UNIVERSITY OF WEST ATTICA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Recent Advances in IoT-Based Wearable Systems for Biosignals Monitoring – Application to Elderly Care

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Outline

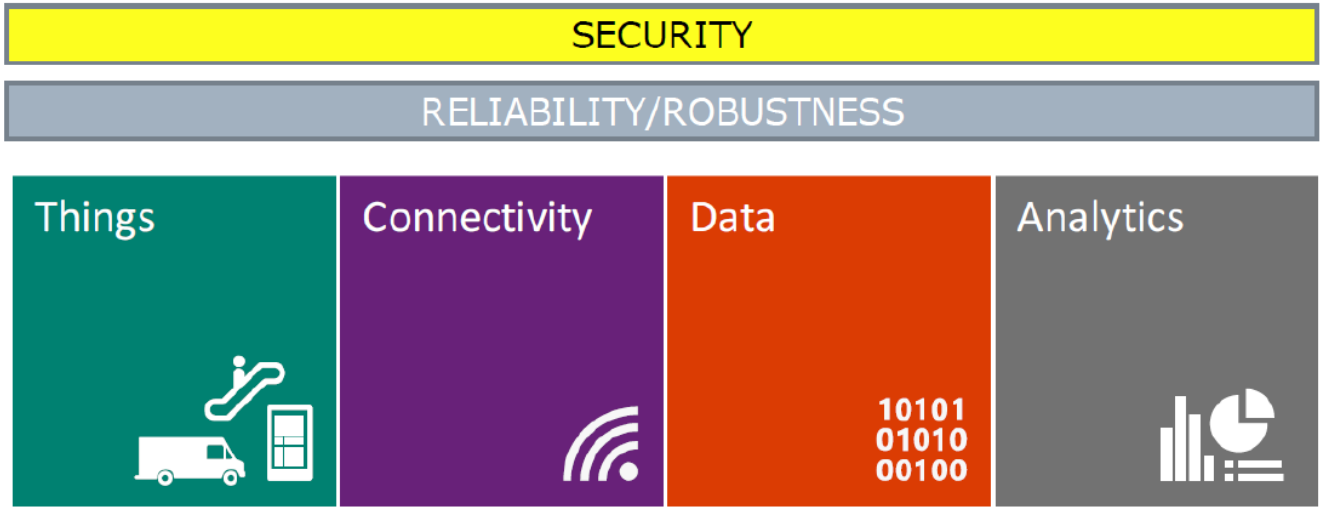
- Introduction
- IoT Wearable Systems for Biosignals Monitoring
- Wireless Technologies for Biosignals Monitoring
- Conclusion
- Future Work

Introduction (1/3)

What is the Internet of Things (IoT)?

- An information network that encompasses a large family of smart applications.
- An interconnection of a massive number of small, low-cost and low-power physical objects.

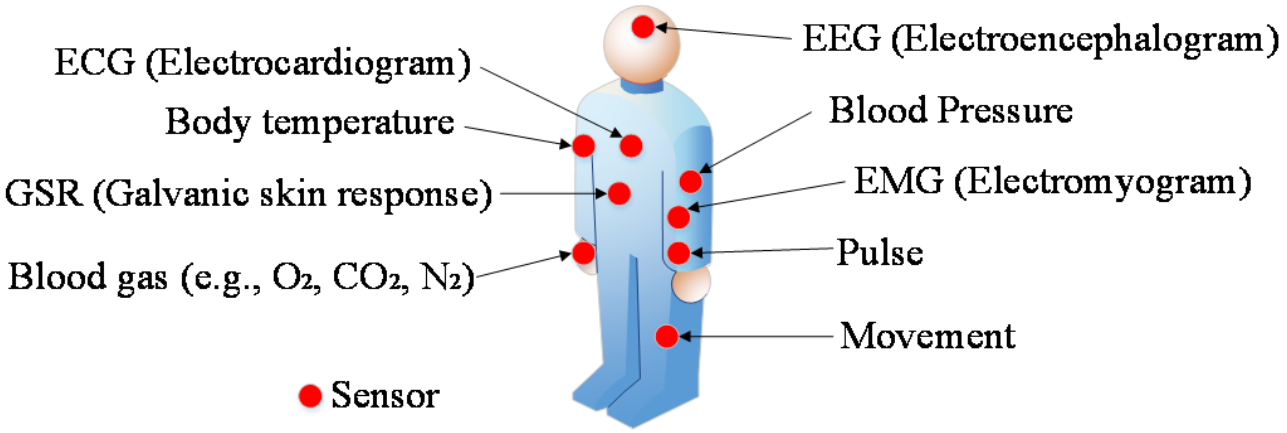
IoT Building Blocks



Introduction (2/3)

IoT & Healthcare

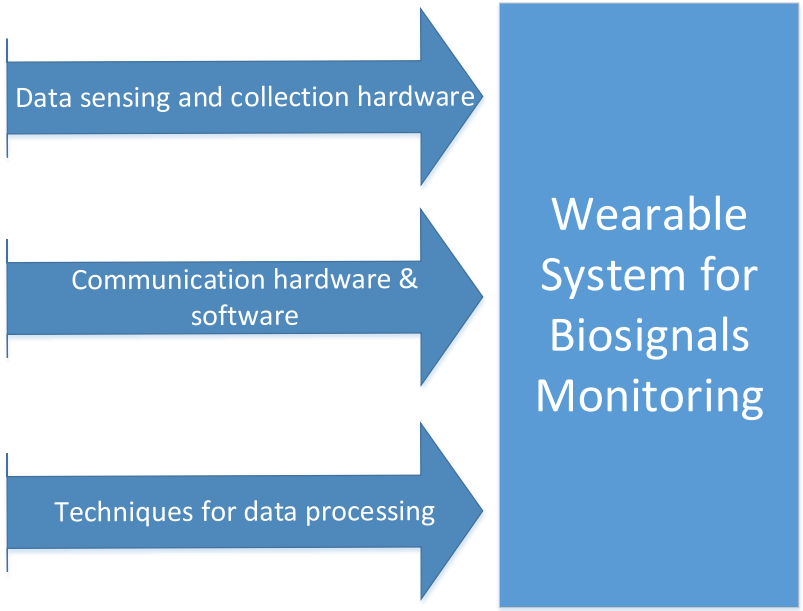
- The IoT has emerged as a key enabler for the provision of challenging healthcare applications.
- The wearable technology has been widely adopted to fabricate assisting devices that focus on various categories, such as elderly people.
- The wearable systems contain non-invasive sensors, which are used to measure physiological or biomechanical signs.



Introduction (3/3)

IoT & Wireless Technologies

- Wearable monitoring systems and IoT have been directly linked to wireless communication technologies, which enable the data interaction of devices worn by elderly people in real time with other proximate or remote wireless nodes.
- The adoption of advanced communication technologies facilitates the efficient, flexible, and cost-effective data collection from biomedical sensors and then the transmission of health data to central IoT nodes.



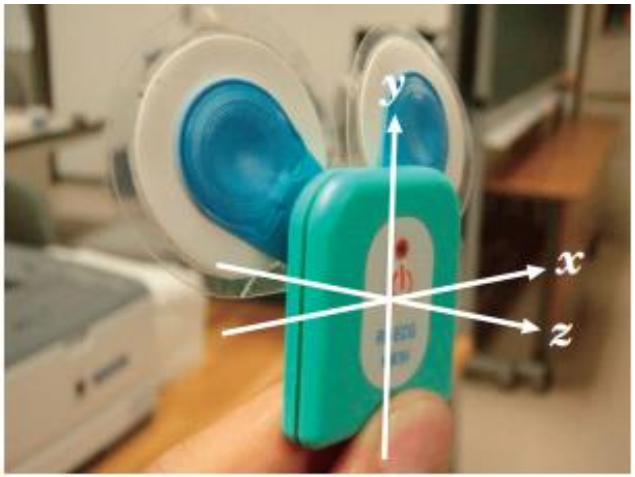
IoT Wearable Systems for Biosignals Monitoring (1/4)

Recently developed wearable devices

- "Abuelometro" is a system that can store and monitor vital signs and can be used in an elderly care facility to help caregiving staff monitor elderly residents.

  [Durán-Vega et. al. DOI: 10.3390/geriatrics4020034]

- An abnormal condition detection system that observes ECG, triaxial acceleration and skin temperature was proposed by S. Yazaki et.al.. In case abnormal conditions are detected, caregivers and relatives can be notified by email.



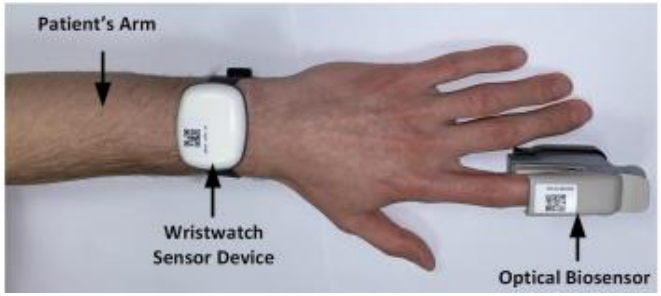
[S. Yazaki et.al. in Proc. 47th Annual Conference of the Society of Instrument and Control Engineers (SICE) of Japan, pp. 2234-2238, 2008.

IoT Wearable Systems for Biosignals Monitoring (2/4)

Recently developed wearable devices

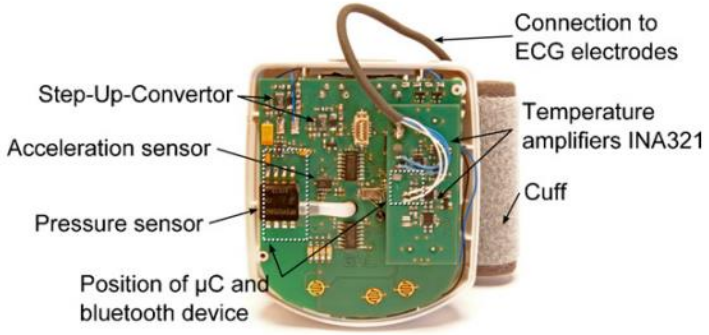
- A device that can monitor vital signs in real time was presented by Kumar et al.. It includes an optical sensor using the Photoplethysmography (PPG) method, in order to monitor the blood change of the vessels, as well as a printed Radio Frequency (RF) antenna. The communication protocol used is the Mi-Wi.

[S. Kumar, et al., Sensors, vol. 20, no. 6, p. 1675, Mar. 2020.



- A wearable device able to record blood pressure via ECG electrodes along with body and environmental temperature was presented by Zheng et al.

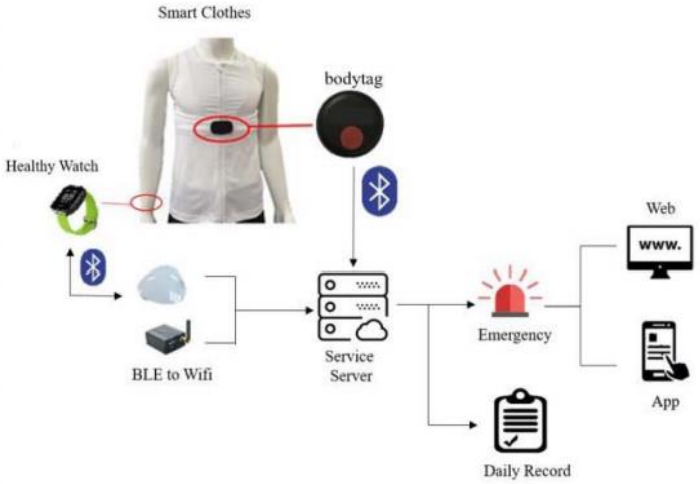
[Zheng et. al. DOI:10.1007/s10916-016-0558-6]



IoT Wearable Systems for Biosignals Monitoring (3/4)

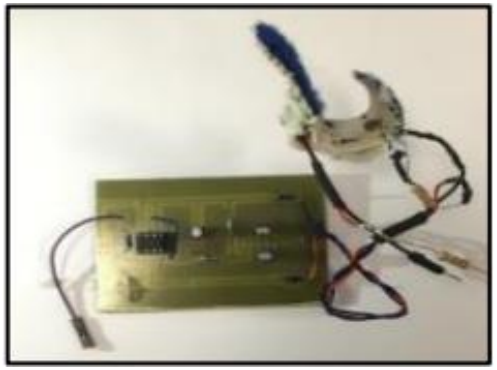
Recently developed wearable devices

- A system capable of monitoring vital signs and alerting caregivers in case of an emergency was presented by P. Huang et. It consists of a health watch with an attached optical sensor for PPG measurements, smart clothes (vest) constructed of conductive fiber, in order to collect the ECG signals and a body tag, incorporating a 3-axis accelerometer and gyroscope for body movements monitoring.



[P. Huang et. al, in Proc. Prognostics and System Health Management Conference (PHM-Paris), Paris, France, pp. 249-252, 2019.]

- Cohen et al. presented an optical cuffless PPG sensor that monitors blood pressure and heart rate in real time and consists of a Light-Dependent Resistor (LDR) and a circuit with a Light Emitting Diode (LED) enclosed in an elastic material held to the user's finger.



[Cohen et. al., DOI:10.1109/JSEN.2017.2704098]

IoT Wearable Systems for Biosignals Monitoring (4/4)

Recently developed wearable devices

- A vital signs collector and a wearable device called “smart clothing” embedded a Negative Temperature Coefficient (NTC) thermistor for temperature monitoring was proposed by L. Hu et. al.

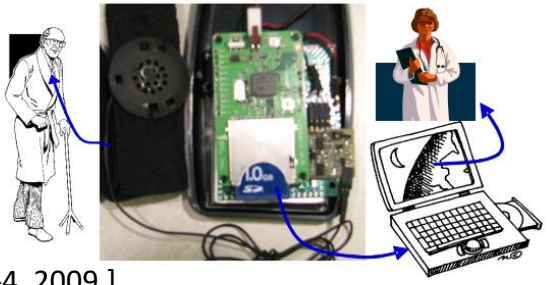
  [L. Hu et. al. Future Generation Computer Systems, vol. 86, pp. 329-338, Sep. 2018.]

- The SMARTA project was demonstrated by L. Pigini et al., who developed and tested a personal health system by integrating environmental sensors and wearable devices, to telemonitor vital signs and detect anomalies.

  [L. Pigini, et al., Gerontology, vol. 63, no. 3, pp. 281-286, 2017.]

- A. Dinh et al. presented a wearable device for monitoring elderly people. An individual can use this device to collect physical activity data on a memory card. An accelerometer, a gyroscope, and a heart rate sensor are used to track activities and vital signs.

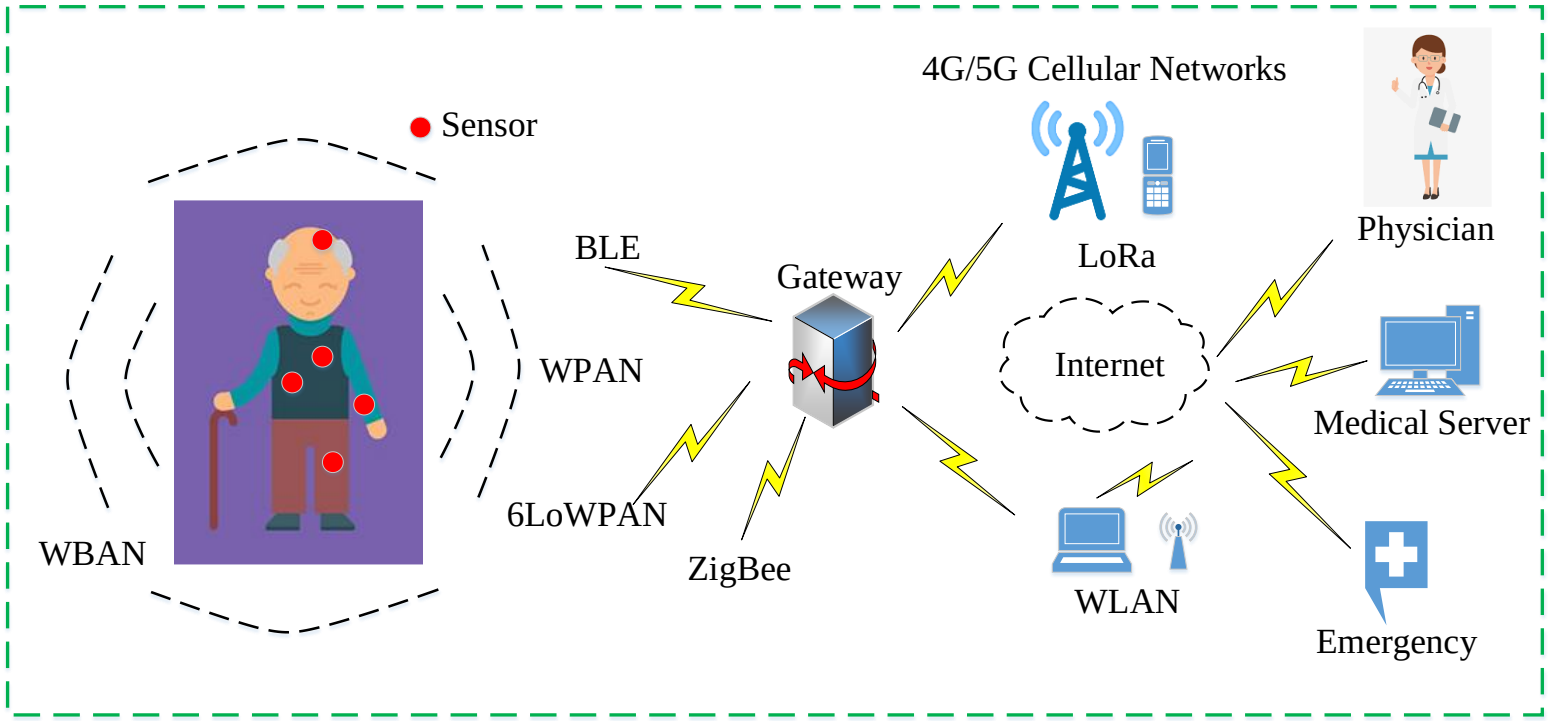
  [A. Dinh, et al., in Proc. 3rd Int. Conf. on Bioinformatics and Biomedical Engineering, pp. 1-4, 2009.]



Wireless Technologies for Biosignals Monitoring (1/7)

- The wearables inherently have constraints in terms of computation, memory, energy, and operational cost.
- Appropriate lightweight protocols (e.g., Constrained Application Protocol (CoAP), Message Queue Telemetry Transport (MQTT), and Extensible Messaging and Presence Protocol (XMPP)) have been adopted to enable the interaction among devices.
- The local connectivity in IoT-based wearable systems is provided by means of a Wireless Local Area Network (WLAN) or short-range wireless networks, such as the Wireless Personal Area Network (WPAN).
- One or multiple appropriate radio access technologies can be used, e.g., BLE, ZigBee, and IPv6 over Low-Power Wireless Personal Area Networks (6LoWPAN).
- Long-range wireless connectivity can be achieved using conventional, i.e., Fourth Generation (4G) and Fifth Generation (5G) cellular networks, satellite networks, and Low-Power Wide Area Network (LPWAN) technologies, e.g., Long Range (LoRa), Sigfox, and Narrowband-IoT (NB-IoT).

Wireless Technologies for Biosignals Monitoring (2/7)

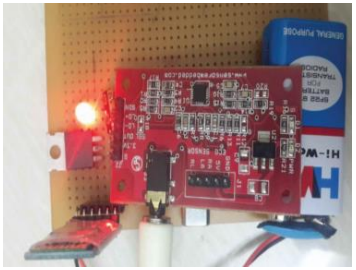


A wearable sensor network and relevant short-range and long-range wireless communication technologies for biosignals monitoring of elderly people.

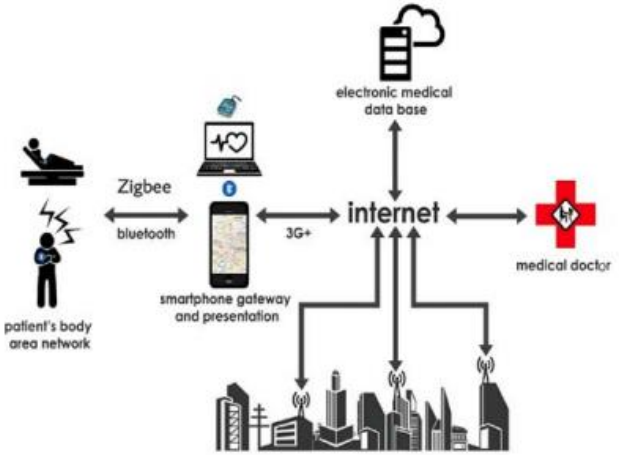
Wireless Technologies for Biosignals Monitoring (3/7)

Recent Work

- An Arduino-based deployment with Bluetooth capabilities for ECG measurement.



- A low-cost and energy-efficient TI MSP430 microcontroller with a ZigBee/Bluetooth module that monitors heart rate, temperature, humidity and accelerometric data.

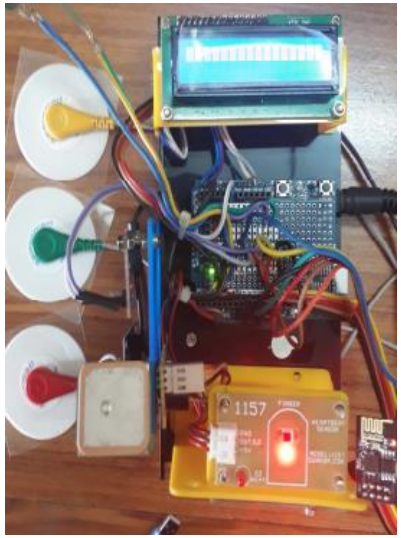


- A Raspberry Pi for remote elderly care. The health information is transferred using a WLAN or a PAN and a Bluetooth modem.

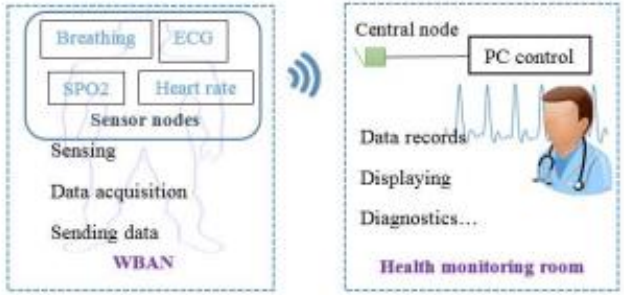
Wireless Technologies for Biosignals Monitoring (4/7)

Recent Work

- Extended connectivity for measuring ECG, heart rate, body temperature and blood pressure using IEEE 802.11 Wi-Fi, Global Positioning System (GPS) and Radio-Frequency Identification (RFID) technologies along with the ThingSpeak IoT platform.



- A large number of patients can be connected to the computer systems using a nRF24L01+ low power transceiver and the Enhanced ShockBurst protocol, whereas the measured data can be visualized using the NI LabVIEW.

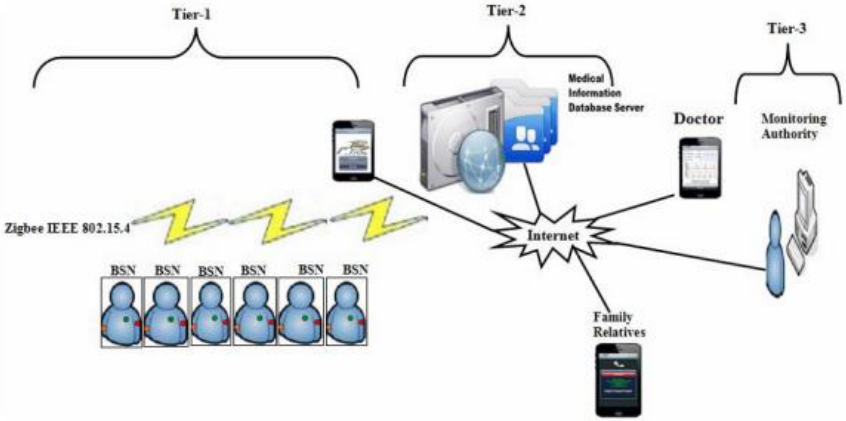


Wireless Technologies for Biosignals Monitoring (5/7)

Recent Work

- Several wireless technologies (i.e., 6LoWPAN, ZigBee, BLE) and protocols (i.e., CoAP and MQTT) can be combined to obtain reliable sleep apnea diagnosis.

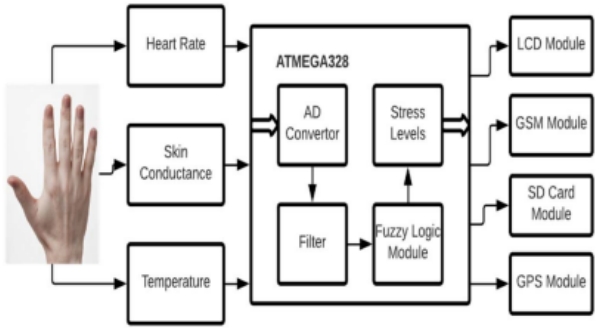
- A monitoring system for elderly care that uses a Zigbee-based Body Sensor Network (BSN) and the patients' smartphones to store and send the measured health information to remote servers.



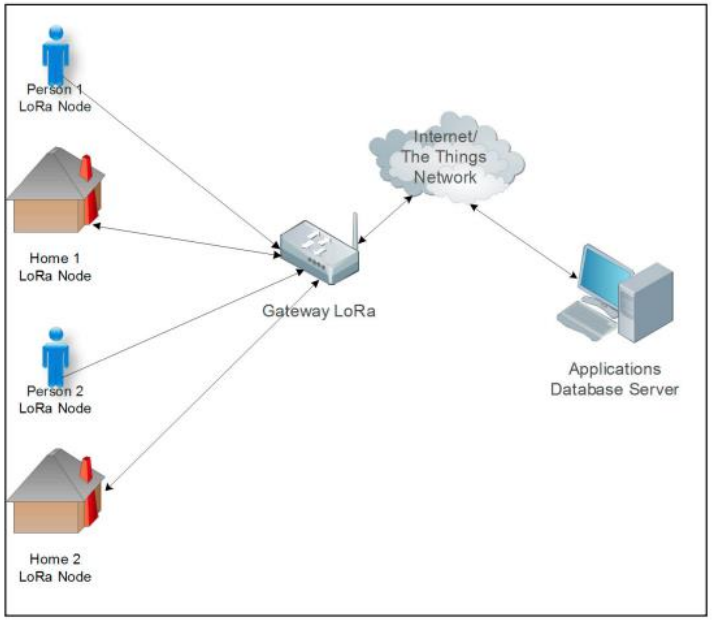
Wireless Technologies for Biosignals Monitoring (6/7)

Recent Work

- A Global System for Mobile Communications (GSM)/GPS-based module that enables mobile monitoring and attribute in real-time the stress levels of patients by measuring the heart rate, skin resistance and body temperature.



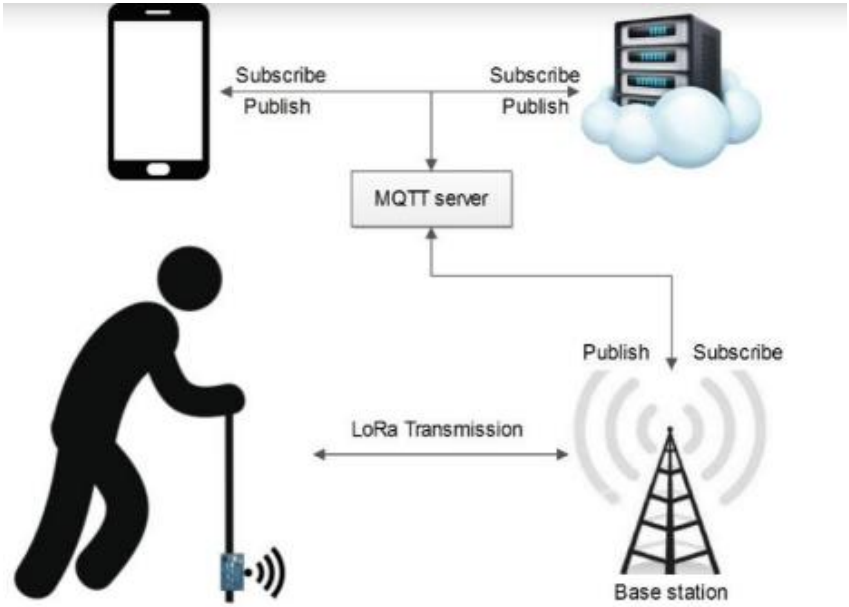
- A cost-effective IoT system and a LoRa-based gateway that monitor the health condition of elderly people located in their residence, thus improving their quality of life.



Wireless Technologies for Biosignals Monitoring (7/7)

Recent Work

- The combination of LoRa and the MQTT protocol.



Conclusion

- The role of advanced wearables and wireless technologies in the IoT-based biosignals monitoring area for effective elderly care has been described.
- The system implementation of various wearable devices has been presented, including the sensors, measurement techniques, vital signs detection methods, communication process, and fabrication forms.
- Both conventional and low-power wireless technologies can drastically change the landscape of medical industries and strongly support the evolution of IoT-based wearable systems.

Future Work

- There are several issues that require further investigation, such as mobility, heterogeneity, interoperability, scalability, security, and privacy.
- An interesting research area stands for the application of Machine Learning (ML) algorithms to accurately predict risk and dangerous or harmful situations for elderly people.
- Jointly adopting Device-to-Device (D2D) and Mobile Edge Computing (MEC) to enhance the computation capacity of the network is also envisioned.

Thank you!