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MODELING AND SIMULATION OF INDOOR VISIBLE LIGHT COMMUNICATION SYSTEM FOR USE IN HOSPITAL

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ABSTRACT

Visible light communication (VLC) becomes one of the promising technologies for new generation systems where communication and illumination both are considered an important factor. In order to achieve high speed indoor wireless system, optical wireless communication can be a feasible technology. Communication link quality in VLC systems can be improved by achieving a good link switching and mobility scenarios. For mobility scenarios full connectivity is needed in order to make the VLC system more practical. White LEDs are not only used for illumination but also for Visible Light Communication system. Usually plural lights are used in order to consider the optical path difference. In this paper, we consider two scenarios for indoor visible light communication system in a hospital environment for patient monitoring purpose. Both scenarios work on the principle of uniform and non-uniform lighting system for achieving seamless data connectivity.

Keywords- Visible Light Communication, SNR, link switching.

I. INTRODUCTION

For an indoor environment radio frequency communication faces many problems in order to meet the requirement of high data rate and network connectivity also have limited bandwidth and electromagnetic interference. Various indoor wireless communication systems have been proposed for future generation technology [1]. For this purpose, visible light communication (VLC) system becomes one of the alternative and corresponding technologies for radio frequency system. Visible light communication (VLC) uses light emitting diode (LED) for their communication purpose because it is capable of dual- functionality i.e. both communication and illumination. Visible light communication (VLC) has the merits of LEDs such as longer lifespan, smaller size, cooler operation and lower power consumption. But for an indoor environment, deployment of these high speed point-to-point system in real time is always difficult because requirements of the mobility, illumination and communication performance.

In Visible Light Communication, link switching is a significant factor to understand the "handover process" in cellular wireless transmission. In case of mobility, handover process considered as an essential process in order to maintain and improve the communication link [9]. Vertical handover between RF and VLC has been developed in many works in the literature [10, 11].When user wants to switch between receiving data of one light source to the other light source light horizontal handover does not attracts more attention. In order to reduce the unwanted link switching ratio and link switching delay, a new pre-scanning and received signal strength (RSS) prediction method is planned [12]. For designing a system, various parameters of indoor visible light communication system on a link switching algorithm is needed for signifying the control. To acquire this, overlapping area between LEDs is considered because switching process can be occurred in that area. Various overlap area conditions require various algorithms in the cellular wireless system. However, in reality this overlap area is large enough to provide continuous connectivity when switching process is takes place and this area also depends on starting algorithm and switching delay time [13].

Dual property of visible light communication system that is both communication and illumination, the LEDs operation affects both the number of cells and coverage area of an access point. Hence, handover for the system performance are firmly attached to the light configuration [13].

The optimization problem of LEDs is not attracts much attention because all concentration is on the LEDs distance optimization and signal to noise ratio (SNR). In specific cases, arrangement of LEDs is proposed in order to reduce the SNR variation in the room and also provide same SNR value for users in different room locations [14]. For different receiver conditions, two LEDs array optimum placement is achieved with the target of increasing the average area spectral efficiency [15], which is defined as the addition of the maximum bit rates per hertz per unit area in a cell. Furthermore, the concentration is on to examine how LED chips with LED array changes the performance of visible light communication system [16].

Visible light communication mostly depends on line-of-sight propagation for their transmission purpose. But line-of-sight configuration cannot be definite especially for an indoor environment because large no. of obstructions is present due to surrounding objects and mobile terminals random movement. Hence, Visible Light Communication system are not able to provide nonstop data access. In order to support the VLC and RF systems a newly heterogeneous network was investigated.

In a diverse visible light communication system and radio frequency network, high data rates are achieved when data distribution is done with the line-of-sight link and this link is also capable of providing mobile terminals (MTs) a noticeable Quality of Experience (QoE). Mobile Terminals (MTs) experience large QoE degradation because of the communication disturbance, when the Line-of-Sight (LOS) link is lost. Then this link wants to go on the backup radio frequency communication in order to provide constant data transmission whose quality is decreased. When the link recovery is system is go back on VLC connection. Though, Line of Sight (LOS) configuration blocking is a temporary fact which lasts for a very less period of time and we want to wait till the end of blocking, importantly for the services that does not takes place in a real time environment. Additionally, latency and signaling cost will cause when switching back and forth takes place. However, instantly switching between RF and VLC may not be a good strategy because it creates ping-pong effects. In reality, the “waiting” action after the blocking duration is able to avoid unwanted switching. However, this switching action is used to avoid a transmission breakdown [17].

In this paper, a viable analysis of mobility in visible light communication (VLC) system for an indoor healthcare environment is described. We proposed a handover method which provides a continuous connectivity in an indoor hospital environment where patients are supposed to be in both mobile and static condition. The system contains a set a whit LEDs for lighting of all the cells in a room. The goal of the proposed handover technique is to restrict the network disconnections by working in both proactive and reactive modes. With the help of mobile devices in the environment this feature is achieved and mobile devices are able to share their information through lighting the cells. In proposed scenario of patient monitoring system, security and reliability of data becomes an essential factor [9]. Radio frequency have highly congested networks and frequency spectrum which is not safe for human health and have high risk of hacking also. Therefore, Visible Light Communication comes as an emerging technolgy which is more secure and greener option as compared with RF technolgy[12]. In VLC system LEDs are used as a transmitter and photodiode used as a receiver. For monitoring a patient in a hospital room some sensors are placed on a human body for their continious monitoring. Sensors reads the patient data which is send to the microcontroller unit, then this data can be wirelessly transmitted and at the receiver side this data can be decoded and able to get the pateints information safely.

The arrangement of this paper is as follow: Section 1 consists of the introduction part in which we provide brief description of visible light communication system. In section 2 we give an overview of a handover mechanism and their optimization techniques. Section 3 contains a proposed model in which we describe two scenarios of an indoor hospital environment. Finally, conclusions and reference are added in this paper.

II. HANDOVER MECHANISM AND OPTIMIZATION TECHNIQUE

Users can uphold their connectivity in mobility conditions with the help of an automatic and flawless technique known as handover. This is like a switching process from one serving network to a receiving network. Horizontal handover is a classic handover technique which allows continuous switching whenever a mobile user moves from one access point to another access point without changing their current access network [9]. Handover is generally used in cellular system in order to avoid network disconnections because of mobility reasons. Handover technique is generally started with the measurements of physical parameters like as received signal strength (RSS) that provides the service maintenance when serving cell power level starts decreasing. A satisfactory criterion of handover decisions for balancing different factors includes installation cost, Quality of service and positioning factor and the last is power consumption problem [19].

Optical Wireless and Radio Frequency technologies came together for achieving unbreakable connectivity between the cells [12, 13]. Vertical handover is based on fuzzy logic that developed an integrated WiFi – IR system [20]. The profit of this method is to gain satisfactory handover where handover decisions are taken as short and long time interruptions. In this paper we investigate how basic horizontal handover mechanisms can be applied in VLC systems in which the user connectivity switches from one lighting cell to another. Uniform and spotlighting coverage have been assumed in this work. By exploiting the analogy between the RSS parameter in cellular systems and the Received Signal Intensity (RSI) in optical wireless, we extend the traditional RSS-based handover procedures into an RSI-based technique for mobile VLC systems.

Optimization of handover is needed for avoiding problems such as radio-link and ping-pong handover state failure. In mobile communication system performance of handover is a very serious quality measure. Without any service disruption or call dropping, mobile user wants flawless mobility. Also the system load created by the handover is to be kept on sensible limits.

III. SIMULATIONS

3.1 SIMULATION OF SCENARIO FOR STATIC PATIENT IN A HOSPITAL ROOM

For this scenario, gaining a flawless connectivity is a major difficulty. This scenario contains a set of light emitting diodes for spotlighting the cells which is separated by a distance of y[m].For directed line of sight communication system there is no overlapping field of view. Their transmitters are placed vertically to the receiver at a distance d such as ceiling to desktop and each transmitter projections are of radius r on the receiver surface. The receiver coverage is considered to be broad all over. This visible light communication scenario provides focused and intense light and mostly used for line of sight communication. It is various advantageous because of smaller channel distortion and high information rate. For static patient monitoring scenario directed line of sight transmission technique is very efficient because it is only directed on the patient and chances of interference is also very less.

Before disconnecting the connection with the serving lighting cell (SLC), mobile terminal starts a handover procedure in a very reactive manner with the help of this approach. Because of the simple intensity test, mobile terminal get the knowledge of new neighbor spotlighting cells. Received signal intensity (RSI)[W/m^2] acknowledges the existence of the other lightening system when mobile terminal reaches at the boundary of the serving lighting cell (SLC). This intensity test determines the existence of overlapping cells, and works like a first alarm when RSI level reaches the below threshold. If neighbour lighting cells are overlapped then this alarm shows negative and it shows positive when there are no overlapping cells in between the neighbours. Therefore, in this scenario monitoring of patient can be achieved effectively without any channel interruptions and interference and patient's data can be extracted easily with the help of direct line-of-sight communication.

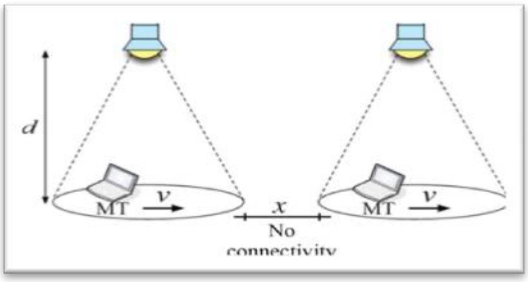

Figure 1 Handover between non- overlapping cells [21]

3.2 SIMULATION OF SCENARIO FOR MOBILE PATIENT IN A HOSPITAL ROOM

In this scenario, the uniform lighting system is used because of their wide Field-of-View (FOV). In this mode, LEDs are uniformly placed on ceilings and provides a total coverage area. If handover (HO) is quickly done between cells then uniform lighting system avoids network disconnectivity between the cells in a hospital environment. Data is continuously transmitted between the cells due to large FOV of LEDs which overlaps each other and able to provide seamless handover connections.

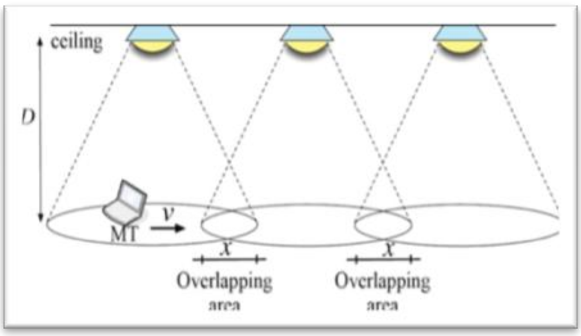

Figure 2 Handover between the overlapping cells

Let consider a given scenario in which we assumed that three lighting cells are uniformly placed at an equal radius of r and have data rate B. Irrespective of the distance from the receiver, the cells overlapping depends on the lighting coverage area i.e., $0 < x < r$. The patient moves in a straight line in a serving lighting cell with a speed of v [m/s] and achieves a data rate B [b/s]. When the mobile patient crosses the lighting coverage x [m], handover will be started with an increasing data rate between serving lighting cell (SLC) to new lighting cell (NLC). For this case the intensity test will show a negative and proactive handover. For reactive handover condition it is very important to notice that mobile devices moving only inside in a room and continuously share information with the positioning of the lighting cells.

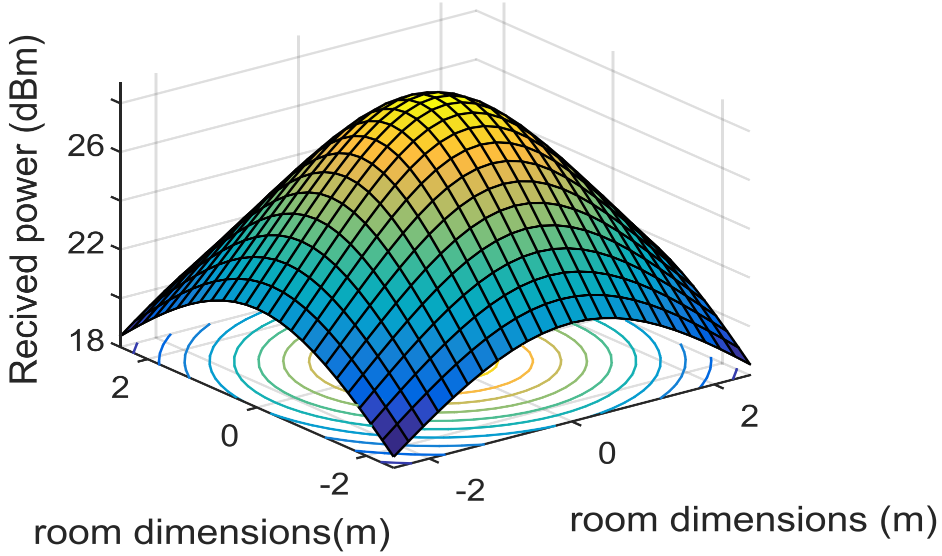

Figure 3.Optical Power Distribution of LOS Link at Receiving Plane for a Typical Room

3.3 SYSTEM PARAMETERS

[1] For spotlighting system	
Room dimensions	5×5× 5meters
Access points	(5,2,3), (5,5,3), (5,8,3)
Data rate	10 Mb/s
Standard deviation	1
[2] For uniform lighting system	
Room dimensions	5×5×5 meters
Access points	(5,2,3), (5,5,3), (5,8,3)
Data rate	50 Mb/s
Standard deviation	4

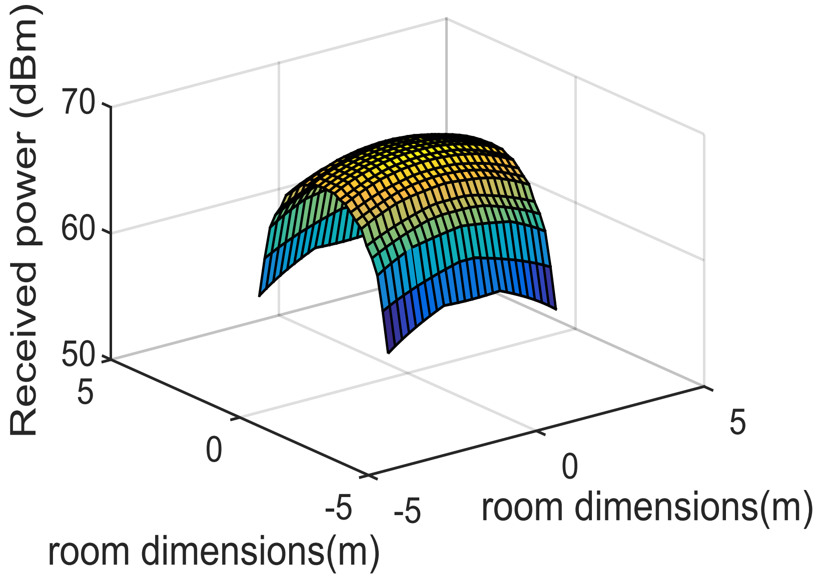

Figure 4. The distribution of received power with reflection

IV. CONCLUSION

This paper presented the mobility and static scenarios of patient monitoring using an indoor visible light communication system. This VLC system uses various cellular lighting systems for both the scenarios. The flawless connectivity can be gained with the help of handover mechanism for the both proactive and reactive modes. These two scenarios can be investigated by considering the overlapping and non overlapping lighting cells. Simulation results are enough for understanding the optical power distribution for both the scenarios and handover algorithm is sufficient for different lighting configurations. Future work will be based on the concepts of the lighting testbed for demonstrating the proposed handover technique in VLC system.

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