Potentiality of a Bi-directional System Based on 60GHz and VLC Technologies for E-health Applications

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***Abstract*-To support the E-HEALTH services, a locatable, radiation-free and high-capacity communication system is urgently needed in Hospitals. In this paper, a bi-directional system is proposed combining 60GHz technology for the uplink communications and VLC downlink communications in order to offer new services of HD files as well as indoor localization. Meanwhile, state-of-the-art localization techniques based on mmW will be presented.**

I. INTRODUCTION

The unlicensed 57–64 GHz range provides significant advantages compared to the lower part of the microwave spectrum. First, very high data rates (up to 5 Gbit/s) can be reached thanks to the large available spectrum (7 GHz worldwide). Secondly, the free-space loss around 60 GHz due to the atmospheric oxygen induced absorption results in a high level of security and low interference with adjacent networks. Finally, the size of on-body devices is strongly reduced compared to similar systems operating at lower frequencies [1].

Particular interest of 60GHz is paid to the medical applications where the body sensors deployed around the wearer can collect significant amount of health parameters (i.e. temperature, blood pressure, etc.) for long term recording and process them to some central collecting node.

The objective of this project is to design a broadband network architecture that is integrated with the light network in the room.

Visual Light Communication is taken into consideration mainly due to its convenience as LED lights are necessary and everywhere in hospitals. Since it can only transmit in one way [2], VLC is used as a downlink to transfer instructions and alerts in this scenario.

As a bonus, 60GHz can also be used for localization of patients. Different localization techniques will be discussed in this paper.

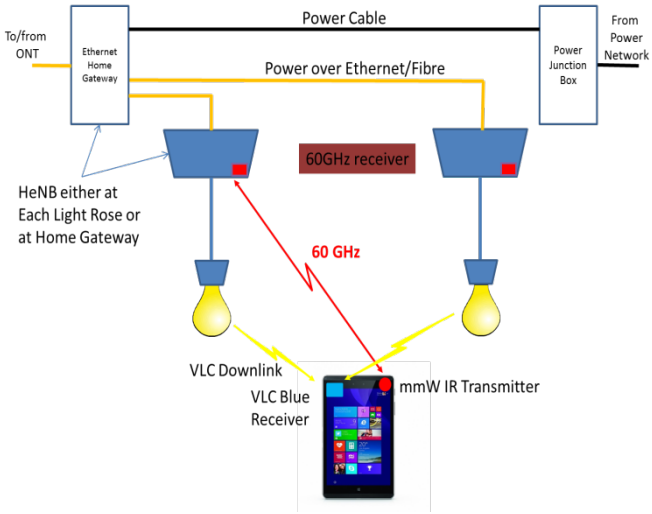


Figure 1.Construction of 60GHz uplink and VLC downlink in hospitals

II. BI-DIRECTIONAL VLC & 60GHZ SYSTEM SCENARIO

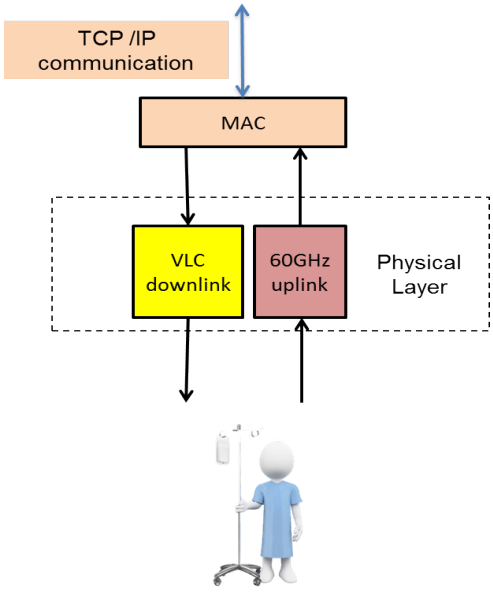


Figure 2.simplified picture of the whole system of different layers

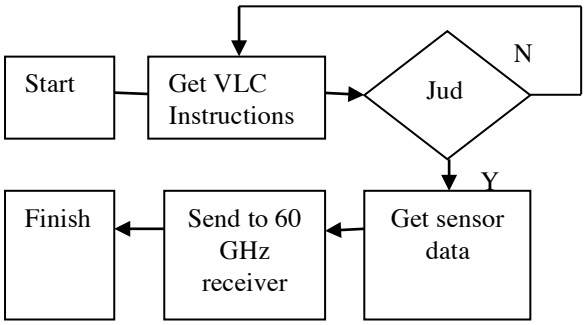
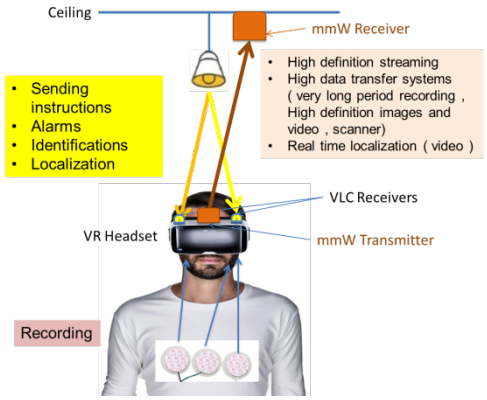


Figure3. Flow chart of the operating principle

In figure 1, a real scenario in a room or corridor of a hospital with 60GHz and VLC systems is presented.

Thank to on body sensors, it is possible to transmit important health information such as EEG, ECG to the receiver antenna using the 60GHz link. Afterwards, all the data are transmitted to different terminals so doctors will be able to monitor the patient's health condition in real time through Ethernet or ad WI-FI standard (IEEE 802.11.ad). As for VLC, it is used to give instructions and alerts. If the doctor wants the information now, VLC will be used to give the



instruction since LED is always needed in a room.

Figure4. Scenario of use

For example, the doctor wants the information of a patient whose ID is 002. VLC transmits the instruction of finding the ID 002. After the patient is located, the sensors are activated, and data will be sent to a transmitter antenna. By 60GHz link, the receivers on wall will get the data and transmit to different terminals.

There is a great advantage of 60GHz communication in e-health. Due to its wide band width, big amount of information such as images with very high definitions (scanners, videos) can be easily transferred. Moreover, long period of monitoring patients' health condition can also be possible. Secondly, The range of 60GHz transmission is between 1 meter to 3 meters for some Gbps communications, so that high security and low interference are insured. As long as enough receivers are placed on the wall, the information will not be affected by other electromagnetic waves for other uses.

In conclusion, as is shown in figure 3, VLC is used to give instructions and then the receiver on human body will judge if the instruction is for this specific person. If yes, then the sensors on body will be activated and the information will be transferred between two antennas, which is a 60GHz uplink. After that, different terminals will be able to get the information by Ethernet or optical channel.

III. LOCALIZATION TECHNIQUES

In this case, high-precision indoor localization is also demanded as the position of the patient is vital if anything urgent happens. Because of its high resolution, low power consumption, high multipath recognition and anti-interference ability, 60 GHz is suitable for locating under the indoor environment as well.

The four main localization methods are TOA, TDOA, AOA and RSS. TOA relies on the transit time between transmitter and receiver to determine the distance [3]. The TDOA method uses the differences of the arrival times measured on pairs of transmission paths between the target and fixed terminals [3]. Both two methods require very precise clock synchronization. The AOA method provides the angle of the incoming signal which requires an antenna array. The RSS method uses more than 3 receivers to measure the signal strength of the transmitter node, estimating the distance between the transmitter and the receiver. This method can be implemented without the need for additional hardware, timing synchronization and complex algorithms. Only the ability to read the Received Signal Strength Indicator (RSSI) is required. However, it can have significant variation in signal strength due to multipath effects, especially at larger distances [4].

In the literature there exists a scarce amount of material regarding localization exploiting the peculiar characteristics of millimetre waves. The following is a short survey of the state of the art regarding localization with millimetre waves.

Authors in [2] evaluate performance of RSS-, TDoA- and AoA-based localization schemes assuming the presence of several anchor nodes deployed over a circumference around the receiver. It is observed that the AoA approach achieves the smallest localization error because of the broad AoA spectrum diversity originating from the circular geometry of the anchor nodes deployment.

In [3], a method is developed for the estimation of the TDoA based on the interference between Orthogonal Frequency Division Multiplexing (OFDM) symbols from two different transmitters. The technique

makes it possible to leverage actual data communications for location estimation, without having to rely on a different, specific protocol.

In [4], the authors exploit Differential Time Difference of Arrival (DTDoA), an improved version of TDoA, which does not require synchronization between the anchor nodes. Time information is extracted from the 60GHz OFDM transmission frames exchanged by the node to be localized and, at least, 4 anchor nodes. The localization error of the developed system has been investigated, and showed a median of about 1m.

All four methods can be possible to locate the position at 60GHz, which are maintained further discussion.

IV. CONCLUSION

E-health services including 60GHz, VLC technologies and localization techniques are investigated and demonstrated. It was shown that in a real scenario of a hospital, how doctors can locate patients and get a large amount of health information in real time with a 60GHz uplink and VLC downlink.

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