IoT compliant sensory platform for use in personal patient monitoring

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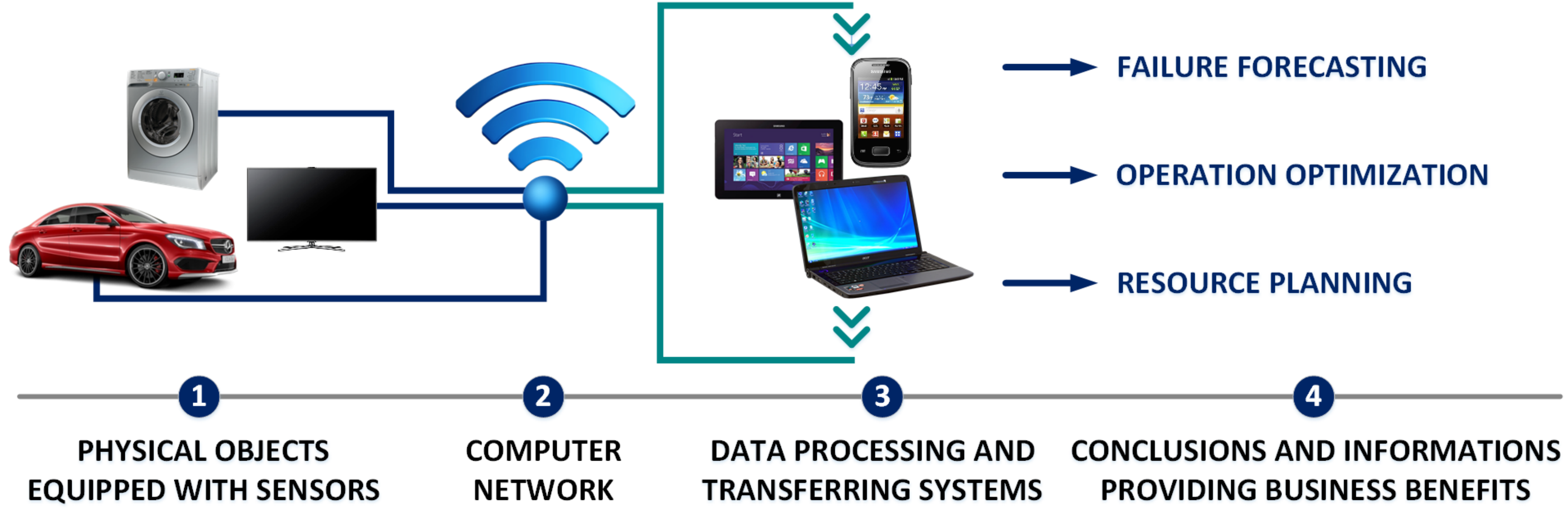
Presentation plan

- IoT, communication and definition
- Examples of sensory platforms
- Bluetooth and profiles
- Sensory platforms in telemedicine
- Implemented solution
- Data synchronisation
- Conclusion

Internet of Things (IoT)

The idea of Internet of Things (IoT) was started by a concept of Machine to Machine (M2M) platform, including a wide array of telecommunication solutions, allowing for rapid data exchange between machines.



Communication conditions

A IoT device has to fulfill three requirements:

The first one is having a sensor capable of gathering environmental data and transmitting it further.

The second one is the presence of a device that can receive data from the sensor, is able to process it and act accordingly.

The last requirement for proper ecosystem operation is presence of a communication interface (like Bluetooth Smart).

Sensory platform

The sensory platform consists of a microprocessor device supplied with a set of sensors obtaining information from the environment and a communication interface sending the data to the data processing device.

Sensor networks may envelop whole cities and gather information about traffic, weather conditions or pollution levels.

They can also accompany people suffering from illnesses, under medical care or undergoing recuperation to monitor the health condition.

Example architecture

The only limitation and direction in IoT device development is fulfilling the needs of the consumers by producers.

Development of the Internet and mobile devices resulted in the market being filled with a wide array of sensory platform that fit the IoT profile.

Two platforms were considered, SensorTag and nRF51DK.

SensorTag

SensorTag Platform produced by National Instruments

- 32-bit ARM Cortex-M3 microprocessor

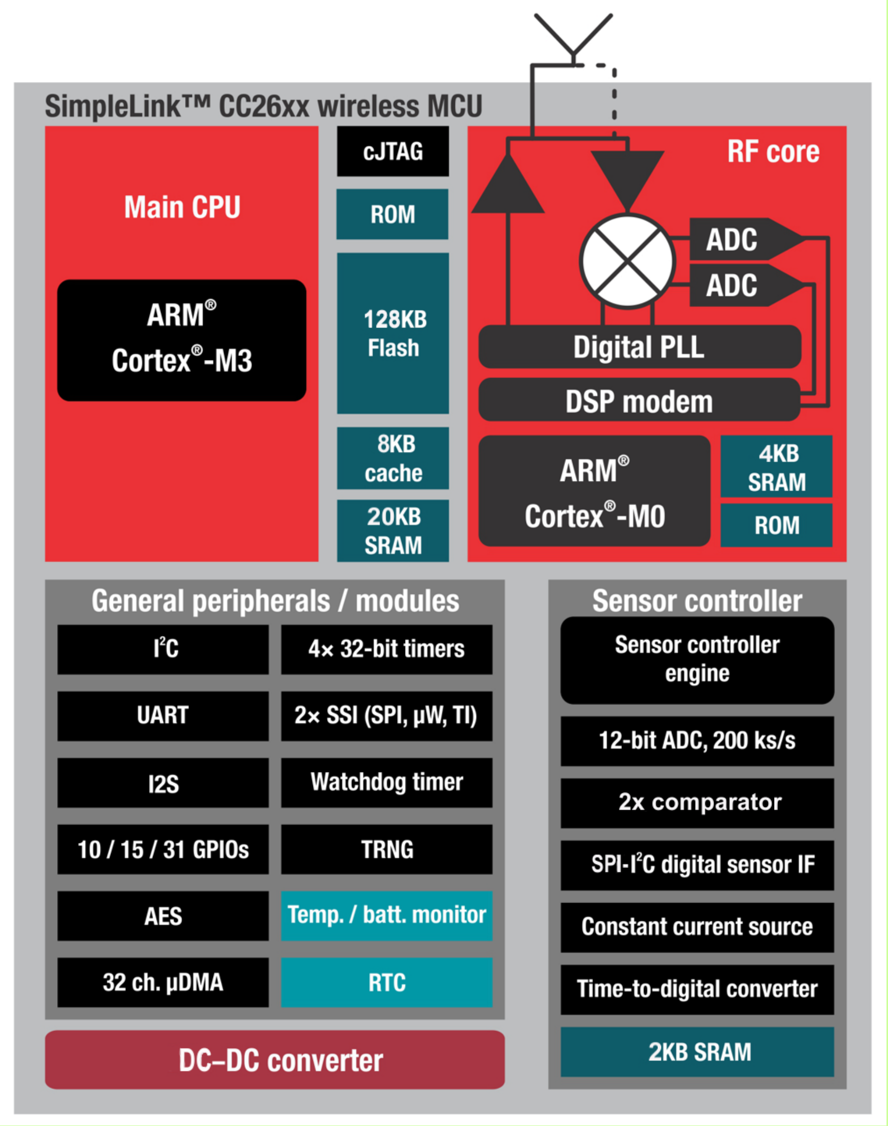
- 48MHz clock

- good processing capabilities while still maintaining low energy consumption

- additional Cortex-M0 processor is tasked with providing and controlling communication

- BLE, 6LoWPAN and ZigBee

-128KB of Flash memory, 8KB of cache and 20KB of SRAM memory as well as ROM and a wide array of peripheral devices and serial interfaces



nRF51DK

The nRF51 DK platform produced by Nordic Semiconductor

- ARM Cortex-M0 32-bit

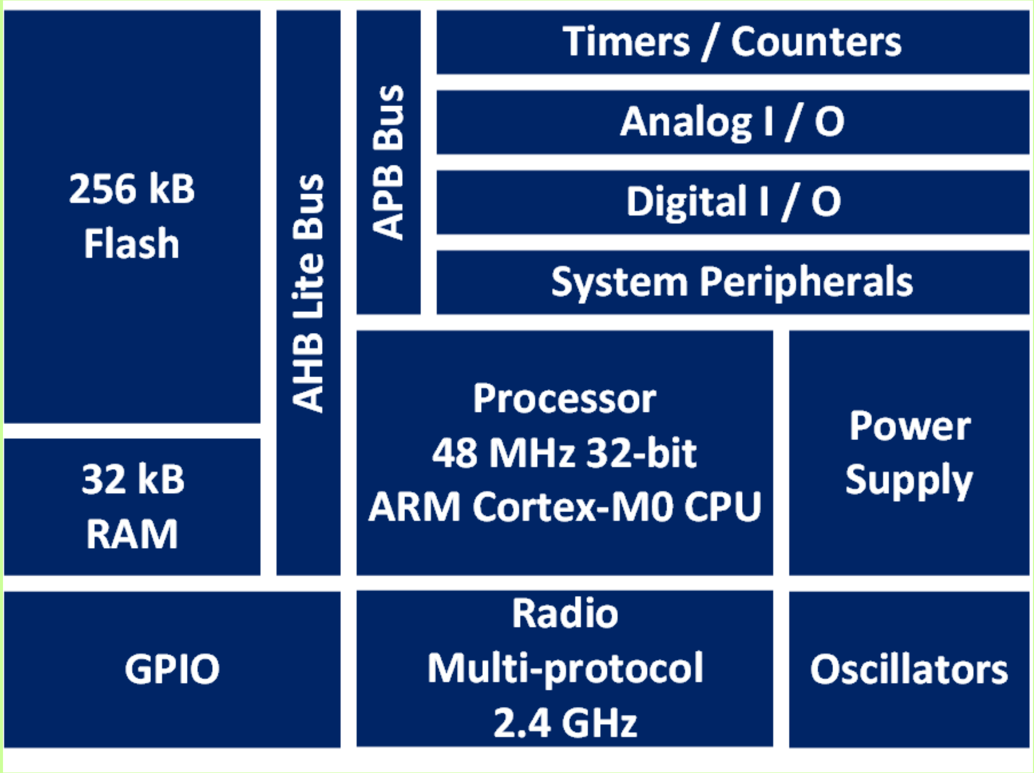
- 48 MHz system clock

- for usage in embedded systems

- the 16-bit and 32-bit instructions set provides significant benefits when memory requirements are considered

- NVIC interrupt controller system and power management system.

- in 256kB and 32kB RAM variants



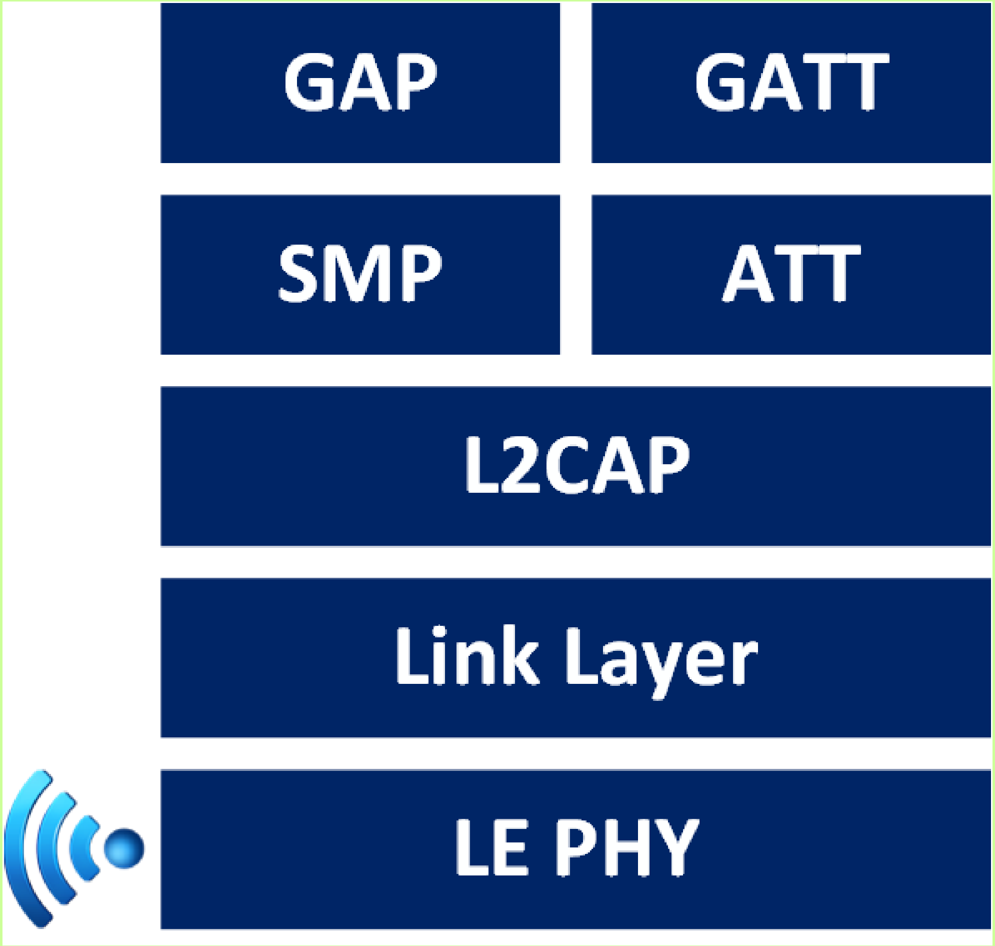
Bluetooth Low Energy

Both sensory platforms described before allow for BLE (Bluetooth Low Energy) standard communication.

- 2.400 GHz to 2.4835 GHz frequency band like the classical version of Bluetooth.

- BLE divides the band into 40 channels, each 2 MHz wide

- these include 37 data channels and 3 broadcast channels



GAPP and GATT profile

- The GAP (Generic Access Profile) is responsible for broadcasting and connection management in BLE.

- This profile defines the various roles that the various devices can take.

- These can include the Peripheral Device and Central Device roles.

- The GATT (Generic Attribute Profile) defines a way in which two BLE compatible devices can share data.

- This profile uses ATT (Attribute Protocol), which stores information about services, characteristics and other data as a table.

Hierarchy

- GATT operations performed in BLE are based on a hierarchy of nested objects including profiles, services and characteristics.

- A profile is a predefined collection of simple services established by Bluetooth SIG (Special Interest Group) or designers of the peripheral device.

- The services are used to divide data into simpler, smaller logical units. They contain specific fragments called characteristics.

- A service can have one or more characteristics.

Sensory platforms in telemedicine

- An example of use of the discussed sensory platforms is a design of a mobile IoT-compatible ECG platform, using a specialized ECG amplifier working in a three lead configuration.

- The amplifier produces an analog signal, which in turn forces certain development choices in further design, especially the choice of communication interface.

- Besides, the IoT platform concentrator device is supplied with an accelerometer sensor, which allows for activity monitoring.

Assumptions

The following **functional** requirements were established for the projects:

- reading data from a three-lead ECG sensor using ADC conversion,
- reading activity data from a three-axis accelerometer using I2C protocol,
- sending the data to the mobile application using BLE.

The following **non – functional** requirements were established:

- ability to monitor heart rate during 24 hours,
- energy consumption management for lengthening the work time using batteries, while still being able to fulfil the rest of requirements,
- ability to detect BLE packet transmission errors.

Testing platform

- Any sensor with an analog output in place of the ECG module.

-The 3-lead ECG sensor as one of the analog signal converted using the ADC interface. The data is sent using BLE to the mobile application.

- A specialized profile consisting of two services.

- First service samples the ECG signal using 500S/s sample rate.

- The samples get an identifier used for error detection and the data is sent using BLE to the mobile application.

- The ADC resolution is 10 bits, the data is divided into two 8 – bit fields.

- The second service is used to read and send accelerometer data.

Energy conservation

To limit power consumption the operation was divided into four phases:

- Broadcasting – the device is active, not connected. It continuously broadcasts it's UUID and the UUID of the services. In case of failure to connect for more than 180 seconds the device enters sleep mode.
- Sensor stabilization - the device is active and connected to thecentral device. The phase takes 30 until the ECG signal reading stabilizes.
- Measurements – the ECG is stable and sampled at 500S/s rate and the accelerometer is sampled ad 20S/s rate. The data is being sent by BLE to the central device. The phase takes 90 seconds.
- Sleep – the device enters sleep mode, all the peripherals are inactive. The BLE is connected. This phase takes 510 seconds. Afterwards, the device enters phase three and the cycle repeats.

Data synchronisation

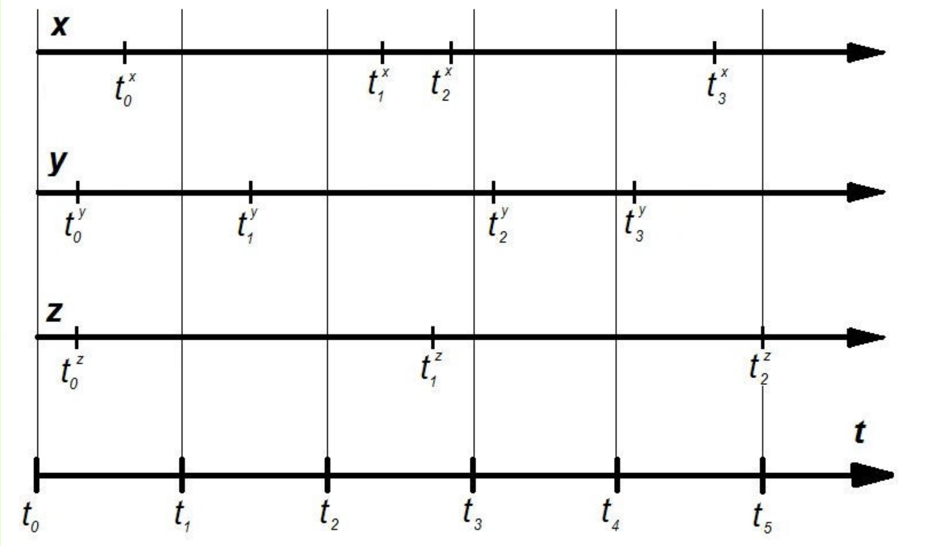
- Each sensor sends data in a certain time.

- The ECG is sent as a value and the accelerometer produces values from three axes.

- Nevertheless the data is sampled at different frequencies and sent using BLE in packets.

- They are usually a part of a time sequence, but sampled at different intervals.

- Solving this problem requires transformation of the sample set do a data sequence with constant time intervals.



Conclusion

New methods of data acquisition, processing and visualisation are based on three premises:

- a device with a set of environmental data sensors is required,

- a device with the capability of receiving, processing and reacting to data is required,

- a communication medium for transmission of data between the devices in the ecosystem is required.

Conclusion

The SensorTag and nRF51 platforms presented in this article are compatible with the IoT standard. They are based on the ARM microprocessor.

The SensorTag board uses the Cortex M3 architecture, giving it a better performance and lower energy consumption, while nRF51 utilizes Cortex M0.

Additionally, the SensorTag can service up to 240 different interrupts and use them to switch between sleep and active mode and deep sleep. The more advanced core results in more capable platform.