Mobility-Aware QoS Provisioning in LED-ID Networks

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Abstract

Quality of service (QoS) provisioning is an important issue in wireless networks. The less interruption time or packet loss of a communication session is, the better quality of service is. In this paper, we propose a new link switching scheme for LED-ID networks based on the history of location of mobile devices (as known as readers). Our proposed scheme is based on the standpoint that in indoor environments people tendentiously move in restricted trajectories. The simulation results show that our proposed scheme outperforms the conventional scheme.

Keywords: *LED-ID, visible light, location information, QoS provisioning, handover, and link switching*

1. Introduction

Nowadays, the improvement of human life brings about the high requirements in quality of service. Communication systems have been developed strongly to satisfy the increasing demands of users. Recent years, a new technology called LED-ID (light emitting diode - identification) [1]-[3] has been researched and gradually implemented to supply a ubiquitous information communication service in indoor environment. LED is considered as a next generation lighting and communication devices. LED has some salient features, such as low power consumption, fast response times, low cost, safeness for human eyes, high rate of data transmission, and etc. LED-ID networks intend to serve mobile users in indoor environments, such as museums, supermarkets, car parkings, department stores, product expos, kiosks, and etc.

A problem that we have to consider in LED-ID networks is the quality of service when a mobile user (as known as reader) moves from the coverage area of a transmitter (as known as tag) to another one, called as link switching. The link switching procedure is quite similar to handover processes in standardizations, such as IEEE 802.16e wireless MAN protocol [4] and IEEE 802.11 wireless LAN protocol [5]. All of these protocols aim to support seamless connectivity for mobile users. To improve the performance of a link switching scheme as well as a handover scheme, using location information of mobile users is an effective approach. In [6], a location management method for Hierarchical Mobile IPv6 using the mobile node's mobile history is proposed. In this method, when a mobile node (MN) needs to perform a handover, the Access Router calculates the area-covered rate of each upper Mobility Anchor Point (MAP) from the MN's mobile history and selects the MAP that best manages the MN in accordance with its rate. In [7], a method based on non-GPS location techniques is proposed to estimate the velocity of the mobile station for suppressing the ping-pong effect in cellular systems. The proposed method exploits the correlation properties of shadow fadings to avoid unnecessary handovers in the overall environment.

In this paper, we propose a novel efficient link switching scheme based on the location information of readers. With the use of a location server which connects to all the tags in the

LED-ID network, the coordinates of readers moving in the area managed by LED-ID network are saved and used to help a reader choose the next serving tag swiftly. The simulation results show that our proposed scheme achieves a better performance than conventional scheme.

This paper is organized as follows: In Section 2, we go into detail of our proposed scheme. The performance evaluation is described in Section 3. Finally, the conclusions are discussed in Section 4.

2. Mobility-Aware Link Switching

In order to use our proposed scheme, all the tags in a LED-ID network are connected with a location server. This location server has two main functions: 1) managing the location of readers which are moving in the LED-ID environment; 2) finding out the next serving tag for a reader.

To manage the location of readers, first we divide the area managed by LED-ID network into small and uniform sub-areas (we call them location blocks), as illustrated in Figure 1. This location map is managed by the location server of the LED-ID network. While a reader is moving in the LED-ID network, after every certain interval, it estimates its location and reports this location information to the location server through the serving tag. Based on the reported location from the reader, the location server can determine in which location block the reader is being located. For example, we say that at time t_k the reader is being located at the location block 1 if the following conditions are met:

$$x_1 \le x_k < x_2 \tag{1}$$

$$y_1 \le y_k < y_2 \tag{2}$$

where (x_1, x_2) and $(y_1,\ y_2)$ are the x-coordinate range and y-coordinate range of the location block 1, respectively, and (x_k, y_k) is the reader's coordinate at time t_k.

To manage and to support the link switching process, the location server has a link switching table. This table includes the previous location block (PLB), the current location block (CLB), the current serving tag, the next serving tag, and the probability that a reader

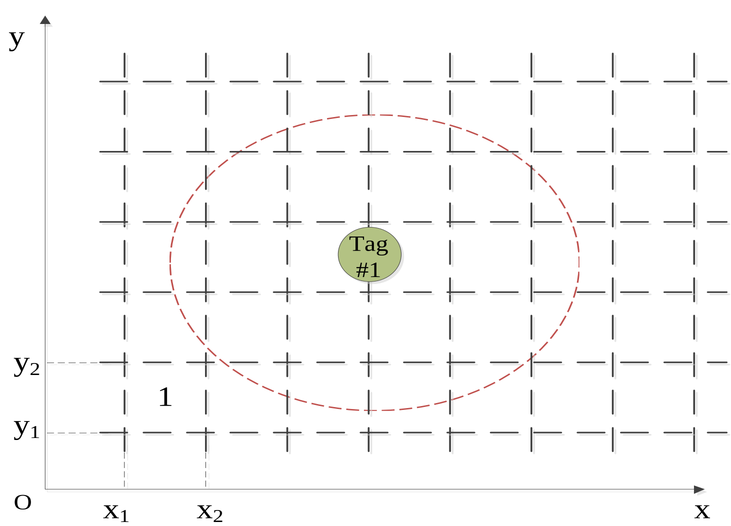

Figure 1. An Example of Location Block Division

selects this next serving tag. In the beginning of link switching procedure, a reader sends a message to the location server in order to request the information about the next serving tag. Based on the reader's movement history (PLB, CLB), firstly the location server determines whether there is any statistic of this movement history in the link switching table. If there is not any statistic of this movement history, the location server informs the reader, and the reader has to perform the conventional link switching scheme (it means that in order to find the next serving tag, the reader has to scan all the neighbor tags and choose the best one). After that, the location server has to determine whether the reader moves backwards. The reader is said not to move backwards if this following criterion is met:

$$P_k \leq P_b \quad (3)$$

where P_b is a threshold constant, P_k is the probability that Tag #k is the current serving tag as well as the next serving tag of the reader.

After that, the location server chooses the candidate tags to inform the reader based on their probabilities. The number of candidate tags chosen to inform the reader depends on this following equation:

$$\sum_{j \neq k} P_{k,j} \geq P_0 \quad (4)$$

where P_0 is the probability threshold, $P_{k,j}$ is the probability that the next serving tag is Tag #j, k is the index of the current serving tag.

After the location server has informed the reader about the candidate tags, the reader starts scanning the informed tags to find out the best one. Finally, after the reader has chosen the next serving tag, it informs the location server about this selection. Based on this information, the location server updates the probability value of the link switching table.

3. Performance Evaluation

In this section, we describe the performance evaluation of our proposed scheme compared to the conventional scheme. To get the objective results, the trajectories of readers in the LED-ID environments are set to random, such as zic-zac, arc line, straight line, and etc. Table 1 shows the parameters used in the simulation. The evaluation metrics are link switching delay and unnecessary link switchings ratio.

Table 1. Basic Assumptions

Parameter	Value
Distance between two adjacent tags (CS)	4 m
Signal sensitivity	-85 mW
Signal thermal noise	-110 dBm
Beacon interval	20 ms
The length of an edge of a location block	40 cm
Number of readers	100
P_0	0.6
P_b	0.8
SNR threshold	13.6 dB

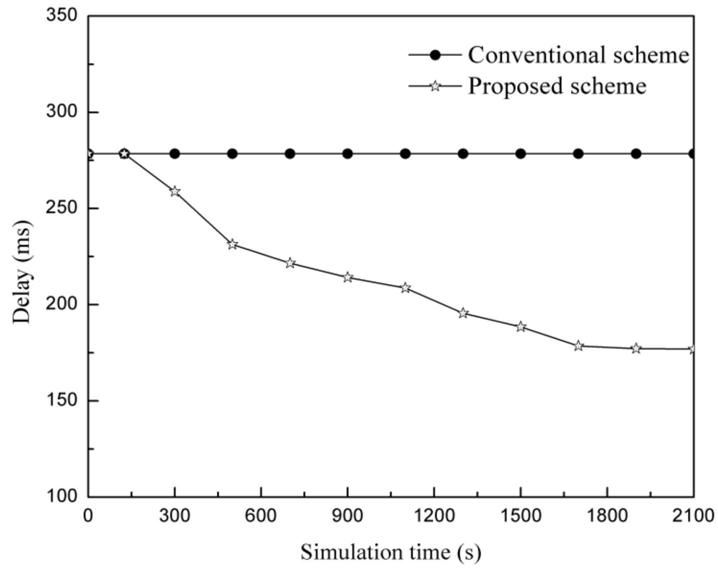

Figure 2. Link Switching Delay over Simulation Time

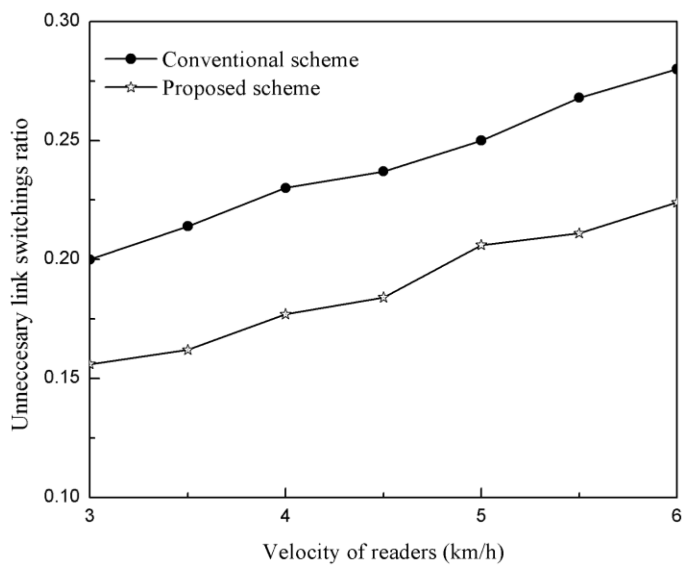

Figure 3. Unnecessary Link Switchings Ratio vs. Velocity of Readers

Figure 2 shows the relation between link switching delay and simulation time. By using our proposed scheme, the number of neighbor tags which a reader has to scan in the link switching procedure is decreased. Since then the link switching delay is also decreased. When the link switching table of the location server contains complete data, the link switching delay of our proposed scheme becomes saturated. Figure 3 shows the relation between unnecessary link switchings ratio and velocity of readers. Our proposed scheme considers the history of location of readers and the link switching history (it means the probability value in the link switching table), so that the unnecessary link switchings ratio is decreased compared to the conventional scheme.

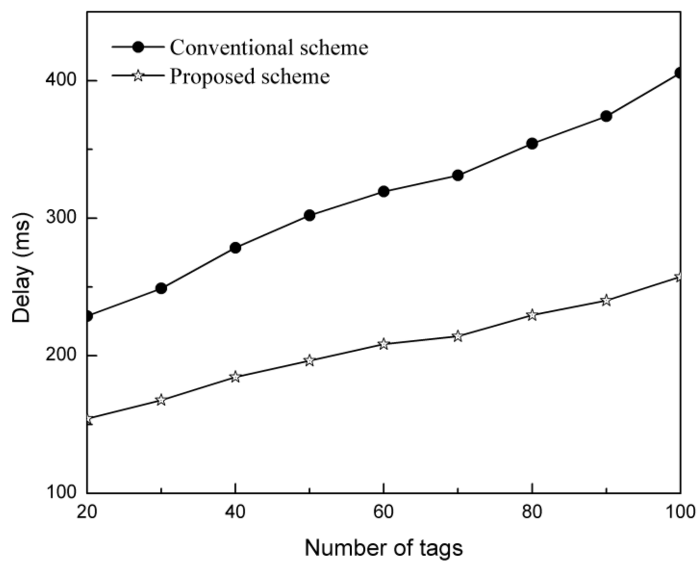

Figure 4. Delay vs. Number of Tags

Figure 4 compares the impact of number of tags on the link switching delay between our proposed scheme and the conventional scheme. In this experiment, we consider the saturated link switching delay of our proposed scheme. When the number of tags is increased, each tag in the network has more neighbor tags. Thus, to find out the next serving tag, a reader has to scan more tags during the link switching procedure. Since then the link switching delay is increased. Our proposed scheme efficiently reduces the link switching delay up to around 35%.

4. Conclusions

Guaranteeing seamless connectivity is an important issue for providing a good quality of service to mobile users. In this paper, we propose a novel link switching scheme for LED-ID networks. Using the knowledge of location information of mobile devices, the location server of LED-ID network can help a reader to choose the next serving tag effectively. With the nature of indoor environments in which the moving space is restricted, our proposed scheme is expected to gain the better performance than the simulation results.

Acknowledgements

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