



DISTANCE TRACKING SCHEME FOR SEAMLESS HANDOVER IN IMS-BASED SYSTEMS WITH UMTS ACCESS NETWORK

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ABSTRACT

This paper proposes a fast and seamless handover scheme for systems based on IP Multimedia Subsystem (IMS) architectural framework with Universal Mobile Telecommunications System (UMTS) access network. In the scheme the location, direction and movement pattern of a Mobile Node (MN) in a network cell are proactively tracked in order to determine the exact moment to trigger the pre-handover process with one of the adjacent cells considering MN's direction before the execution of Layer 2 handover. The performance of the proposed scheme was evaluated by comparing it with the traditional handover scheme and the evaluation shows that the traditional handover scheme introduced a handover delay of about 675.5 ms, whereas the proposed scheme introduced handover delay of about 96.25 ms, which is less than 100 ms, hence the handover delay introduced by the proposed scheme fall within the specified range of best class service for voice traffic and streaming media over IP networks.

Keywords: IMS, Handover delay, Distance Tracking, pre-handover, UMTS.

INTRODUCTION

Handover is a key process in mobile networks for mobility management and is defined as transferring of the mobile node's connection from one network coverage area to another while maintaining good quality of service (QoS) for the ongoing session (Banerjee *et al*, 2004; Kera, *et al*, 2015). Handover is a critical process and if performed incorrectly or not as fast as possible can result in dropping the ongoing session. Dropped sessions are particularly annoying to users, and the increased rate of dropped connections leads to the degraded QoS hence user dissatisfaction. Handover delay of more than 200 ms makes voice communication very unpleasant (Banerjee *et al*, 2004). Unfortunately normal handover process in IMS-based systems with UMTS access network tends to be very long and is intolerable to delay sensitive traffics (Banerjee *et al*, 2004; Kim, Joo and Kyoung-Hee, 2009). Therefore there is a need to devise an effective scheme to minimize the handover delay in IMS-based systems with UMTS access network which if implemented will facilitate fast and seamless handover (Banerjee *et al*, 2004; Kim, Joo and Kyoung-Hee, 2009).

In this paper we adopted the empirical propagation path loss model proposed in (Abhayawardhana *et al*, 2005; Han and Hwang, 2008) and incorporated it with pre-handover process which consists of the execution of pre-registration procedures followed by SIP pre-INVITE procedure to markedly minimize handover delay in IMS-based systems with UMTS

access network. The basic idea is to determine the location of the MN within a network cell and the speed with which the MN is moving in order to determine the right moment to commence the pre-registration procedures (acquiring new IP address, establishment of security association with the target (new) network and so on) and SIP Pre-INVITE procedure to prematurely reestablish the session before the complete detachment of MN from old network i.e. before Layer 2 handover. The rest of this paper is organized as follows. Section 2 provides the description of the underline network architecture of the considered system and explains in detail the traditional handover process in IMS-based systems with UMTS access network. Section 3 describes the proposed distance tracking scheme and in section 4 the performance of the proposed scheme was evaluated. Finally section 5 concludes the paper.

UNDERLINE NETWORK ARCHITECTURE

In this paper UMTS release 5 is considered for demonstration purposes even though the proposed scheme can be applied with some modifications for later generation access networks. UMTS release 5 provides access to Internet services with the help of architectural framework known as IP Multimedia Subsystem (IMS) (Orhan *et al*, 2016; Camarillo and Garcia-Martin, 2006; Kera, *et al*, 2015). The role of all the functional entities of the underline network architecture above can be found in (Orhan *et al*, 2016; Abdulbas *et al*, 2012; Banerjee *et al*, 2004).

Assume a MN connected to Home Network (old network) moves toward new network coverage area while on session with the correspondent

node (CN). MN's services must be handed over to the new network coverage area to ensure session continuity (Figure 1).

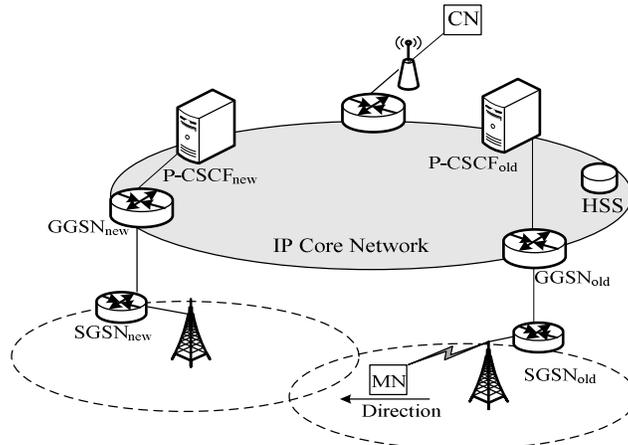


Figure 1: Network Architecture

To connect with a new network, MN must execute three procedures which are: GPRS attach procedure, Packet Data Protocol (PDP) context activation procedure and session re-establishment procedure, the first two procedures are collectively called data connection procedures, further detail on these procedures can be found in (Orhan *et al*, 2016; Banerjee *et al*, 2004). All these three procedures must be performed after Layer 2 handover (Link Switching Operation) and are done to ensure session continuity (Orhan *et al*, 2016; Abdulbaset *et al*, 2012; Banerjee *et al*, 2004).

We referred the above explained handover process as *Traditional Handover Process* in IMS-based systems with UMTS access network. **DISTANCE TRACKING SCHEME FOR FAST AND SEAMLESS HANDOVER IN IMS-BASED SYSTEMS WITH UMTS ACCESS NETWORK**

In the Proposed handover scheme data connection procedures is prematurely executed with only one of the neighboring cells with higher probability of receiving the handover considering the movement direction of MN then followed by SIP pre-INVITE procedure to prematurely reestablish a session with the CN (Note that the pre-handover process is to be executed before the complete detachment of the MN from the old network). To this end, each cell is divided into 2 zones using concentric circles based on the strength of the radio signal received from the base station (BS) at the center of the cell. The inner zone is referred to as the cell-core. The outer zone is then further subdivided into six (6) sectors using cell sectoring technique (Han, Lee, & Hwang, 2008). We referred these individual sectors to pre-handover regions. This process is illustrated in Figure 2.

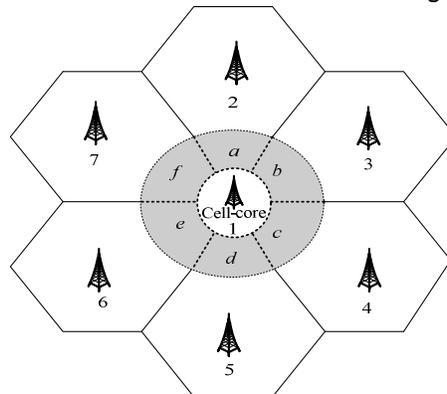


Figure 2: Cell Division

If the MN is in pre-handover region *a* (sector *a*), it can only move to sector *b*, sector *f* or cell 2. If the MN moves to sector *b* or *f*, then an intra-cell handover will take place which does not require much time to execute. Therefore, pre-

handover is performed only with cell 2. When a MN is inside the cell-core, the probability of a handover request is considered to be low; as such pre-handover process will not be initiated.

To decided when to execute pre-handover procedures it is important to know the location of the MN within the current cell, to determine the location of MN two variables were used: which are distance between MN and base station denoted by d and the radius of cell-core

denoted by r . If $d > r$, then MN is outside the cell-core else it is in the cell-core. MN periodically measured its distance from the base station by executing Equation (1) (Abhayawardhana *et al*, 2005).

$$d = 10^x, \quad (1)$$

$$PL - 46.30 - 33.90 \log f + 13.82 \log h_{BS} + \varepsilon_i - \delta_i$$

Where $x = \frac{PL - 46.30 - 33.90 \log f + 13.82 \log h_{BS} + \varepsilon_i - \delta_i}{44.90 - 6.55 \log h_{BS}}$.

Denoted by f the frequency in MHz, h_{BS} is the BS antenna height above ground level in meters (from 30m to 200m); d is the distance between the BS and the MN antenna in

kilometers. The index i denote the environment (urban, suburban or rural). The parameter δ_i is the correction factor for the environment and is:

$$\delta_i = \begin{cases} 0 \text{ dB} & \text{if } i = \text{Rural} = \text{Suburban} \\ 3 \text{ dB} & \text{if } i = \text{Urban} \end{cases}, \quad (2)$$

The parameter ε_i is a correction factor for effective mobile antenna height, which is a function of the coverage area and is defined as:

$$\varepsilon_i = \begin{cases} (1.10 \log f - 0.70) D - 1.56 \log f + 0.80 & \text{if } i = \text{Rural} = \text{Suburban} \\ 3.20 \log 138.06 D^2 - 4.97 & \text{if } i = \text{Urban} \end{cases} \quad (3)$$

Where D is the MN's distance above the ground level.

Since, the MNs have difference velocities, we made the size of cell-core to be the function of the MN's velocity so that the higher the velocity the smaller the cell-core and the lower the velocity the larger the cell-core this process is illustrated in Figure 3.

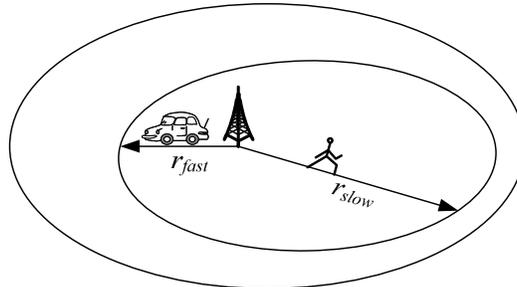


Figure 3: The change of r with a change in V

The radius r is computed using Equation (4).

$$r(V) = R - V \cdot T. \quad (4)$$

Where R is the radius of the entire cell and V is the MN's velocity and is defined as:

$$V = \frac{d(t_i) - d(t_{i-1})}{t_i - t_{i-1}} \quad (5)$$

Where t_i the time at which the distance is measured at i^{th} epoch and that distance is represented as $d(t_i)$.

Denoted by T the average time required to execute data connection procedures and is defined as:

$$T = T_1 + T_2 \quad (6)$$

Where T_1 is the average time to execute data connection procedures and T_2 is the average time to execute pre-INVITE procedure.

MN keeps measuring distance d by executing equation (1) and comparing the measured distance d with r . If $d > r$, then the MN is assumed to be in pre-handover region, and it is at that moment the pre-handover process should start. First step of the pre-handover process is GPRS attach procedure with SGSN_{new} (SGSN of the target network). Then the PDP context activation

procedure, where the MN will obtain a new IP address and the IP address of P-CSCF_{new} (P-CSCF of the target network). After successful completion of the above procedures, MN will

send pre-INVITE request message to the P-CSCF_{old} (P-CSCF of the home network) querying it to reestablish a session using the initial session ID and the newly configured IP address on its behalf (while at the same time the task of switching from old network interface to that of new network is ongoing). P-CSCF_{old} will send pre-INVITE message to CN through P-CSCF_{new}. After successful completion of the pre-INVITE procedure all packets sent by CN to the MN at this stage would be stored in the buffer of the GGSN_{new} (Kim, Joo & Kyoung-Hee, 2009). After

successful L2 handover (Link switching handover), the MN will notify the P-CSCF_{new} that it is fully attached to the new network and can receive all the packets sent from the CN, MN does that by sending handover completed message (*H.O completed*) to the P-CSCF_{new}. When *H.O completed* message is received by P-CSCF_{new}, then it will forward it to the GGSN_{new} querying it to deliver the buffered packets from CN and to release the connection directly to the MN. The explained process is shown in Figure 4.

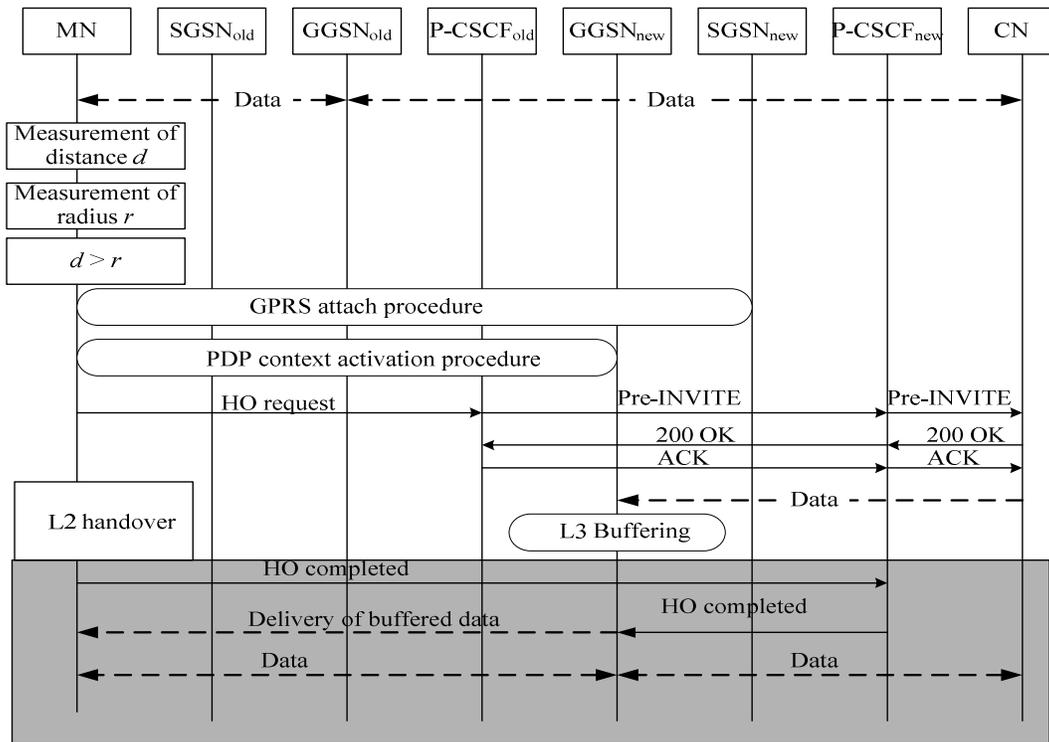


Figure 4: Signal flow chart of distance tracking scheme

PERFORMANCE EVALUATION

A simulation experiment was conducted to evaluate the effectiveness of the proposed scheme and it was implemented using MatLab

(version 9.2, R2017a) software simulator. For that purpose all the three handover procedures mentioned in section 2 combined in a single diagram as shown in Figure 5.

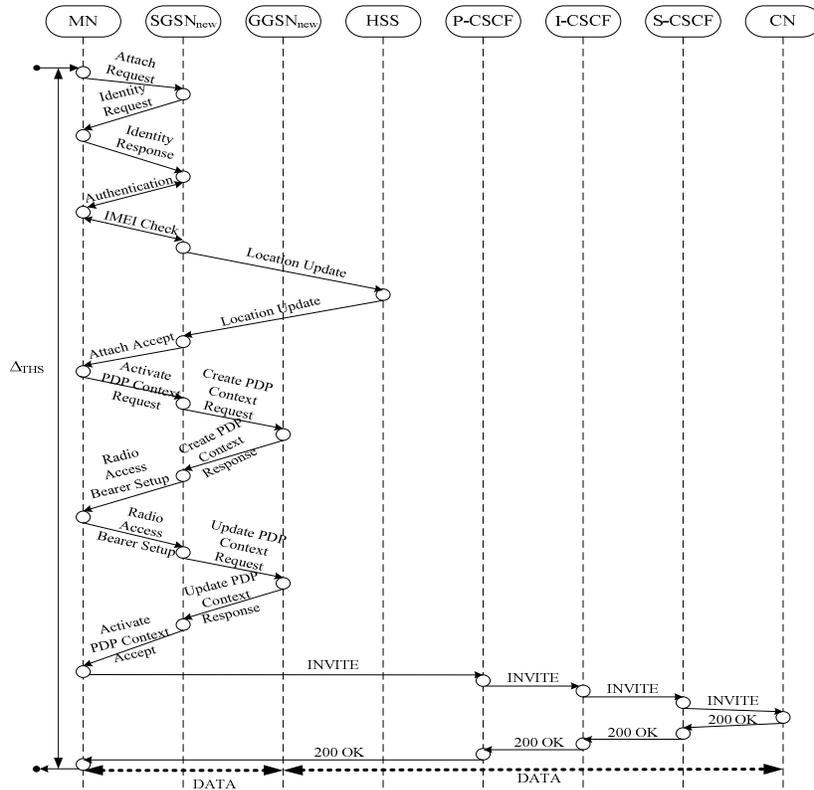


Figure 5: Signaling message flow for the handover process

The set $N = \{1, 2, 3, 4, 5, 6, 7, 8\}$ was obtained by numbering the functional entities that are involved in the handover process from Figure 5. It was assumed that all external arrivals of requests to be a Poisson process with rate λ . The processing rate μ_i , $i = 1, \dots, 8$ at each node is fixed. Signaling message flow between nodes of the network is described by routing matrix

$$\Theta = (\theta_{ij}), \text{ for } i, j \in N.$$

The set M contains all the messages required to be processed to accomplish the entire handover process, where n_m the number of m -message's transitions before reaching its final destination node and L_m the size of m -message in bits, $m \in M$.

The 1-node and 8-node were modeled as $M/M/\text{inf}$ type, whereas the rest of the nodes (2-, 3-, 4-, 5-, 6- and 7- nodes) were modeled as $M/M/1/\text{inf}$ type with service discipline FCFS. Handover process consists of three procedures as mentioned in section 2: GPRS attach procedure, PDP context activation procedure and the session reestablishment procedure using SIP re-INVITE message. The set N was divided into three sets:

$$N^{(1)} = \{1, 2, 4\}, \quad N^{(2)} = \{1, 2, 3\}, \\ N^{(3)} = \{1, 5, 6, 7, 8\}.$$

The first set $N^{(1)}$ contain the nodes that are involved in GPRS attach procedure, second set $N^{(2)}$ contain the nodes that are involved in PDP context activation procedure and the last set $N^{(3)}$ contain the nodes that are involved in session reestablishment procedure. The handover delay for the traditional handover scheme is denoted by Δ_{THS} and for the proposed scheme the handover delay is denoted by Δ_{DTS} .

In the simulation conducted 50 cells were used with a honeycomb-like organization where the transmission ranges were modeled as circles enclosing the cells, each cell contained all the necessary nodes for MNs communications. Random waypoint mobility model was used where the MNs moved along a straight line from two destination points (waypoints) (Santi, 2012), 50 MNs were introduced and their velocities were defined by a uniform distribution.

For the experiment, it was assumed that the average processing rate at 1-node and 8-node is 0.4 ms, average processing rate at 2-node, 3-node and 4-node is 0.5 ms and the average processing rate at 5-node, 6-node and 7-node is 0.4 ms (Banerjee et al, 2004).

It was assumed also that the average size of GPRS attach messages is 43 bytes, the average size of PDP Context Activation messages is 573 bytes and average size of SIP messages for session reestablishment is 731 bytes (Ohta, 2007), the MN speed was chosen between the interval of 1 m/s to 20 m/s in order to reflect the velocity of walking MNs and the velocity of fast moving MNs. Channel with 128 kbps was considered.

Results obtained were presented in Figure 6, it can be observed from the graph that the

average handover delay for the traditional handover scheme was around 675.5 ms for the MNs, which is significantly long, and such a delay may not be tolerated by the time sensitive services, however, the average handover delay for the proposed scheme was around 96.25 ms for the MNs, which fall within the specified range of best class service for voice traffic and streaming media over IP networks (Banerjee *et al*, 2004).

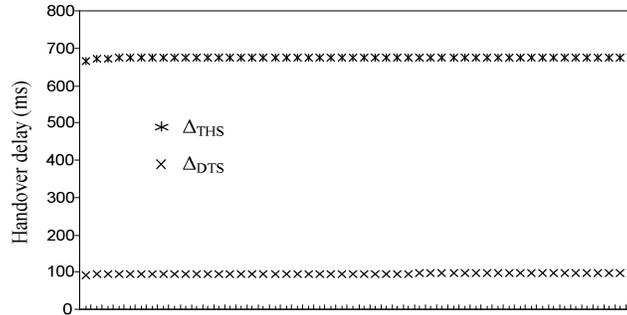


Figure 6: Handover delay for traditional handover scheme and the distance tracking scheme

CONCLUSION

In this paper a fast and seamless handover scheme was proposed for IMS-based systems with UMTS access network. In the scheme the location, direction and movement pattern of a Mobile Node (MN) in a network cell dictates the right moment to trigger the pre-handover process with one of the adjacent cells having the highest chance of receiving the handover. In the proposed scheme however, SIP protocol was slightly modified where pre-INVITE message was introduced to prematurely reestablish the

session with the CN before Layer 2 handover. The performance of the proposed scheme was evaluated by comparing it with the traditional handover scheme and the evaluation shows that the traditional handover scheme introduced a handover delay of about 675.5 ms, whereas the proposed scheme introduced handover delay of about 96.25 ms, which is less than 100 ms, hence the handover delay introduced by the proposed scheme fall within the specified range of best class service for voice traffic and streaming media over IP networks.

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