Optical Wireless Communication for the Internet of Things

The IoT (Internet of Things) has become a well-known concept in all fields of engineering. It is an ecosystem where different kinds of end-devices, interacting with each other through a network, are connected to the internet. This enables us to build either automated systems that can send information about their current state in the network, or networks of environmental/health sensors. The most commonly used information technologies in the IoT are mainly wireless solutions [1]: Bluetooth, WSN (Wireless Sensor Networks), ZigBee, NFC (Near Field Communication), low energy wireless protocols, LoRa (WAN), and others.

In this contribution, Optical Wireless Communication (OWC), which encompasses the communication technologies that use the license-free visible (Visible Light Communication (VLC)), infrared, or UV spectrums to transmit data, is introduced as a complementary solution to the classical wire and wireless offers that already exist [1].

A conventional VLC system has a light source as a transmitter and equipment sensitive to light variations as a receiver. The light source is often chosen between a Light Emitting Diode (LED) or a Laser Diode (LD). On the receiver side, a photodiode (PD), a camera (Optical Camera Communication (OCC)), or a solar panel can decode the data. In most bidirectional applications, VLC is used for downlink and infrared communications for uplink for eye safety sake. In the VLC communication segment, as data is encoded in the intensity of the light, a VLC system can combine illumination and communication into one setup.

Field deployed applications of OWC systems already exist in domains such as healthcare (Wireless Integrated Medical Assistance Systems, Optical Body Area Network) [2], smart cities (ITS Intelligent Transportation System, Smart furniture) [2][3], industrial (IIOT) (Wearable VLC device for safety in an industrial environment, actuators of robot arms being triggered by VLC) [5]. These are also the main ones targeted by IoT, which underline their great interest as communication systems. Furthermore, the high penetration rate of LED lighting makes this particular technology relevant to most sectors.

In order to stimulate the use of OWC in IoT, the 2018 IEEE 802.15.7 standard [6] is a keystone as it includes low to moderate data rates. The topologies available within that standard are to be chosen between star, peer-to-peer, and broadcast, making OWC usable either in the sensing layer (between sensors) and the network layer (to connect the gateway to the processing units) of IoT networks. The main networked application of OWC is Li-Fi (Light-Fidelity), which is the "enlightened" version of Wi-Fi (Wireless-Fidelity).

Nowadays, many European projects working on VLC technology also study its use in IoT. In this context, we can mention e.g., the VISION and Wal-e-Cities projects. One of the objectives of the latter is to study the use of OWC for smart city use cases in Wallonia, Belgium.

In smart cities' scope, applications including sensors measuring quantities like air quality, space occupancy, or visibility, all of them distributed everywhere along the streets can be envisioned. Those applications are designed to be energy efficient as they can run on batteries, and, in a hybrid way, to transmit data occasionally using wireless communication mediums up to a gateway. Streetlights can play the role of gateways by collecting data from surrounding smart street furniture and sensors and by sending them to be processed in the cloud. They can also send orders to actuators located under their light beam.

Furthermore, VLC can also be implemented for geolocation purposes. In this operation mode developed nowadays for an indoor environment, each LED lamp is given a unique ID that triggers relevant location-information on the end user's receiver. This concept can be scaled in a smart city to receive information at a bus stop or a smart signboard. Cars are currently being equipped with LEDs for their head and rear lamps. Some simple warning information coming from the car at the front could be sent to the one at the back, creating a V2V (Vehicle-to-Vehicle) communication path in heavy traffic conditions or car platooning operations. Traffic lights can also send messages regarding their state to the incoming cars (V2I Vehicle-to-Infrastructure communication).

Nevertheless, OWC for IoT is still an emerging technology that faces some challenges. The interference with artificial light and sunlight must be considered for both environments or the potential shadowing of the receiver. In general, the weather conditions are less critical for IoT applications due to the short communication distance and the scarcity of data exchanges.

On a bright side, OWC has an excellent potential to stand alongside the other IoT communication technologies bringing some specific advantages of using this part of the spectrum as OWC can work in RF-sensitive areas (avoidance of Electromagnetic Interference (EMI)), the existing infrastructure can be used (thanks to the increasing deployment of LED lighting) and communications are secure (light does not penetrate walls so no attacks from outside the room can happen nor from outside the glowing halo).

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