Light Fidelity (LiFi)

The new wireless communication system

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Abstract— **Optical Wireless Communications (OWC) refer to communication based on the unguided propagation of optic waves. This technique was the only wireless communication solution for millennia and the past 30 years have seen a significant improvement in two main areas: Outdoor applications, i.e., FSO (Free Space Optic), communications between satellites or ground/air transmission; and Indoor application like the remote controller and Light Fidelity (LiFi) system. Orange Labs has investigated, through open innovation, the potential for PmP (Point to multiPoint) indoor application of this technology. Light Fidelity solution may be a wireless alternative to radio systems and could gain attractiveness in case of saturation of the radio spectrum. The paper will present an overview of optical wireless communication technologies, the ecosystem and standards. Before conclusion, some use cases are presented.**

Keyword-Light Fidelity (LiFi); Visible Light Communication (VLC); Infrared Communication (IRC); Optical Wireless Communication (OWC); user requirements; business cases.

I.   INTRODUCTION

Optical Wireless Communications (OWC) or Light Fidelity (LiFi) refer to communications based on the unguided propagation of electromagnetic radiation with frequencies over 30 THz [1]. The system performance (distance, coverage, etc.) is related to the propagation type, from the diffuse system, with wide field of view and low data rate (such as the remote controller) to Line Of Sight (LOS) systems, which could provide less coverage and higher data rates.

Facing the growing needs for high data rate and wireless connectivity, estimated to 50 billion of devices by 2020 [2], LiFi is an alternative solution to the radio system with several advantages over "Light and Communication":

With a large and license free spectral availability, more than 700 000 GHz, this is an alternative solution to radio spectrum crunch mentioned by Ericsson and Cisco [3].

For the security aspect, light does not pass through walls and there is non-interference with radio devices.

The radiofrequency wave customer sensitivity is growing in Europe with 46 % customers "concerned about potential health risk of electromagnetic fields" [4] and in the world with World Health Organization (WHO) radiofrequency classification (2B) means "Probably carcinogenic to humans" [5].

In the context of French Techimages [6] and European FP7 Omega [7] projects, studies and development have shown proofs of concept with, for instance, 16 LEDs on a ceiling broadcasting 100 Mbps on 5 m^2 coverage; infrared prototype with high data rate bilateral solution (1.25 Gbps) over 1 m^2 coverage and 300 Mbps over 30 m^2 coverage. Currently, there is no available commercial product because availability and maturity of radio solutions currently do not leave market share for alternative solutions. Nevertheless, the LiFi market drives now several important economic players.

II.   LiFi MARKET

The digital development was favored by games consoles and laptops specifically dedicated to the content management and internet connectivity. Smartphones and tablets come to complete the multimedia terminals landscape and constitute the newest trends.

To propose OWC as an alternative to wireless systems, several specifications were finalized during the last years OWMAC [7], VLCC [8] and IrDA [9]. The IEEE 802.15.7 [10] is the most active one with a recent revision process able to propose, at least, spectrum extension (infrared and ultraviolet) and Optical Communication for Camera (OCC) on smartphone or tablet.

LiFi business has a lot of technical "bricks" already available, even if several visions exist according to the actors and their respective business sector (see Figure 1).

- The LED lamp manufacturers area is still undergoing restructuring, especially in Europe.
- LiFi manufacturers propose already some commercial products and services such as LBS (Location Base Service) or Broadcast solution.
- Some devices manufacturer work to potentially integrate OCC and Emitter for LiFi communication.
- Operators wish to enrich the offerings with new features and answer to users' expectation.
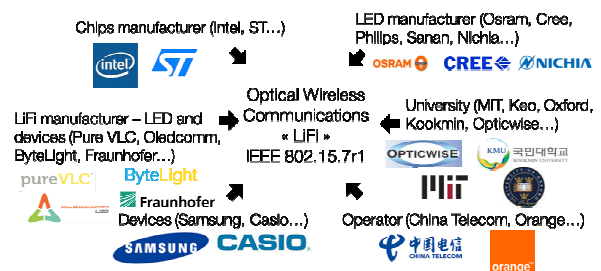

Figure 1. LiFi actors

III.   CHALLENGES FOR TECHNOLOGY

To become a successful story, LiFi systems need important levers adapted to users' expectations or new use cases.

The European Acemind [11] project worked on an analysis of European users' point of view about LiFi, with brainstorming, face to face interviews and focus group sessions (France, Germany and Turkey). The main results are:

- Despite Wifi satisfaction, customers expecting solutions face to its weakness: radiofrequency radiation, security management and reliability.
- Users have quickly integrated the concept, it is intuitive (beam = communication) but their main request is focused on full duplex communication (symmetric or asymmetric) product.
- However, there is still open questions: what about the installation to the ceiling, the integration to the device and the potential extra cost, is there any solution to have 5G outdoor communication and LiFi indoor communication with handover, how to manage no light and data, how to manage several LiFi lamps…

Concerning the use cases, a lot of applications are not only dedicated to the home networking perimeter. For instance (see Figure 2), after LBS, Intelligent Transport Services (ITS) could be a massive application opportunity with low data rate by using LED lamps cars, traffic signal, traffic lights, and street lamps for communication [12].

Another potential application is Fast Content Delivery (FCD) for devices like smartphones or tablets on airports, trains or tube stations with LiFi solution.

The application considered as the most promising one is the Wireless Local Area Networks (WLAN) or Indoor Networking in nomadism situation with LiFi lamp on ceiling and integrated LiFi module on smartphone, laptop or tablet. The first markets could be museums, banks, maternities or schools with high added value applications where precise location and/or minimum interference are expected with existing equipment and appliances.

Currently, the video transmission is the "greediest" application in bandwidth, but the quality perceived by the customer is defined by first the screen size (laptop, tablet or smartphone). For those devices, an Orange Labs study [13] showed a video quality perception less discernible between a 720p and Full HD format over 14 inches screen size. This is equivalent to 5 Mbps data rate with Mpeg4 (or H264) video file transmission format for one user. In addition, it is advisable to take into account the next new coding formats such as HEVC (H265) [14]. With the same quality, the throughput can be reduced to 2.5 Mbps and with existing modulation solution (OFDM/DMT) the frequency baseband could be under 250 kHz. This modulation choice offers also a better resistance face to Inter Symbol Interference (ISI).

One of the Acemind project goals is to propose a LiFi demonstrator with Oledcomm partner. The final objective is to provide an asymmetric bilateral communication with two devices, one coordinator in the ceiling and one device plugged to a tablet or a laptop.

IV.   CONCLUSION

In this paper, we have presented a LiFi overview, the ecosystem and a standardization process. Some use cases have also been defined.
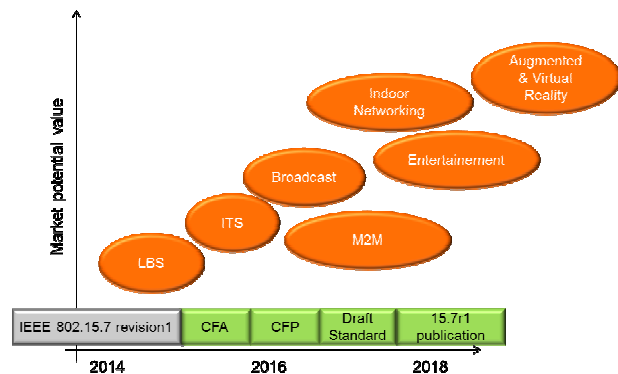

Figure 2. LiFi roadmap

Now, companies want to "crossing the chasm" [15] and are looking for cost effective applications. Currently, LBS (Location Base Service) or Broadcast solution are commercially available. The next step could be a LiFi WLAN for B2B market with high added value on specific business cases and could grow towards mass market. In the long term, the LiFi could become an alternative solution to radio for wireless high data rate room connectivity and new adapted service, such as augmented or virtual reality.

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