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Evaluation of performance information downloading of (optical – radio frequency) hybrid system network

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ABSTRACT

In this study the evaluation performance of (Optical light– radio Frequency) hybrid network system. We determine first the coverage area of optical system Li-Fi (light-fidelity) and radio frequency system (Wi-Fi) as well as the data rate downloading file size of them for single mobile user case. Secondly, we study the hybrid network system Li-Fi/Wi-Fi in an indoor for single mobile user case and the user mobility at the region of the coverage area. Throughput versus distance relationships has studied also for Li-Fi and Wi-Fi system in order to assess the performance of these system. The effect of the numbers of LED light sources Li-Fi hotspots and the velocity of user is introduced in the take in account coverage region reconsidered on the assess performance of the hybrid networks systems Li-Fi/Wi-Fi. The evaluate performance of the hybrid network system hotspots Li-Fi/Wi-Fi for the information rate downloading size on the mobility have been conducted. The results show that the performance of hybrid network system hotspots Li-Fi/Wi-Fi have a significant effect because of the velocity of user. As well as, the results show that the performance of the hybrid network system hotspots Li-Fi/Wi-Fi increased when the number of light sources spotlights in the room are increases.

Keywords: Optical system communication, Light-fidelity (Li-Fi), Hybrid network system.

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1. Introduction

The expanding number of multi-media cell phones and the broad band utilization of information requesting mobile applications imply that present versatile systems are at their most extreme limit because of the constrained accessibility of the Radio Frequency (RF) spectrum [1, 2]. As well, he interests in demand for real-time Internet interactive services (e.g. high-definition video) becomes widespread nowadays. Although, Wi-Fi access points (APs) and extra small cells are distributed to accommodate the developing number of mobile subscribers, the staggering request for low-delay and high-throughput of Internet services is seldom met. This expanding request will bring about diminishing the quality-of-service (QoS). To reduce this issue, novel methodologies that use extra spectrum ought to be explored [3].
Radio communication is the brilliance innovation used to give untethered connectivity between individuals, machines and others. Without a doubt, the lion's share of wireless and mobile connections today is based on the utilization of radio. The dwindling spectrum of radio frequency (RF) is no applicable solution to provide the requests of end clients [4]. Wi-Fi is the most flexible, skillful and effective innovation that consolidated with microwave frequencies for fast wireless data transmission.

Notwithstanding, Wi-Fi is confronting numerous difficulties and issues regarding of capacity, efficiency, availability and security due to hasty request for wireless communications [5, 6].
Lately, optical communication has emerged as a similarly appealing alternative. Visible Light Communication (VLC) has been captivating both the academia and industry for as long as decade, essentially because of the huge license-spectrum of the light. The innovation is new and was proposed by the German physicist Harald Haas in 2011 TED (Technology, Entertainment, Design) Global Talk on VLC [5-7].
VLC alludes to a kind of short-range optical wireless communication correspondence the visible light spectrum from (380 – 780) nm that is ten-thousand times extensive than RF spectrum. In VLC, data information is transmitted by modulating optical sources, for example Light Emitting Diodes (LEDs). Since these optical sources can be turned on and off rapidly (in the request of million times per second), it has no effect on the brightening light seen by human's eyes, however can be detected by light sensors [8].VLC is emerging as a suitable means to conquer the crowded radio spectrum for very restricted-localized systems. VLC underpins data communication and illumination in indoor situations where new vitality proficient LED materials and devices will supplant old incandescent and fluorescent lighting.
Among various points of interest, VLC utilizes a tremendous unregulated and free spectrum. Light signals likewise can be coordinated and sequestered permitting a VLC-empowered environment to transmit data in small cells and accomplish high bandwidth densities (Mb/s/m2). This incorporates cells in nearby rooms or in a single room. VLC system has developed as a domain friendly and green technology of communication with unregulated bandwidth resource to serve as an option for conventional wireless technologies [9].
In spite of the fact that VLC systems achieves a higher data rate when contrasted with RF system, anyway its repression to smaller cells leads to limited coverage area thus limiting the client mobility. The VLC also experiences link blockages as light cannot sneak an obstacle. These restrictions can be defeated if the VLC with a RF systems are supplemented that not only supply larger cell radius as well as have higher breakthrough ability [4]. Because of their corresponding in both capacity and coverage RF/VLC combination has assembled attention of specialists. Hybrid wireless network, as a strategy to consolidate diverse access technologies, contains the potential abilities of enhancing the productivity of used spectral resource. A hybrid conjunction of Wi-Fii/iLi-Fi is predictable to enhance both the average throughput system and quality of service (QoS) of the users. Since Li-Fi network system does not influences Wi-Fi throughput and coverage, the aggregate model system of other output of a Li-Fi/Wi-Fi hybrid system network is constantly greater than that of independent Wi-Fi or Li-Fi networks [1, 3, 6].
In this paper, discuss the evaluation of performance of (Optical light– radio Frequency) hybrid network system. The hybrid network system Li-Fi/Wi-Fi in an indoor for single client situation and the user mobility at the region of the coverage area was study.

2. Methodology of the System Design Model

2.1 Optical-Radio Frequency Hybrid system indoor (Li-Fi/Wi-Fi)

In optical – radio frequency hybrid networks system, a combine of two or multiple wireless technologies, cell size, radio frequencies, and different architectures of network which are utilized to ideally respond according to the user and multi-service providers.
In hybrid optical – radio frequency networks system, we assumed that a mobiles device is equipped with radio (Wi-Fi) and optical (Li-Fi) air interfaces which are enable to connect to either optical and radio networks. However, the decision to be connected to a radio or optical networks is based on the quality of the channel or availability.

2.2 Coverage area and data rate downloading of optical system networks (Li-Fi)

A small cell area of the optical system (Li-Fi) comparison to the larger coverage area of the radio frequency (Wi-Fi) cell have considered in Optical-Radio Frequency Hybrid system indoor network. The small area cell of

(Li-Fi) known as spot lighting has been conducted for communication and illumination. Therefore, a number of small area cells of Li-Fi has used to provide a higher data rate. In this paper, the coverage regions cell was dynamically altered according to the required signal-to-interference-plus-noise ratio (SINR) which is distributed in an indoor area while maintaining constant illumination. In addition, we consider Li-Fi small cell for providing higher data rate and Wi-Fi for providing wide coverage area.
In case of Li-Fi small area cell, we have required light irradiance *Pr*of circular lighting source LED that can be determined from lighting field radius *R*s and transmit power *Pt* of LED regardless
of the distance parameter, it is expressed as [10]

$$p_t = \frac{p_r}{\pi R_s^2} \qquad (1)$$

2.3 Coverage area and data rate downloading of radio frequency system networks (Wi-Fi)

Radio frequency system networks (Wi-Fi) is a multi-rate system, which is meaning that when the mobile moves inside the cell of the coverage area, so, the SNR received will be changed according to the distance between mobile and access point. So, in multi-rate systems, Signal to noise ratio (SNR) is arbitrary variable, and therefore, the mobile users can be operated at the multi-rate choices of data rates downloaded according to the value of its received signal to noise ratio SNR. In a single user, the average carried out throughput will be the average of all data rate at which it operates while moving in the area. Therefore, the observed data rates average by a user located arbitrary in the coverage area of multi-rate system, which can be expressed in equation 2 [11].

$$R_{av} = \sum_{n=1}^{N_{rate}} P_n R_n \qquad (2)$$

Where, P_n the probability of occurrence of that data rate downloading,R_n is one of the available multi-rate downloading, and R_{av} is the average spatial data rate.If the terminal is located arbitrary in the coverage area, the probability of each area is given by the ratio of the area for the specific data rates to the total coverage area as

$$P_n = \frac{A_i}{\pi D_{max}^2} \qquad (3)$$

Where, D_{max} and A_i are the maximum coverage range and the specific data rate area respectively.
The simplest method to represent the relationship between the distance between the transmitter and the receiver versus the effects of all the factors (refraction, diffraction, propagation medium) is by utilizing the path loss sample. The path loss sample in multi constructing (rooms)expressed as in Eq. 4 [10].

$$L_p = L_0 + nF + 10\log(L_{tr}), \qquad (4)$$

Where, *nF* represent the attenuation of the signal, L_0 represented path loss at the primary meter, n number of floors. Through , which the signals pass, L_{tr} is istance between the eceiver and ransmitter in meters. In the purpose of actuality, the proper specific client (user) channel system model is not finding to all condition environment. consequently, a valid system model of encasement area for wireless System can only be founded by doing the calculations and measurements for the conveyance (propagation)iline in that proper specific channel system environments.
In this article, instead of the path loss system model, it has been used the distance – throughput relationships system model for characterize the channels propagations according to distance for the indoor Wi-Fi proper channel system.
The linear system is regarding the simplest model to find the throughput-distance relationship. Thus, In the linear relationship model of throughput-distance shows the throughput decreases linearly while distance between the access point and mobile user increases. The coverage area for Wi-Fi and throughput-distance relationship model are shown in Figures 1and 2 respectively.

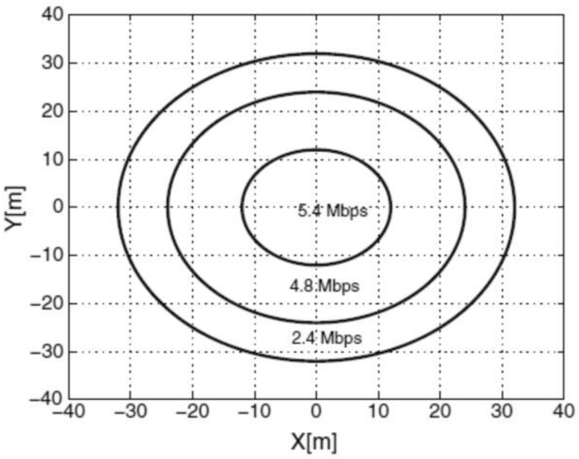

Figure 1. The coverage area Indoor for Wi-Fi

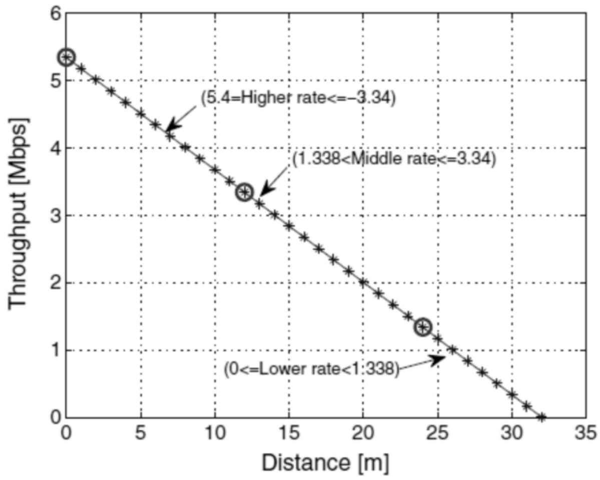

Figure 2. Throughput-distance relationship model for Wi-Fi indoor networks

Therefore, in Wi-Fi, the relationship between distance and throughput $S(r_w)$ is given by the equation 4:

$$S(r_w) = \begin{cases} a_{max} r_w + b_{max}, & 0 < r_w < R_{max} \\ 0\,, & otherwise, \end{cases} \quad (5)$$

Where, the parameters a_{max} and b_{max} are utilized to calculate the greatest coverage area distances and greatest data rates provided of access point respectively. When the($r_w = 0$) the maximum rate of data which received by telephone users are $S(0) = b_{max}$, while, theparametet a_{max} related to the ultimate coverage area zone distance of access point which follows as $a_{max} = -\frac{b_{max}}{R_{max}}$.

2.4 Hybrid Optical-Radio Frequency (Li-Fi/Wi-Fi) Networks

In this part we will study the scenario for information downloading rate (data downloading) in optical hybrid networks system (Li-Fi/Wi-Fi) hotspot for single user:

2.4.1 single-user case

Figure 3 has shown the scenario for information rate downloading in hybrid network system Li-Fi/Wi-Fi hotspot. In this single user, the width limitation and a relative long area in the room building is regard as service coverage of hybrid system Li-Fi/Wi-Fi networks hotspot where suppose the walls of the room area are transparent. Therefore, at the daytime we regard the indirect sunlight present at the photo detector. So, in this article, a series of spotlighting sources (LED light) have arranged in succession (row) in the room ceiling for illuminations, in addition to the communication purpose. Coverage area of each light sources LED (spotlighting) can be considered as a Li-Fi hotspot. So, depending on the position of LED, the number of spotlighting sources (LED light) will be representing the number of lights hotspot in the coverage of the room (office). In addition to considering multiple Li-Fi hotspots within a more extensive range area of Wi-Fi encasement area (coverage area). Information rates of radio frequency Wi-Fi is channel adaptive. Then, as per the position of Wi-Fi access point, diverse information rates will be provided to the users in the coverage area of Wi-Fi and these data rates may higher information rate, lower information rate and a moderate information data. The distance between two sequential LED (Li-Fi) may change depending on the position of optical LED light source hotspots

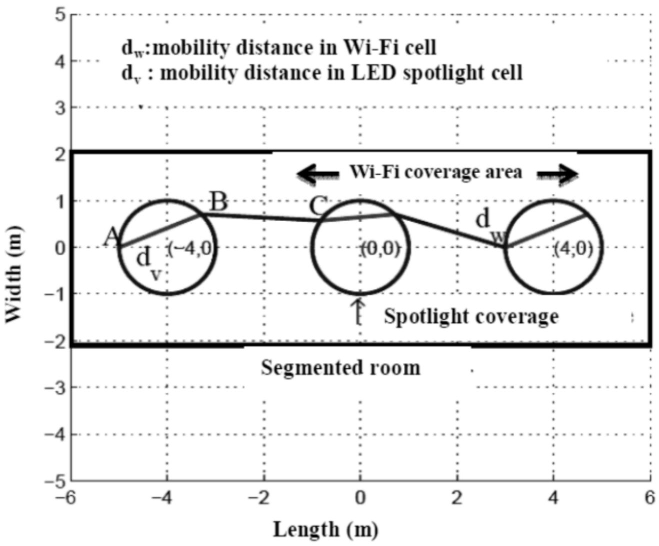

Figure 3. the scenario for information downloading in hybrid network system Li-Fi/Wi-Fi hotspot

As well as we assumed that the terminal of mobile users has equipped with both radio and optical transceivers. In this article we proposed that the scenario telephone users will have found everywhere coverage area of Wi-Fi, which means that when the telephone users are in coverage area or out of the coverage area of the Li-Fi hotspots, therefore, anybody may have a connection with the Wi-Fi link. However, in this paper we have also suppose that when the client is in Li-Fi coverage area of spotlighting he/she will be connected with the Li-Fi link. Therefore, in this situation, we have supposed that the receiver and transmitter are arranged to each other in the Li-Fi coverage hotspots by using a tracking system. As well as we supposed that initial and final network connectivity of the phone client amid information rate downloading will be begun and finished at the Li-Fi area hotspot as in Figure 3. Which illustrated that the vertical handover is considered between the Wi-Fi and Li-Fi hotspot The amount of date(information) download to the phone client storage device depends on radio and optical parameters, for example FOV(field of view) of spot lighting LED optical light, physical photo detector space, photo detector PD, user movement, and environment condition (day or night) time, time of dwelling in the coverage area of Wi-Fi or Li-Fi hotspots. Figure 4 shown the mobility in Li-Fi for single user cases, where the clients enters the coverage area at the point A which has coordinates ($x_a;y_a$) known as the entering point of coverage area, and the point B is the exits of coverage area with coordinates ($x_b;y_b$) known as the exit point of coverage area, as shown in Figure 4. We can show for entrance angle and exit angle of the inclined path are denoted by α_1, and α_2 respectively. The angle between entry angle and exit angle of inclined path is called the travelling angle θ. We supposed the velocity is constant so, the path that the phone client voyages can be expressed as:

$$\{x(t), y(t)\} = \{(x_b - x_a)t_p + x_a, (y_b - y_a)t_p + y_a)\} \qquad (6)$$

Where, the parameter t_p changes from zero to one which identical to the entry point and the exit point respectively. Let be assume that the characterize of the throughput is an element function of the distance, i.e., the average throughput at distance r is *S(r)*. The instantaneous distance from the center of encasement (coverage) area to the client can be calculated from equation 7.

$$r = \sqrt{[(x_b - x_a)t_p + x_a]^2 + [(y_b - y_a)t_p + y_a]^2}, \qquad (7)$$

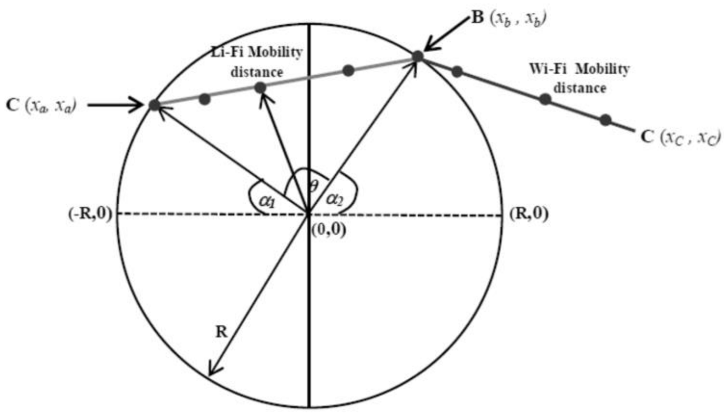

Figure 4. the mobility in Li-Fi for single client (user) situations

In cases of single client (phone user), a special situation of an arbitrary walk movement (be moved freely and easily) model which has limited movement direction and constant speed was embraced to predict the users mobility throughout hybrid system Li-Fi/Wi-Fi hotspots coverage area. Two assumptions have been made in dealing with the movement of the mobile users in Wi-Fi and Li-Fi hotspot coverage area as appeared in Figure 4. The main assumption, we have supposed that the mobility path of mobile users (client) will be a straight, horizontal or inclined path within the coverage area of Li-Fi hotspots or Wi-Fi network system.

The Second assunption is that the users will turn at the change point onlybetween the optical sources Li-Fihotspots and radio Wi-Fi. This transition pointsconsist the entery point of the next Li-Fi hotspotsand the present of the exit point of hotspots. for instance, if A, B are the entrance points and exit points of the Li-Fi hotspots, then C which represented the transition pointsis the entry point of the next Li-Fihotspots. In that case, the moving distance in Li-Fi coverage area hotspots will be $|A\text{-}B|_2$ and themoving distance in Wi-Ficoverage area hotspots will be $|B\text{-}C|_2$ as shown in Figure 4. Where $|\cdot|_2$Euclidean norm. It has been noted that the travelling angles to be uniformly distributed is done by generation random entry and exit point.

The transferred information size from the Li-Fi hotspots during the time of dwelling at velocity v and for travelling distance in Li-Fi region $d_{\text{Li-Fi}}$ with average throughput $S_{\text{Li-Fi}}$ is $I_{\text{Li-Fi}}= (S_{\text{Li-Fi}} \,.\, d_{\text{Li-Fi}})/v$. Similarly, for the Wi-Fi region the transferred information size for mobility distance $d_{\text{Wi-Fi}}$ and with throughput $S_{\text{Wi-Fi}}$, $I_{\text{Wi-Fi}}= (S_{\text{Wi-Fi}} \,.\, d_{\text{Wi-Fi}})/v$. The computation of the average of throughput in coverage area of hybrid system Li-Fi/Wi-Fi will be as:

$$S_{hybrid} = \left(\frac{S_{Li-Fi}\hat{d}_{Li-Fi}}{S_{Li-Fi}+\hat{d}_{Wi-Fi}} + \frac{S_{Wi-Fi}\hat{d}_{Wi-Fi}}{S_{Li-Fi}+\hat{d}_{Wi-Fi}}\right). \qquad (8)$$

Where, $\hat{d}_{\text{Wi-Fi}}$ and $\hat{d}_{\text{Li-Fi}}$are the total distance moved by the users in the Wi-Fi and Li-Fi coverage area, respectively. Finally, the size of information received in hybrid system area of Li-Fi/Wi-Fi can be expressed as in equation 9.

$$I_{hybrid} = S_{hybrid} t_t \qquad (9)$$

Where, t_t the sum of dwelling time residence which is spent by a client in the Li-Fi spotlight region and the Wi-Fi coverage area.

3. The Performance Evaluation of Hybrid System Li-Fi/Wi-Fi for Single User

A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis. The performance evaluation of the hybrid system Li-Fi/Wi-Fi communication for indoor at sunny day and night time for the single client (phone user) situation. The numerical results have been conducted using measurements and analytically which is based on the average throughput-distance relationships for the Li-Fi and Wi-Fi respectively. Monte-Carlo simulation results have achieved for 500 times iterations for arbitrary movement for the client along with other parameters of system hybrid design, as in Table 1.

The size of file received of mobility client avail as execution metric for the single client situation and average network connectivity will be whole study of this paper

Table 1. Parameters of simulations

Parameters of Simulations	values
power transmitted	22mW
Responsively of Photodiode	0.25
Semi angle	60^0
Field of View (FOV) in the receiver	30^o
Detector area of Photodiode	25 mm2
velocity of user	[0.5 − 1] m/sec
Numbers of LED	[4, 6, 8]
Bit Error Rate (BER)	10^{-3}
$R_{\max}$	32 meter
radius of Li-Fi (R)	1meter

The size of file received has shown in Figure 5in hybrid system model Li-Fi / Wi-Fi and Li-Fi,the coverage area for an indoor room at different bit error rate (BER) at night time which only requirements for single client situation . In this special simulation condition, we used eight light sources (spotlights). It is observed that the size of file received has decreased as increased the bit error rate BER requirement for both the hybrid system Li-

Fi / Wi-Fi and Li-Fi situations. It has been noted that the evaluation performance difference between the hybrid system Li-Fi / Wi-Fi and Li-Fi only is not significant at all bit error rate BER requirement.

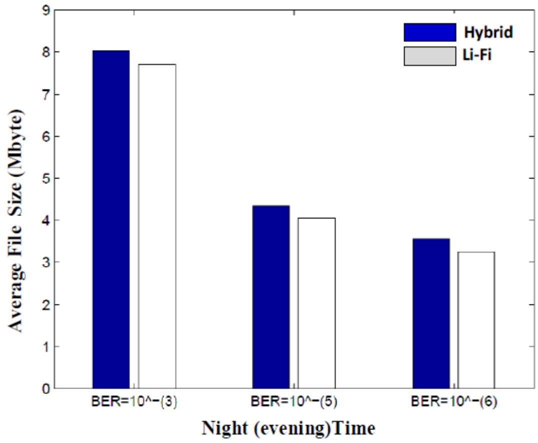

Figure 5. The average size of file received for single client

This behaviour due to the arrangement of light sources (LED) Li-Fi spotlights and movement model system for the single client situation (as show in Figure 3). The space between two spotlights adjacent (LED) is 2 meters. In that situation, the dwelling interval in Wi-Fi area will be much less than Li-Fi light sources (LED) spotlights area. because of that, the contribution of information size download from the Wi-Fi coverage area will be much less than hybrid system Li-Fi/Wi-Fi. Therefore, in the situation of a narrow office area,i.e. 2-meter width, only Li-Fi network coverage can provide reasonable data rate downloaded file size in comparison to the hybrid Li-Fi/Wi-Fi, if light sources Li-Fi spotlights are placed closely space enough.

The size of file of the hybrid system Li-Fi/Wi-Fi and Li-Fi spotlights coverage area for the indoor room during sunny day at different bit error rate (BER) requirements for a single client have shown in Figure 6. The Figure show that the performance evaluation of hybrid system Li-Fi/Wi-Fi and Li-Fihave decreased at all values of bit error rate (BER) levels when it is comparison with the performance at night time for indoor room. the decrement occurs in the performance of sunny day because the effect of indirect sun on the photo detector.

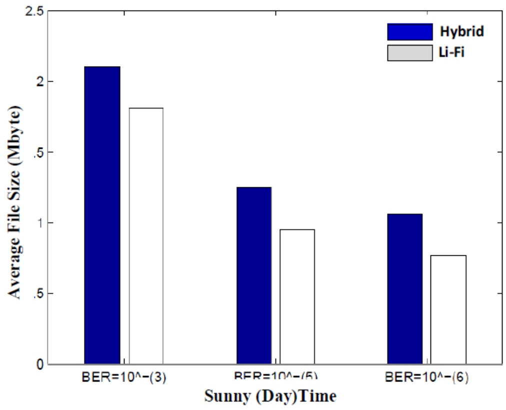

Figure 6. The average size of file received for single client (user) at sunny day

The three groups of CDF cumulative distribution function diagrams of the file size of received data during the evening time for three different group of LED light sources spreaded in a room or office for the single client (phone user) have shown in Figure 7.

In this article, the simulations have concentrated on studying the effect of the numbers of light sources (LED) spotlights spreading in a certain area of room or office for hybrid network Li-Fi/Wi-Fi system.So, The aim of

this study is to the evaluated performance of the system hybrid Li-Fi/Wi-Fi networks in concerning of received information size while the single client (user)mobility through the office or room.
It is clear that from results when the numbers of LED spotlights increase, the received information size (downloading) has also increased. because that when the numbers LED (spotlights) increases, the high information size downloading area of Li-Fi and dwelling time of aclient in Li-Fi are increased in the coverage area of Li-Fi/Wi-Fi combined. wherefore, the received signal (file size downloading) increased. It can show that with the probability50% the amounts of data rate downloading of information will be approximately less than or equal to the 4.451 Mbyte, 6.231 Mbyte and 8.019Mbyte at the bit error rate (BER) is 10^{-3} and the velocity of user (v) is 1m/sec when the numbers of Li-F LED lights will be 4., 6. , and 8, respectively

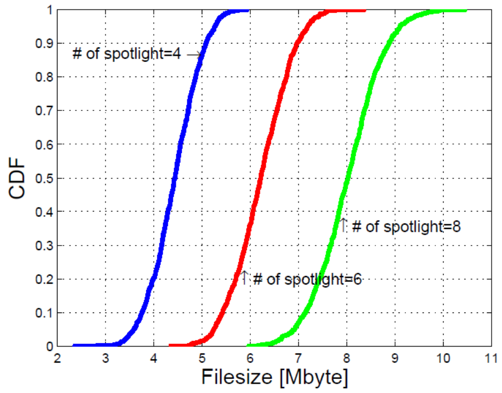

Figure 7. cumulative distribution function of the file size of received data at evening time for different three group of LED

The three groups of CDF cumulative distribution function diagrams of the file size of received data at sunny time for different three group of LED light sources spreaded in a room or office for the single client have shown in Figure 8.withinsunny time condition, the receivedinformations signal (downloading) will be less than at night. With probability of 50%, the amounts of file size will be smaller or equal to (1.01, 1.6 and 2)Mbyte when the numbers of light sources (LED) is 4, 6, and 8, respectively. We can show that at the probability of 50% the received information size downloaded will be twice as the numbers of Li-FiLED double. Where bit error rate (BER) is 10^{-3} and the velocity of user (v) is 1m/sec.

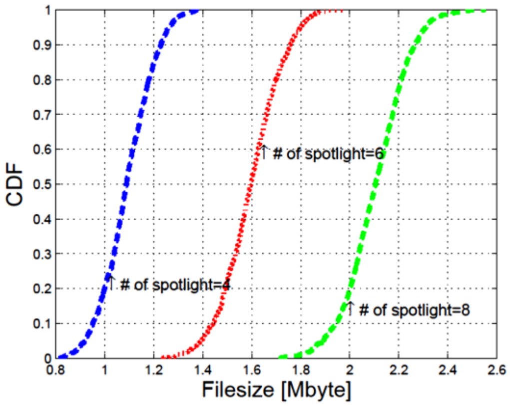

Figure 8. cumulative distribution function of the file size of received data at sunny time for different three group of LED

Figures 9 and 10 shows the received file size downloading of information at night and sunny time of the hybrid Li-Fi/Wi-Fi and Wi-Fi at different velocities, respectively. The first aim of this study is to evaluate performance the effect of velocity of clients on the valuation performance of the systemhybridnetwork Li-Fi/Wi-Fi only. It can shows that the performance of both hybrid Li-Fi/Wi-Fi and Wi-Fi onlydecreases when velocity of mobile user increases.For instance,in hybrid network systemLi-Fi/Wi-Fi, we can show thatthe amounts of file size downloadingwill be littler than or equivalent to 16.11 and 10.712 Mbyte at velocity range 0.5 to 0.75 m /sec, respectively with 50% probability. So, at the same velocity of the client, the differences of evaluate performance are not much between the hybrid network systemLi-Fi/Wi-Fiand Wi-Fi only. It also can show from the results that the amounts of file size downloadingwill be smaller than or equal to 16.101 and 15.482 Mbyte at velocity of mobile user 0.5 m/sec, respectively with 50% probability. This is because of the position of numbers of LED hotspots (Li-Fi).In both cases (Figure 40, and Figure 41),from Figures 9 and 10, it can be concluded that when the velocity increases, the dwelling time in hybrid network system Li-Fi/Wi-Fi or Wi-Fi also decreases. So, file size downloaded rate will be smaller when the velocity of client increases.

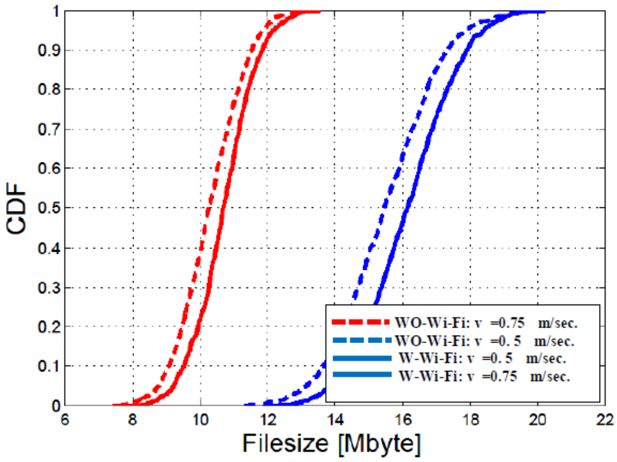

Figure 9. the size downloading file of information received at night time of the hybrid Li-Fi/Wi-Fi and Wi-Fi at different velocities

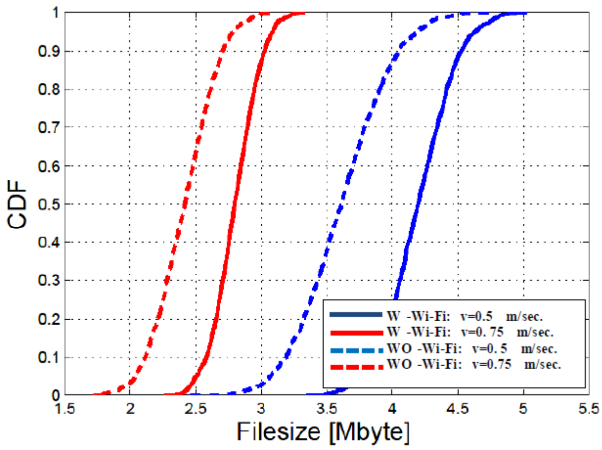

Figure 10. the size downloading file of information received at sunny time of the hybrid Li-Fi/Wi-Fi and Wi-Fi at different velocities

4. Conclusions

The evaluate performance of the hybrid network system hotspots Li-Fi/Wi-Fi in a datarate download file size on the mobility scenario have been studied. These evaluateperformance is characterized by considering the average throughput of optical source and radio frequency system technology. In additional to the throughput parameter, other parameters are also taken into the account such as user velocity, mobility (movement) angle and field of view (FOV) of the lights sources hotspots LED.

Finally, the simulations process has been conducted to evaluate performance of the hybrid network system hotspots Li-Fi/Wi-Fifor the information rate downloading size on the mobility scenario. The results show that the performance of hybrid network system hotspots Li-Fi/Wi-Fi have a significant effect because of the velocity of user. As well as, the results show that the performance of the hybrid network system hotspots Li-Fi/Wi-Fi increased when the number of light sources spotlights in the room are increases.

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