ The model is validated by designed architecture using OpenBCI device, BrainFlow library, Node-RED and FRED
- ▶ Node-RED is used as browser-based flow programming tool and acts as a gateway to the IoT
- ▶ FRED is used for cloud computing in the Sense Tecnic cloud
- ▶ A new node, called "openbci-input", is designed and inserted in the Node-RED library. It is an input node and sends parameters to a "pythonshell" function node for accessing the BrainFlow APIs according to the selected device and processing needs
- ▶ Different output nodes that can be used in Node-RED are: *mqtt out, serial out, http response, play audio, generic-BLE out, etc.*

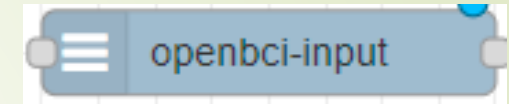


# System architecture *background*

- ▶ OpenBCI boards
  - ▶ Arduino-compatible neural interfaces with a 32-bit processor and 8 up to 16 EEG channels.
  - ▶ The communication is wireless
  - ▶ In our case study, the board samples EEG signals at 125 Hz on each of its 16 channels, however the model can be applied also for the OpenBCI 16-channel WiFi improved version set with sampling data at 500Hz.
  - ▶ OpenBCI hardware comes with a free software development kit and support the BrainFlow framework for building applications via Python and other programming languages
- ▶ BrainFlow
  - ▶ Software framework for building BCI applications via conventional programming languages
  - ▶ Supports more than ten EEG-based BCI devices
  - ▶ We use the BrainFlow Python library intending to obtain, parse and analyze EEG data from the boards
- ▶ Node-Red - low-code tool for wiring together devices, services and APIs, providing a gateway to the IoT
- ▶ FRED: Front End For Node-RED - is Docker based and manages one or many Node-RED instances

# New node “openbci-input”

- Designed and developed by us, contributes to the transformation of these BCI devices into *things* only by visual programming in Node-RED and without having to write any code.
- Provides an easy way how the OpenBCI users to specify the board Id, data type and electrodes of interest.
- Based on the input values entered in the node properties, a JavaScript file within the node processes and generates the output in JSON format that is appended as input parameters to the relevant BrainFlow APIs called from Node-RED.
- The “openbci-input” node can be used for acquisition of the raw EEG signals or for obtaining the signals’ power content over each unit of frequency - Power Spectral Density (PSD).



Edit openbci-input node

Delete Cancel Done

Properties

Name

Data Type PSD

Serial port COM3

Board ID 2

Pin/Channel 3

Band Lowbeta

Window size 2

# CONCLUSION

- Proposed is a brain-computer interface model for IoE by which the connectivity of the BCI devices and their ability to transmit data over the Internet to the web or cloud can be extended
- A new node “openbci-input” was designed and developed for publishing as *npm* module to Node-RED library to extended the Node-RED capabilities
- In the future, the proposed solution for BCI connections to *everything* will be applied for different EEG devices, filtering methods and for transmitting the EEG metrics “relaxation” and “concentration” over the Internet



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Thank you!

Adelina Kremenska