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High-Rate Full-Duplex Optical Wireless Data Transmission for Medical Applications

Jahid HASAN[1,2], Ali KHALIGHI[1], Jorge GARCIA[2]

[1]*CNRS, Aix Marseille Université, Centrale Marseille, Institut Fresnel UMR 7249, 13013 Marseille, France*

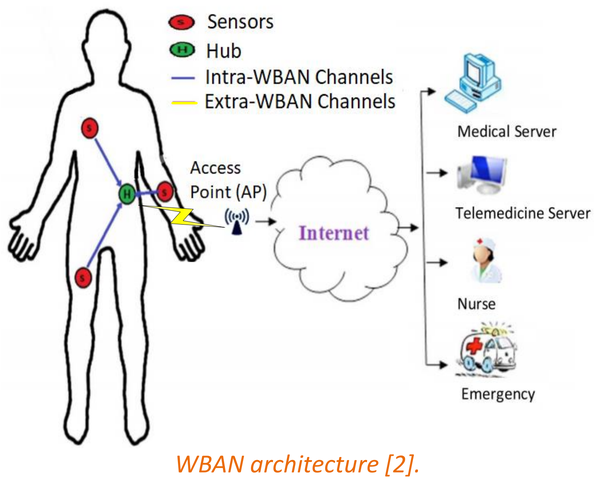
[2] Oledcomm SAS, 10-12 Avenue de l'Europe, 78140 Velizy-Villacoublay, France

Abstract: Health monitoring of aged people from a remote distance and continuous monitoring of patients in medical centers or hospitals is very crucial to avoid receiving wrong medical treatments. This can be accomplished by sending timely data from several medical devices via a wireless body-area network (WBAN). WBANs based on radiofrequency technology are susceptible to electromagnetic interference and potentially suffer from security concerns. Optical wireless communications (OWC) have evolved as a more appropriate technology for wireless data transfer within WBANs.

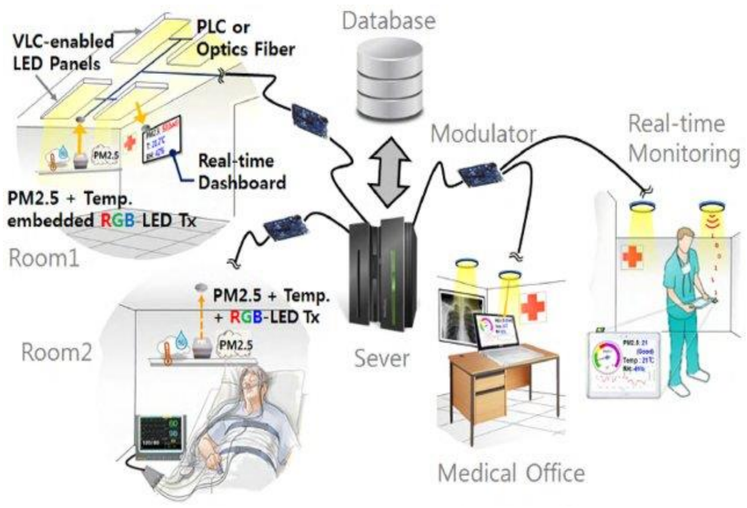
The main objective of this thesis is to design and develop a high-rate full-duplex transmission link for medical WBANs. We investigate OWC transmission between an access point (AP) and a number of users for downlink and uplink data communication. Particular attention is devoted to the suitable modulation and multiple access techniques insuring reliable data transmission in different use cases.

Wireless Body Area Networks

- Promising technology that provides a remote mechanism to monitor and collect a patient's health record data using wearable sensors.
- Network architecture is classified as intra-WBAN (on-body communication between sensors and a hub) and extra-WBAN (communication between the hub and an external network or AP) [1].



WBAN architecture [2].



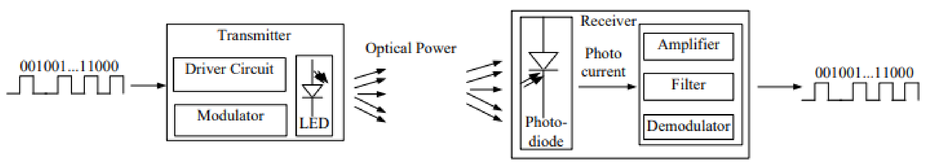
VLC in Hospital environment monitoring [3].

Interest of Optical Wireless Communications

- Conventional RF-based WBANs are subject to electromagnetic interference in contrary to OWC-based ones.
- OWC networks are confined within the room boundaries, thereby enhancing security.
- OWC offers license-free huge unregulated spectrum.

OWC Transmission

- Data is transmitted using intensity modulation/direct detection.
- On-off keying is used (relatively low data rates are required: ~Mbps at most).
- Data can be received from both LOS and NLOS.



Basic transmission blocks in a VLC system [4].

Full-Duplex Transmission for Extra-WBAN

- We use visible-light communications (VLC) for downlink data transmission and infra-red communications (IRC) for uplink.
- Hub or coordinator node is placed on the patient's body consisting of an IR transmitter (LED) and a VLC receiver (photodiode).
- Focus is made on uplink (IRC).
- The data collected by the hub from sensors are sent to the AP placed on the ceiling.

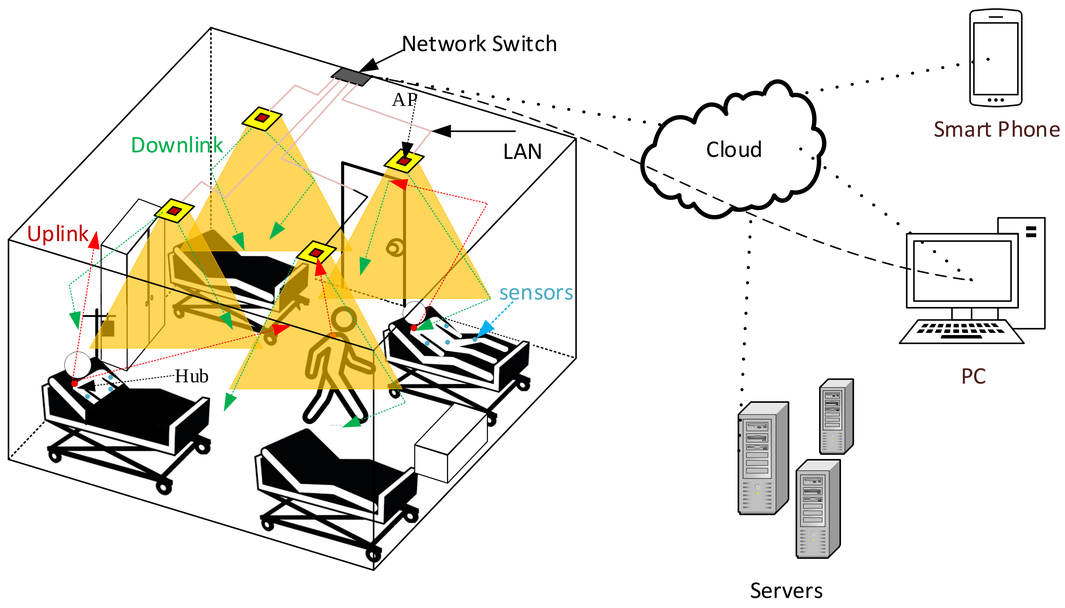
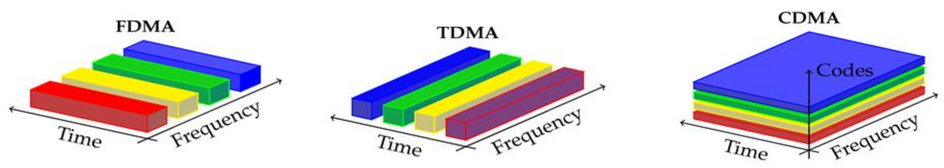


Illustration of a VLC based WBAN scenario in a hospital environment.

Multiple Access Techniques

- Need to handle multiple users in a room.
- Design of suitable multiple Access (MA) technique to manage multi-user interference.
- Classical MA techniques: FDMA, TDMA, CDMA.
- As OWC systems transmit real and non-negative information signals, such MA schemes (in their basic form) should be appropriately adapted to the optical domain.
- Our current work focuses on optical-CDMA.



Classical multiple access techniques in wireless communication.

Summary

After defining typical use-cases for multiple patients in different medical applications, we are investigating appropriate MA techniques taking into account user mobility and changing position and studying their robustness and performance.

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