

# Channel Modeling and Multiple Access Solutions for VLC-based WBAN Links

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**Abstract :** Wireless body area networks (WBANs), connecting a number of sensors placed around and inside the human body, are a promising technology in medical applications by improving healthcare services through, for example, patient monitoring and remote control of medical devices. Radiofrequency-based WBANs suffer from several drawbacks including the risk of electromagnetic interference, the specific absorption rate limitations near the body surface, as well as data security (i.e. vulnerability to eavesdropping), and multipath propagation. To overcome these limitations, visible light communications (VLC) have emerged as a viable alternative for wireless data exchange between WBAN nodes.

In this thesis, realistic indoor VLC channel modeling and characterization of in- and on-body WBAN links will be performed. The effects of body configuration, its position inside the room, and the placement of sensors will be taken into account as well. Also, we will work on the development of optimal multiple access (MA) techniques and efficient physical and upper-layer signaling schemes for interconnecting medical sensors, while satisfying the requirements of user mobility, low energy consumption, and low implementation complexity. Furthermore, we will propose efficient solutions for time synchronization and MA interference management. Experimental verification of the developed VLC-based network will be done at the last stages of the thesis.

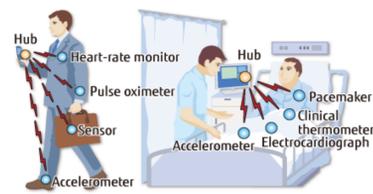
## Introduction

### Wireless Body Area Networks

- WBAN is a promising technology in providing services for patients and healthcare professionals
- Management of chronic conditions or detection of health emergencies can be greatly enhanced by the use of WBANs

#### Challenges for RF-based WBANs:

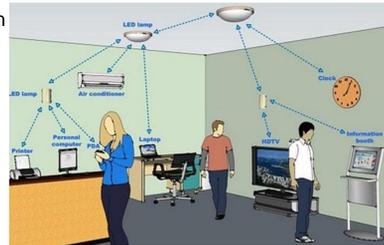
- RF signals are subject to high attenuation, multipath fading, and shadowing
- RF radiations have to be avoided in sensitive environments (i.e., hospitals): interference with other equipment, impact of radiations on the human body



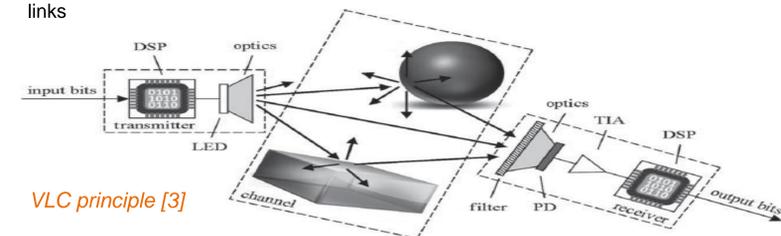
WBAN for health monitoring [1]

### Visible Light Communications

- VLC : alternative and/or complementary solution for future indoor RF networks
- Reducing RF interference
- Offering a huge unregulated bandwidth, and enhanced transmission security
- LED at Tx, photo-detector at Rx
- Communication can be realized via LOS/NLOS links



VLC applications for indoor environment [2]



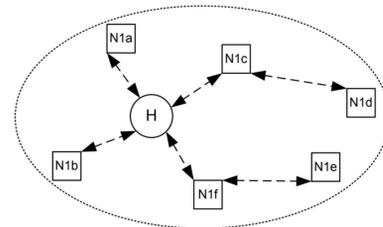
VLC principle [3]

## PHY Layer Design

- Appropriate modulation and coding techniques should be used based on the channel characteristics
- Design of suitable Multiple Access techniques
- Minimizing Outage probability and link Bit-Error-Rate, design of equalization techniques

#### • Network Topology:

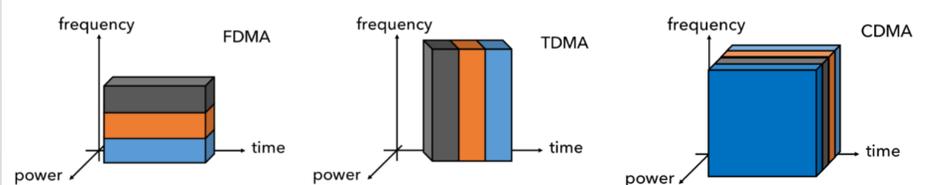
- Star topology: multiple nodes communicating with a single central (coordinator) node
- Relay nodes can be inserted to increase link reliability at the cost of increased complexity and delay latency.



Two-hop extended star topology for WBANs [4]

## Multiple Access Solutions

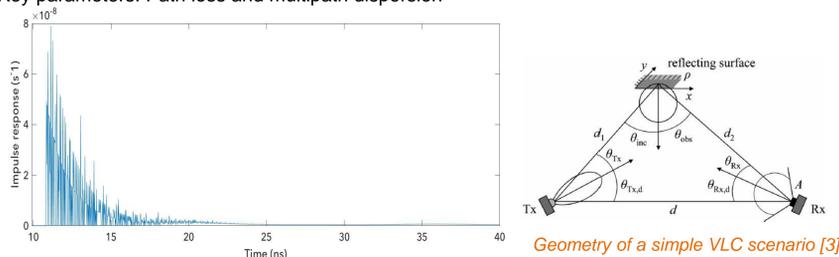
- The coordinator node must be able to serve multiple nodes as well as multiple users simultaneously.
- Classical MA techniques used in cellular radio systems such as TDMA, FDMA, and CDMA



Classical Multiple Access Techniques

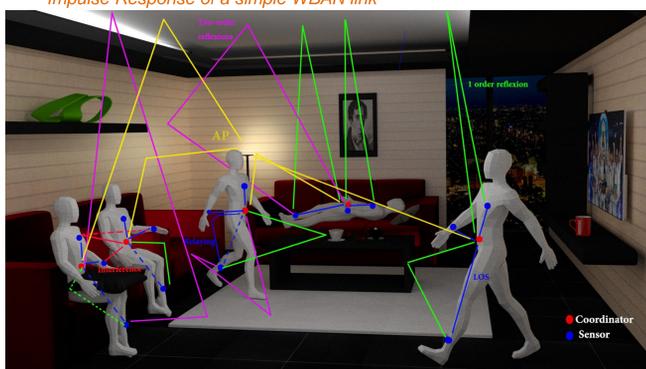
## Channel Modeling

- Intensity Modulation/ Direct Detection : IM/DD
- Need to accurate channel characterization to understand the performance limitations and design issues
- Key parameters: Path loss and multipath dispersion



Impulse Response of a simple WBAN link

Geometry of a simple VLC scenario [3]



Communication scenarios illustration in Optical WBANs

## Conclusion

We aim firstly at characterizing a realistic indoor VLC channel model while taking into account effects of body configuration, its position inside the room, and the placement of sensors. Also, we will develop optimal MA techniques, robust physical and upper-layer signaling schemes and efficient solutions for time while satisfying constraints of user mobility, low energy consumption, and low implementation complexity.

## Acknowledgments

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## References

- [1] B. Buckiewicz, FCC requirements for medical Body Area Networks (2012), <https://www.lsr.com/white-papers/fcc-requirements-for-medical-body-area-networks>
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- [3] H. Hass, D. Svilen, *Principles of LED Communications: Toward a Networked LiFi*, Cambridge Univ Press (2015)
- [4] IEEE Std 802.15.6 – Part 15.6 (2012)