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RSS Threshold-based Location Registration and Paging Algorithm for Indoor Heterogeneous Wireless Networks

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Abstract: The indoor wireless environments suffer from the coverage disconnection. The trends in the future wireless networks are to enable the mobile terminal to be connected anytime and anywhere. An efficient location management will solve the problem of frequent location registration in the small area of indoor environment. This study treats the problem by developing an indoor location registration with sequential paging algorithm for future heterogeneous wireless networks. The algorithm is based on the RSS signal that received from the surrounding sources. The proposed algorithm has been compared with conventional registration with blanket paging algorithm in terms of the performed location registration and paging messages.

Key words: Location registration, location paging, heterogeneous wireless networks, indoor user mobility, WLAN, RSS

INTRODUCTION

The future heterogeneous wireless systems network will be the integration of Wireless Local Area Network (WLAN), WiMAX and Beyond Third Generation (B3G) cellular network infrastructure. In such network, to achieve seamless roaming across various access technologies, the interoperation of mobility management techniques is essential. Location update (registration) and paging are two important aspects of mobility management that ensure the mobile users to receive service anywhere and anytime. In indoor environment that suffer severe multipath fading and Non-Line of Sight (NLOS) propagation impairment, the location update and paging procedure consumes most of the channel resources due to increase in the signalling cost resulted from more frequent registration and paging process. Hence, there is a need for a simple and an efficient indoor location registration and paging algorithm.

Solutions have been proposed by Ramjee *et al*. (2001) and Soliman *et al*. (2000) to support mobility in future IP based wireless networks. The IEEE 802.11 Wireless Local Area Network (WLAN) was selected to be the wireless communications technology in an indoor environment with the microstrip patch antenna that can satisfy the WLAN applications (Saeed and Sabira, 2005). WLAN networks are being deployed in the most of the building and it is expected a major penetration in the next years (Llombart *et al*., 2008). These networks provide excellent coverage with the minimum required infrastructures (Wong and Leung, 2000). The user can connect to different 802.11 WLAN or any other indoor networks such as ad hoc providers while at home or at any indoor area for communication purposes or for tele-emergency system (Viswacheda *et al*., 2007). Similarly, even though multiple wide-area cellular service providers may use the same access technology. The user can dynamically switch between different providers to obtain different sets of customized services. The integration of WLAN into cellular networks (Sasikala and Srivatsa, 2006) and other networks will provide users in indoor areas to use the high-speed wireless network (Ferrus *et al*., 2010; Shashwat, 2003) and use the cellular data network when the user is outdoors. Sakamoto *et al*. (1996) divided the indoor registration area to private and public registration areas as shown in Fig. 1. Private area could be a room or an office. Halls, stairs and elevators are considered as public areas. The movement of the mobile terminal from one private area to another will be cross the public areas. The movement of the mobile terminals during lunch time from private area to a cafeteria located in the first floor of the building has been considered. At this time the location registration traffic of the system is at its extreme. The private areas are denoted with Aij as in Fig. 1, where

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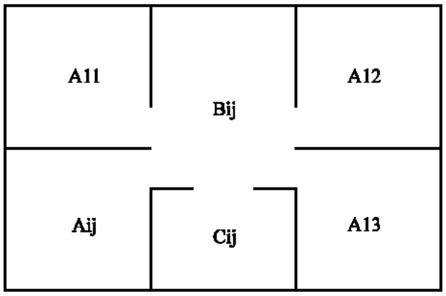

Fig 1: Area structure model for an office building

I is the floor number and j is the private area number. Area Bij is a public area on the i-th floor and area Cij is a public area common to all floors (elevators and stairs).

The location registration has been performed based on the type of the registration area to which the mobile terminal enters. The authors used three methods of registrations to cope with the congested control traffic for multimedia communication systems.

The objective of this work is to establish an indoor mobility model to represent the behavior of the mobile terminal inside buildings and to propose an efficient location registration and paging algorithm based on the established mobility model for in indoor heterogeneous wireless networks. We propose RSS threshold-based location registration with sequential paging algorithm to update the location information of the mobile terminal database when MT is in an indoor environment and out of coverage from its service provider.

INDOOR USER MOBILITY MODEL

The movement of the Mobile Terminals (MT) has been modeled in an indoor environment. The mobility model describes the way a MT moves through the system. We did not differentiate between public and private area. The registration area is considered as any area surrounding the transmitters inside the building without consideration of the physical wall partitions. The user mobility pattern is modeled as follow:

- The Mobile Terminal (MT) starts its trip from its private area (office)
- MT will go through the hall and then to the stairs or elevator
- The MT uses again the public area of the stairs and elevator at the cafeteria floor
- The hall of the cafeteria will be the last public area used to reach the cafeteria
- We consider a one way trip of the MT from its office to the cafeteria located in the first floor

NETWORK MODEL

Here, is defined a simple network model containing the layout of Registration Area (RA) and paging. The registration area is considered as the area surrounding the transmitters. The network determines the size of the registration area according to the quality of service required based on the received signal strength of the transmitters. The best is the QoS required, the smaller is the RA. The paging area is defined as the area where the mobile terminal has registered last time. The paging request messages send to the transmitters associated with the registration areas. The cell size of the conventional pico-cellular system is in order of an ordinary room or an office. Each area is associated with a single base station or access point.

PROPOSED LOCATION REGISTRATION AND PAGING ALGORITHM

The location registration and paging area in the indoor environment is different from outdoor (Sakamoto *et al*., 1996). It is difficult to implement the outdoor location update and paging algorithms because of the small area of the indoor environment which lead to frequent update and paging procedures. In the conventional location registration, the mobile terminal initiates a registration process whenever, it enters a new registration area such as room or an office. The proposed location registration strategy does not issue location registrations on every movement of the MT, but based on the RSS value from the available transmitters. The location registration decision is made by the mobile terminal based on signal-quality measurements collected and periodically reported by the Mobile Terminal (MT). The MT typically listens to a beacon or a control signal from all surrounding Base Stations (BS) or Access Points (APs) within range and measures the signal quality. The Received Signal Strength (RSS) is used as a measure of signal quality.

Location update procedure: The registration area is considered as area covered by a single access point. The borders of this registration area are defined by power threshold value. The threshold value determines the perimeter of the circular area around the access point. This will reduce the location update process in the overlapping registration areas. The location registration will be performed when the RSS is below the threshold value. The determination of the threshold depends on the wireless indoor application. Figure 2 shows the flow chart of the proposed location registration algorithm. The network defines the RSS threshold value based on the

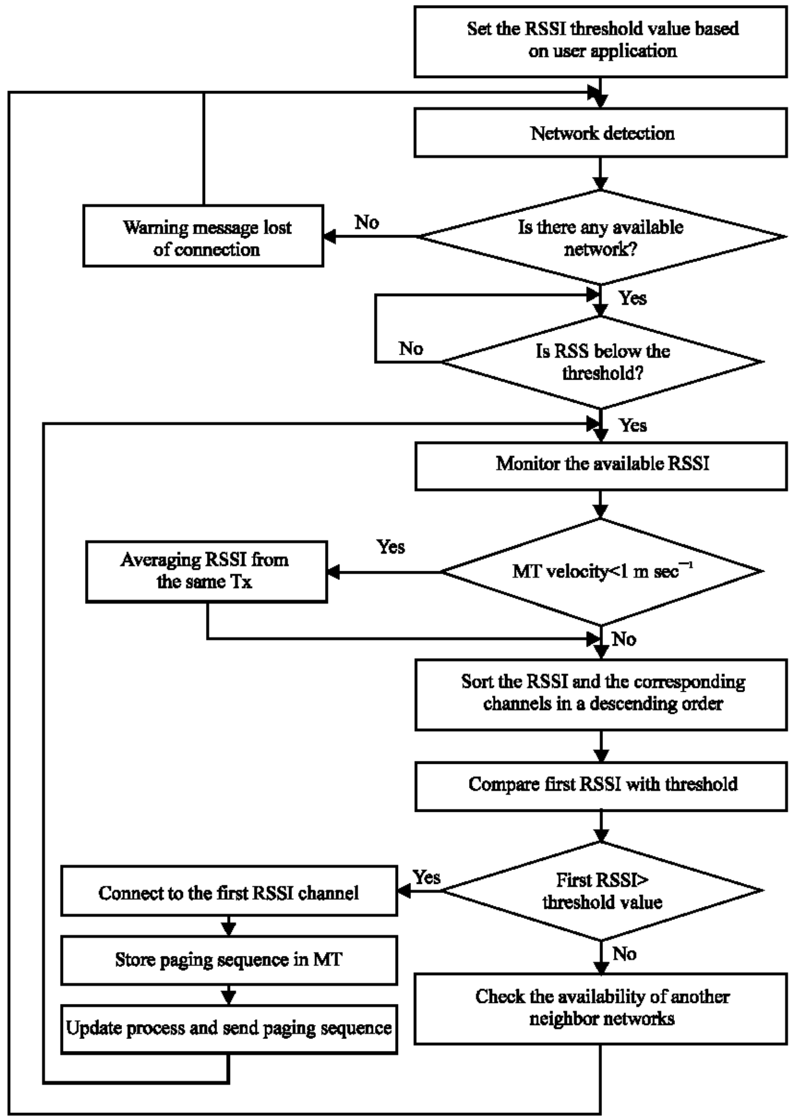

Fig. 2: Flow chart of the proposed location registration algorithm

service requirements. The mobile terminal starts detecting the available networks when enters an indoor environment. The mobile terminal sorts the detected signals in a descending order. These sorted RSS values will be used as paging sequence. If the first RSS in the sequence is higher than the threshold value, the mobile terminal initiates a location registration process and connects to the indoor base station. Furthermore, the mobile terminal stores the paging sequence and sends it to the connected base station. In case of new registration process, the mobile terminal will update the paging sequence according to the new registration.

Paging procedure: A sequential paging is used to reduce the paging traffic by dividing the paging operation into several steps. The paging sequence is consists of the last connected base station and its neighbors where the MT has been registered. When a call arrives, the network identifies the called MT and load it's paging sequence from network database. Then the network sends a paging request to the first base station in paging sequence saved in its database. The paging sequence is updated whenever a new registration process has achieved by mobile terminal. If the mobile terminal does not respond, the network sends another paging request to the next base station in the paging sequence unless the mobile terminal performs a new registration process. The paging process continues until the mobile terminal has been found or the counter of the paging sequence reaches maximum as shown in Fig. 3. Paging traffic can be reduced

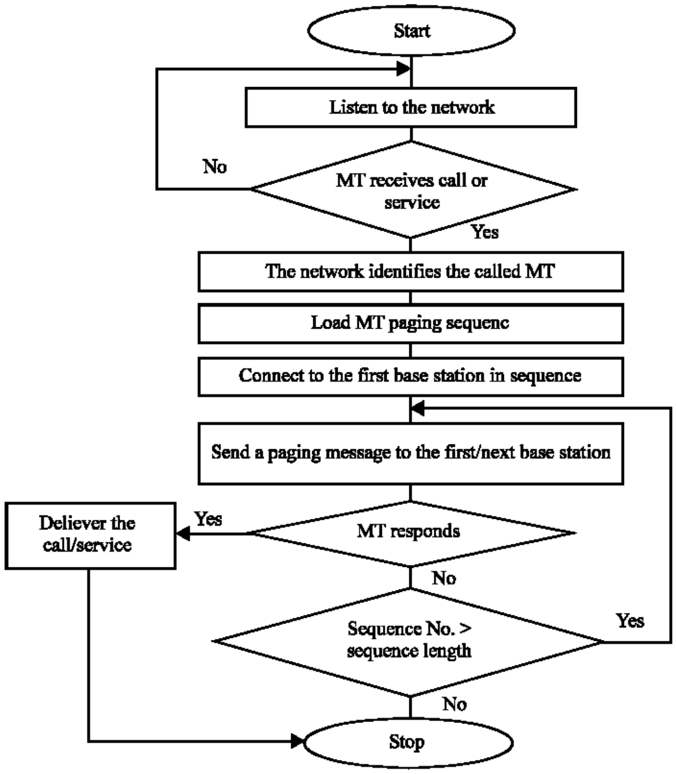

Fig. 3: Flow diagram of the proposed paging algorithm

in this way, because on average paging is not performed in all the registration areas. However, it must also be stressed that sequentially paging causes additional delay if the MT could not be located in the primary paging areas until the terminal is located.

SIMULATION MODEL

Different models and assumptions are being used in evaluating different schemes. Since, it is impractical to develop testbeds or field trials simply for performance comparisons, it is desirable to have a generic analytical or simulation model that can analyze various update and paging schemes in a realistic environment (Wong and Leung, 2000). Simulation of indoor environments presents interesting challenges. Indoor environments tend to be much smaller than the outdoor scenarios. Moreover, modern buildings can have irregular shapes and large numbers of obstacles, which affect both mobile terminal mobility and radio propagation. Finally, buildings typically have multiple floors, which add a three-dimensional aspect to the simulation. We used deterministic channel modeling technique, which combines ray tracing with a building-specific database.

Table 1: Simulation parameters

Parameter	Value
RSS threshold value (dBm)	-50
No. of access points/floor	6
No. of Floors	10
Area of the floor (meter)	21×14
No. of all mobile terminals	100
Transmitter height (m)	1.5
No. of reflections	3
No. of refractions	2

To examine the performance of the proposed location registration and paging scheme, a simulation has been carried in an indoor environment for a mobile terminal roaming in a predefined (known a priori) trajectory along the building. During the mobile terminal movement, on-line mobility-related information includes the number of registrations and the paging sequence stored in a user mobility buffer and subsequent forward link RSSI measurements of the current location from the transmitters around the mobile terminal. Simulation parameters are summarized in the Table 1.

A 3D ray tracing simulator has been developed to build the received signal strength map of the indoor environment. The mobile terminal will use this data to decide the location registration status. Assume that the

Table 2: System parameters

Parameter	Value
Operating frequency (GHz)	2.40
No. of transmitters/floor	6.00
Transmitted power (dBm)	13.00
Power gain of access points (dBi)	2.00
Power gain of mobile terminal (dBi)	7.00
Transmitters and receiver heights (m)	1.50
Transmitted power (W)	0.02

neighboring cellular network received power in the indoor environment is less than the RSS threshold value. Various processes have to be achieved by the simulator. First, a ray tracing process has been achieved based on the system parameters listed in Table 2.

Then mobile terminals route inside the building and measure the received signals from its neighboring base stations during their movements. The mobile terminal has to decide to perform location registration according to the received RSS. The simulation output provides detailed information about location registration and paging messages generated over time by simulated subscribers.

RESULTS

Simulations were performed to analyze the performance of the proposed RSS threshold-based location registration with sequential paging algorithm. The proposed algorithm compared with the conventional algorithm. The conventional algorithm considers the registration and paging area as physical partitions such as rooms, halls, corridors and stairs, while the proposed algorithm uses a circular area centered by access points in the building. These areas could be overlapped in the borders of the rooms. Simulation results show that the proposed algorithm reduced the number of location registrations as well as paging messages and hence the total location management cost significantly smaller as compared to cell based strategy in which the physical borders of rooms are the borders of the cells (registration area). Figure 4 shows that the conventional algorithm performs about 773 registrations processes, while the proposed algorithm performs about 200 registrations. This reduction in the registration messages is about 25.87 %. This value is for the assumed system and simulation parameters given in Table 1 and 2.

In the other side, the number of the performed paging messages sent to find the MT by the conventional algorithm is about 1660 and the proposed algorithm performed about 490 paging messages as shown in Fig. 5. So, the reduction in the paging messages is about 29.52%.

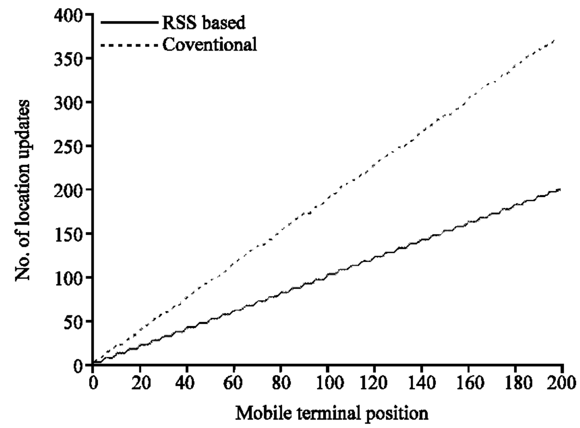

Fig. 4: Number of location registrations for the proposed and conventional algorithms

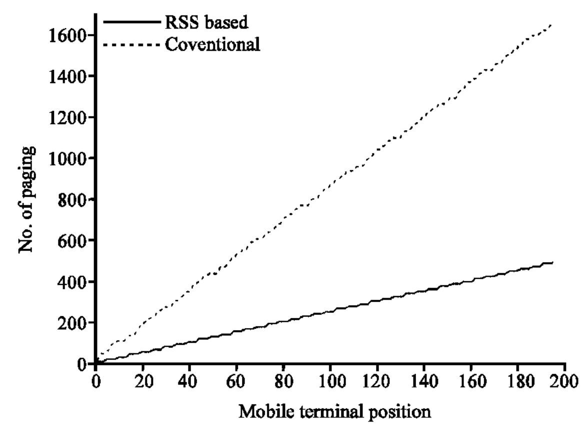

Fig. 5: Number of paging for the proposed and conventional algorithms

CONCLUSIONS

In this study, we proposed RSS threshold-based location registration with sequential paging scheme for the indoor heterogeneous wireless networks. The algorithm was implemented in WLAN networks because they are being deployed in the most of the buildings and it is expected a major penetration in the next years. We have presented a way to minimize the number of registration and paging messages that have to be performed in indoor wireless environments. An indoor user mobility model is presented to model the behavior of the mobile terminals during a congested traffic system during the lunch time in an office building. The proposed algorithm has been compared with the available conventional algorithm. Simulation results show that the proposed algorithm reduces the number of location registration as well as paging messages. According to the simulation results, RSS threshold-based registration algorithm with sequential paging shows a 25.87% effective reduction in number of registrations and 29.52% paging with respect to conventional algorithm with blanket paging.

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