Fast Link Switching Scheme for LED-ID System

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ABSTRACT

LED-ID (light emitting diode - identification) technology is the new paradigm in the identification technology environment. LED-ID system typically needs line of sight (LOS) that supports narrow FOV transceivers links to achieve high data rate. On the other hand, narrow FOV reduces the coverage area. Therefore, the number of tags is increased significantly to cover the whole area. In this case number of link switching is increased when the reader moves within whole coverage area. Link switching delay is the important factor for the moving reader to maintain the communication with high data rate and better QoS. In this paper we propose in literature a new link switching scheme and measure the link switching delay time for LED-ID system.The simulation results show that the proposed link switching scheme is a possible candidate for multi-tag LED-ID system.

Key Words : Link switching, LED-ID, FOV, visible light, anddelay

I. Introduction

Recently green and energy-efficient wireless communication schemes have experienced rapid development and garnered much interest. One such scheme, the visible light communication (VLC), a short-range optical wireless communication utilizing LED lighting so that LED lights can provide both illumination and communication simultaneously, is being touted as one of the most promising wireless communication technologies for the next generation. LED lights have been emerging as a new growth technology which is expected to replace existing illumination infrastructure for its long life expectancy, high tolerance to humidity, low power consumption, low voltage, and small size[1]. The LEDs maintain same chromaticity without significant changes during all their operations.LEDs can be used as communication transmitter without losing their main functionality as illumination sources. Another important property that distinguishes it from traditional lights is that LEDs can be modulated in high speed, indicating it can not only be used to illuminate, but also play an important part in communication as a signal emitter. Their diverse applications include numeric displays, flashlights, liquid crystal backlights, vehicle brake lights, traffic signals, and the ubiquitous power-on indicator light[2].

Currently, the interest in LED communication using white LEDs is gradually growing as necessity for indoor communication systems because there are many devices using the lightings in our offices, home, the lightings on roads, traffic signals, home appliances including TVs, etc[3,4]. The typical LED has special characteristics to light on and off very fast at ultra-high speed. By using visible light for the data transmission, most of problems related to radio communications are resolved or relieved. It has advantages of large potential bandwidth (THz) with no regulation or license. The human eye would not be able to follow these variations. Hence, the lighting will not be affected. As a consequence,

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simple off-the-shelf LEDs can be used to develop cheap transmitters. For example, LED-identification (ID) technology based on the LED communication is ubiquitous information communication service that is used to supply variable information at museum, super market, restaurant, and etc. From the implementation point of view in the LED-ID communication system, there are still many challenging issues to be overcome. One of them includes link switching which mainly occurs in multitag communication case.

In multi-tag scenario of LED-ID system, to cover the whole area, number of tags used for robust communication with reader must be increased. In this case when reader moves within whole area, number of link switching is increased.Therefore, the system needs fast link switching scheme to maintain the seamless communication between tag and reader. Many researchers proposed different schemes for radio wireless network but nobody proposed for LED-ID network yet. In this paper we propose hard link switching scheme for LED-ID network and find out the link switching delay within the tolerable value. There are two components in LED-ID system: reader and tag. All tags are communicated with coordinator, and reader can be connected with one of tags to get data from coordinator. Link switching whereby a reader changes its communication link from a coverage area to another tag via alternative link[5]. There are two kinds of link switching can be implemented, one is hard link switching and other one is soft link switching. Which scheme used in LED-ID system depends on the frequency management. In LED-ID system, frequency band can be divided into seven different bands[5]. So, we assume using different frequency for tags in system, and LED-ID system needs hard link switching scheme [6]. In this paper, we propose in literature a new paradigm of link switching based on knowledge of IEEE 802.15.7 link switching process and IEEE 802.11 handover process. We used INET, one package of OMNET simulator, to simulate our link switching delay scheme and to evaluate performance results of this scheme.

This paper is organized as follow. In Section II, we give some acknowledgement of related works. The hard link switching scheme for LED-ID system is proposed in Section III. In Section IV, we introduce the simulation environment and analysis simulation performance. And finally, conclusion and future work are discussed in Section V.

II. Related Works

In IEEE P802.15.7[5], the link switching process can be divided into some steps: device detection in boundary area, assign and return time slot, and link setup and resource assignment. When device comes to boundary area of some other cells, coordinator detects device by using personal-area-network identifier (PID) received signal. In the second step, coordinator sends the boundary information through cells in that area. When the device receives boundary information message, it requests and is assigned another time slot by coordinator to transmit data parallel with current time slot. After completing move from boundary area to distinguished cell area, device returns the old time slot and continue using new assigned time slot. The last step will complete the switching process and begin data transition.

In the IEEE 802.11[7-9], the handover process can be divided into several steps: network search and selection, open system authentication and association, authentication, and establishment of link layer security associations. When the station (STA) detects degradation of the communication quality, it considers changing of access point and eventually decides to perform a handover to a candidate access point that offers better quality of signal. In the first step, there are two scanning methods, one is passive and other one is active.In active scanning, the STA listens for beacons frames issued by the access points (APs) at regular intervals. The beacon includes information such as subscribe station's identification (SSID), supported rates, and security parameters. By this way, the STA collects information about candidate APs and chooses one of them. The selection of which access point to use depends on several parameters such as quality of signal, access network capabilities, user preferences, and policy. After locating and selecting a handover candidate AP, the STA negotiates the communication data rate and reserves resources on the new AP and performs the second step. The Open System Authentication and Association consist of two exchanges. The STA then issues an Association request that includes the desired SSID and supported rates, the AP finally replies with an Association response including the supported data rates and the session ID. The third step is specific to wireless access networks using 802.11i in "Enterprise" mode. The last step confirms the STA and AP communication.

LED-ID system has some specific characteristics different with the two above systems, so it is needed to have another scheme to maintain communication when data link is switched. In the following sections, we will pass to some issues of our proposed link switching scheme.

Ⅲ. Proposed Link Switching Scheme

LED-ID is a new technology and there is notstandardization yet for the link switching. Hence, we propose in literature a new paradigm of link switching for LED-ID systems based on the knowledge of Cellular/WLAN handover andVLC communication. In this section, we present the concept of link switching procedure, the content of communication processing,link switching decision and reentry processing.

3.1 Link Switching

The procedure is necessary to maintain and improve the communication link. A reader changes its communication link within a coverage area of tag or from one tag to another tag via an alternative link. Link switching is needed due to interference or mobility of the reader. Mobility can be of two types: physical and logical. Physical mobility occurs when the reader changes its position due to the movement within the coverage area of a cell while logical mobility occurs when the reader or tag changes its communication link from a link with one tag to one another tag due to interference or deliberate link switching.

Figure 1 shows link switching scenario of LED-ID system. In this scenario, we consider two tags and one reader moves from serving tag to target tag. Link switching scheme of this scenario is hard link switching

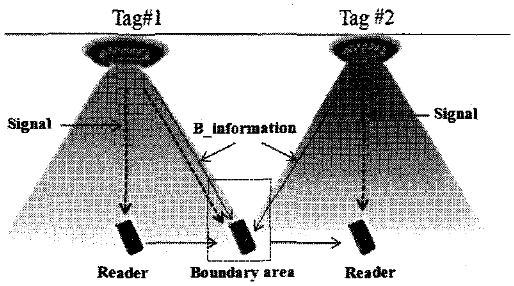

Fig. 1. Link switching scenario of LED-ID system

3.2 Communication Processing

Figure 2 shows the communication processing during link switching. When the reader comes to coverage area of one tag, it will measure the received strength of signal comes from the tag. If the signal strength satisfies larger than saturation power of the reader, the reader will execute the communication processing.

At the initial of communication processing, the reader sends authentication request message to tag. The authentication request message includes reader's ID and header type. Every message has own header type to distinguish with another. When the tag receives one message, it reads the header type and ID to respond corresponding. First receiving message time, tag sends ACK message to inform reader that it received the message and it will respond the request. Same case with tag, when reader receives respond message from tag, it sends the ACK message and then another message. When receiving authentication request message, if there is enough capacity, tag will send the authentication respond with acceptation command. Next state, after receiving the acceptation respond from tag, the reader sends time slot allocation request to the tag. If there's free time slot, the tag will respond and allocate one time slot for sending data to the reader.

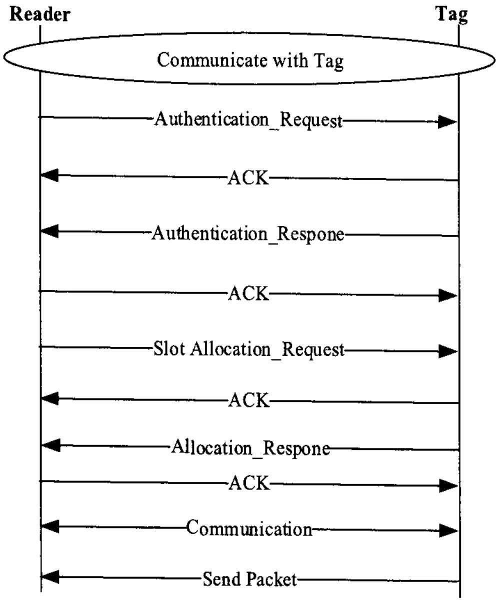

Fig. 2. Communication processing

After communication being success, packet sending process is implemented.

3.3 Synchronization, Link Switching Decision, and Reentry Processing

Synchronization, link switching decision, and reentry processingare shown in Figure 3. When a reader moves to boundary area, strength of the signal received is decreased. Also reader receives another signal from another tag in the boundary area. At that time, link is disconnectedfrom serving tag and synchronization processing is implemented for connecting the target tag.

At the initial of synchronization processing, reader broadcasts its information including reader's ID. If one tag receives broadcast information message, it sends detect device message to reader of which ID has been included in the message. If reader responds with ACK message, tag will send boundary information to the reader. Boundary information includes some parameters which will be used for links switching decision of reader. If reader comes to boundary which has many tags, synchronization processing will take a long time.

After synchronization processing, reader gets all tag information and makes decision to communicate

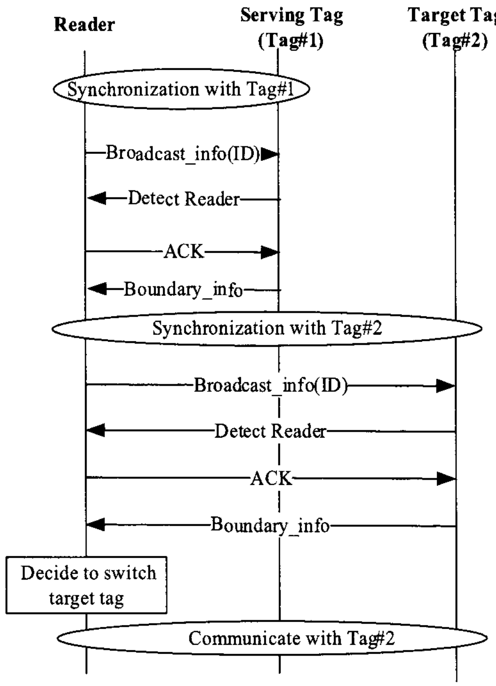

Fig. 3. Synchronization, link switching decision, and reentry processing

with one of them. Making decision can depend on priority mechanism of reader. That mechanism helps the reader to choice the best case for data transfer. Delay in this process depends on used algorithm and usually negligible.

After finishing the decision processing, reader tries to reentry into chosen tag. Reentry processing follows some steps same with communication process. Delay in this process depends on protocol. In our scheme, CSMA/CA protocol is used, because it is a standard and simple scheme to reduce complex of system.

Ⅳ. Simulation Environment and Performance

In this section, we show the simulation scenario, channel model simulation environment, and performance of the simulation.

4.1 Scenarios

In indoor environment, the reader can move to the boundary area covered by dense neighbor tags.

Figure 4 shows the multi-tags scenarios of LED-ID system. In this scenario, we assume that reader is covered by first tier tags when performing link switching process. The second tier tags have a little effect because position is far from reader. Otherwise, first tier tags are enough to cover the reader movement area.

In this scenario, the problem is the significantly increasing scanning time. Because reader can have to perform scanning process with all first tier tags in the worst case.

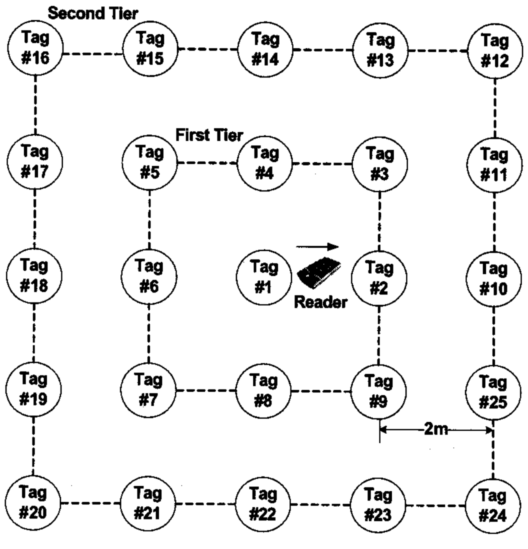

Fig. 4. Multi -tags scenario of LED-ID system

4.2 Optical Channel Model

In LED-ID system, reader uses the visible light link to receive or transmit the data. Two types of link may be used in LED-ID system, one is line of sight (LOS) and another one is non-line of sight (NLOS). It is very difficult to achieve high data rate using NLOS link. LED-ID system needs high data rate. For high data rate applications, link should be line of sight. Therefore in this simulation we use the LOS link for high data rate. We are going to show the behavior of the optical channel when the visible optical signal is passing from tags to the reader. The received power depends on the optical channel gain and the transmitted power. Figure 5 shows the physical model of reader and tag in LED-ID system.

The optical channel gain that is related to

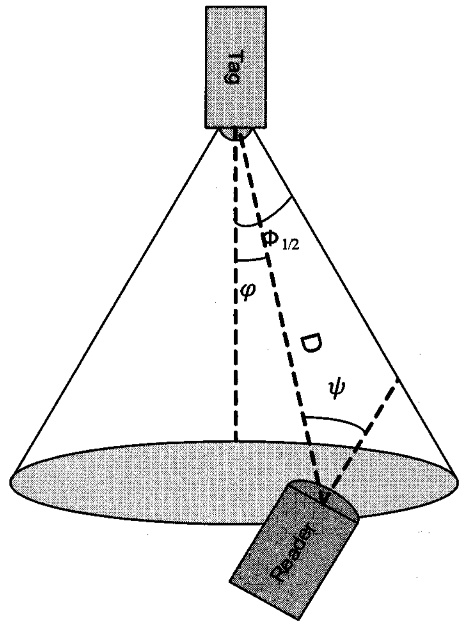

Fig. 5. Physical model of reader and tag in LED-ID system

transmitted and received powers can be expressed as [10]:

$$P_{rLOS} = H_{LOS}(0)P_T \quad (1)$$

where is the transmitted optical power, P_{rLOS} is the received optical power, and $H_{LOS}(0)$ is the channel DC gain.

Considering the LOS link, the channel DC gain is defined as [6]:

$$H_{LOS}(0) = \begin{cases} \frac{(n+1)A}{2\pi D^2}\cos^n(\phi)T_s(\psi) \\ \times g(\psi)\cos(\psi), \quad 0 \le \psi \le \psi_c \\ 0 \qquad\qquad\qquad elsewhere \end{cases} \quad (2)$$

where is the order of Lambertian emission, A is the photo-detector area, D is the distance between the transmitter and receiver, ϕ is the angle of irradiance, ψ is the angle of incidence, $T_s(\psi)$ is the signal transmission coefficient of an optical filter, $g(\psi)$ is the gain of an optical concentrator, and ψ_c is the receiver field of view (FOV).

The order of Lambertian emission n can be found from the equation, $n = -\frac{\ln 2}{\ln(\cos\phi_{1/2})}$ where $\phi_{1/2}$ is the transmitter half power angle. The gain can be determined from the following expression [10]:

$$g(\psi) = \begin{cases} \frac{\delta^2}{\sin^2\psi_c}, & 0 \le \psi \le \psi_c \\ 0 & elsewhere \end{cases} \tag{3}$$

where δ denotes the internal refractive index of the optical concentrator.

4.3 Simulation Model

There are many network simulators to simulate handover performance. We chose OMNET, one of believable network analyzing tools. Otherwise, OMNET is open source software, so it is possible to modify the network due to work purpose. Figure 6 shows simulation environment. Link switching delay scheme is simulated using INET, one package of OMNET simulator. In this scheme, we proposed hard link switching scheme. According to the proposed call flow, the simulation is performed to calculate the link switching delay. In first state, reader can communicate with tag #1. When the reader moves to the target tag #2 and comes into the boundary region,it receives signals from both tags. Boundary information is sent from both tags to the reader. After measuring signals strengths, the reader decides to switch to another tag or not. Finally reader is disconnected from serving tag before connected to the target tag. Link switching delay can be calculated by measuring the interval between the first time reader received data from tag #2 and the last time reader received data from tag #1.

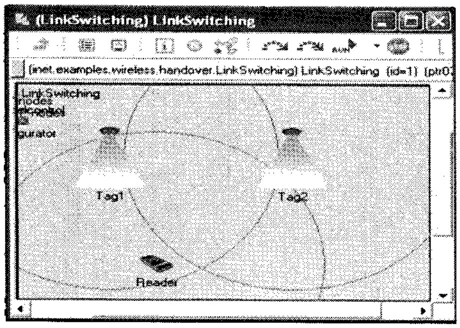

Fig. 6. Simulation environment

4.4 Basic Assumptions

For simulating physical channel, we use the physical model of tag and reader. Physical model of reader and tag in LED-ID system is shown in Figure 5. Also, we need some characteristic parameters in the realistic. Table 1 shows the basic simulation assumption.

Table 1. Basic assumptions for the simulation

Parameter	Value
Carrier frequency	500 THz
Bit rate	1 Mbps
Maximum power	10 mW
Saturation power	-49 dBm
Transmitted power	4mW
Mobility speed	1m/s (3.6km/h)
SNR threshold	13.6 dB
Distance between tag #1 and tag #2	4m
Vertical distance between reader and tag	3m
Photo-detector physical area, A	0.9 (cm2)
Transmission coefficient of filter, $T_s(\psi)$	1.0
Concentrator FOV, ψ_c	60 (degree)
Semi-angle at half power	15 (degree)
Refractive index	1.5
Number of Tags	25
Radio Sensitivity	-85 mW
Radio Thermal Noise	-110 dBm
Beacon Interval	20 ms

4.5 Performance

In this part, we discuss some effects of latency: number of scanning tags in boundary area and transferred data rate.

Figure 7 shows the relation between switching delay time with number of tags in boundary area. As we discussed before, when the number of tags is increased, the reader takes a long time to synchronize all tags completely. Therefore, link switching delay is increased when the number of

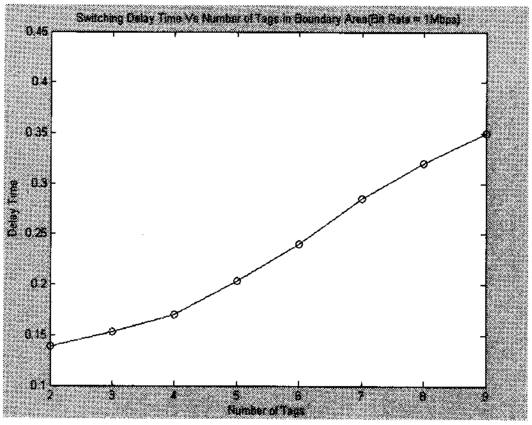

Fig. 7. Switching delay time vs. number of tags in boundary area (bit rate = 1Mbps)

tags is increased.

Figure 8 shows the relation between linkswitching delay time with bit rate. When bit rate is increased, data transfer speed is increased and so that delay is decreased. In Figure 8, when bit rate is increased from 1Mbps to 5 Mbps and 10 Mbps, a large amount of delay is increased. But delay seems not to change when bit rate is increased from 20 Mbps to 50 Mbps and 100 Mbps. The reason of this case is that the length of packet is small, so that packet is transmitted suddenly in the case 20 Mbps, 50 Mbps or 100 Mbps. Therefore, high bit rate case should apply for some applications for high quality video, audio and real-time service.

V. Conclusions

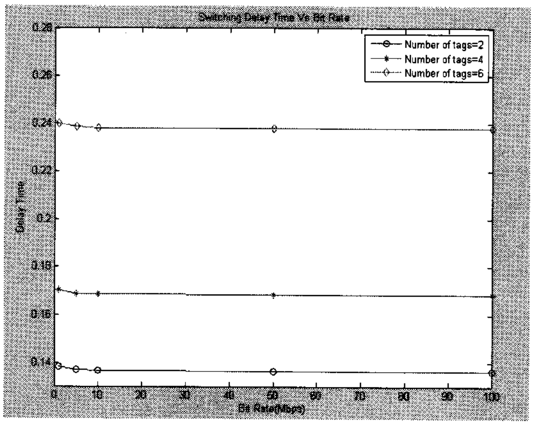

Fig. 8. Switching delay time vs. bit rate (number of tags = 2)

We simulated the link switching delay for LED-ID system where visible light is used as transmission medium. The link switching delay time depends on the number of tags, LED channel model, and visible light link capacity. In the realistic LED-ID environment, there are many tags, so readertakes longer time for synchronization with all tags and,therefore, link switching delay is increased. In our simulation, we have shown that when the number of tags is 2, the link switching delay is 138ms.We currently working on minimizing the link switching delay.

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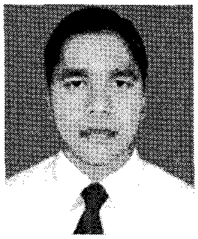

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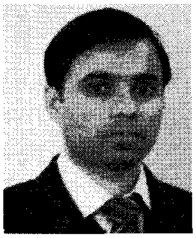

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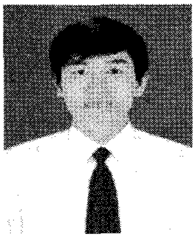

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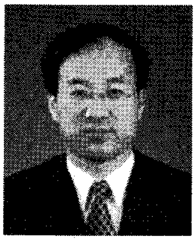

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