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Advance Programme

VTC2018-Spring
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6 **Enhanced Uplink Transmission Performance Based on WFRFT for Future Communication Systems**
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3 **Autonomic Vehicular Networks: Safety, Cybersecurity, Privacy and Societal Issues**
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Jussi Haapola, Samad Ali, University of Oulu; Charalampos Kalalas, Centre Tecnolo?gic de Telecomunicacions de Catalunya; Juho

Extension of Localized Routing to PMIP-SAE based Mobile Networks

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***Abstract*—In existing PMIP-SAE based mobile networks, all the communication traffic go through the centralized Local Mobility Anchor (LMA). Hence the central node, LMA, suffers from huge packet processing overhead and the traffic is delivered via non-optimal routes. In order to overcome these drawbacks, we apply the localized routing to mobile networks based on PMIP-SAE mobility management scheme, while introducing additional control messages of Localized Routing Initiation (LRI) and Local Routing Acknowledgment (LRA). Numerical analysis shows that our proposed scheme performs better than the existing scheme in packet delivery cost, tunneling overhead, and throughput.**

***Index Terms*—PMIPv6, SAE, LTE, Route Optimization.**

I. INTRODUCTION

System Architecture Evaluation (SAE) is the core network architecture of the 3GPP LTE system. To support IP mobility in SAE, the PMIP scheme [1] has been considered in [2] and [3]. However, it has the shortcomings of large GPRS tunneling overhead, registration, and route update delay. As an alternative, an enhanced mobility approach has been proposed in [4], which is called the Enhanced PMIP-SAE (EPMIP-SAE). In the EPMIP-SAE scheme, eNB works as a Mobile Access Gateway (MAG) and two user plane nodes, S-GW and P-GW are aggregated as a single entity, working as a Local Mobility Anchor (LMA). GTP tunnels are not used any more since GRE tunnels are used instead between eNB/MAG and S-GW/P-GW/LMA and also between eNB/MAGs. Unfortunately, EPMIP-SAE scheme still has the problems of traffic overhead and non-optimal routes, because all communications are performed through the centralized LMA. To overcome such limitations, we extend the EPMIP-SAE to involve the local routing with additional control messages of Localized Routing Initiation (LRI) and Local Routing Acknowledgment (LRA) as in PMIP-LR [5].

The rest of this paper is organized as follows. Section II describes the existing EPMIP-SAE scheme. In Section III, we illustrate our proposed scheme. We analyze the performances of our scheme and the existing scheme, and compare them in Section IV. Numerical results are provided in Section V and conclusion follows in Section VI.

II. EXISITNG EPMIP-SAE SCHEME

A. Network Model

We overview the EPMIP-SAE scheme, proposed for SAE networks, with the network model of Fig. 1 [4]. Therein, each eNB works as an MAG and an entity combining S-GW and P-GW plays the role of an LMA. Instead of GTP tunnels, GRE tunnels are used between eNB/MAG and S-GW/P-GW/LMA and between eNB/MAGs. We assume the scenario of both a mobile node (MN) and its correspondent node (CN) residing in the same domain, but in different eNB/MAG regions.

B. Registration and Data Delivery

We illustrate the initial registration procedure of EPMIP-SAE in Fig. 2. When an MN establishes a radio link with an eNB, the eNB sends an *Attach Request* message to the Mobility Management Entity (MME), on behalf of the MN. Then, security-related procedures are performed between MN and MME, and MME updates the associated Home Subscriber Server (HSS). In the sequel, to establish a transmission path, MME sends a *Create Session Request* message to the S-GW/P-GW/LMA. The message includes the *Proxy Binding Update (PBU)* also. Receiving the request message from MME, S-GW/P-GW/LMA responds with a *Create Session Response* message to the MME, which contains the *Proxy Binding Acknowledgement (PBA)* as well. Now, MME relays the information from S-GW/P-GW/LMA to the eNB/MAG through an *Initial Context Setup Request* message, incorporating the *PBA*. This signaling message functions also as the *Attach Accept* notification for the initial *Attach Request*. eNB/MAG responds with an *Initial Context Setup Response* message to the MME. Finally, MN sends an *Attach Complete* message to MME.

For data delivery, suppose that CN sends a data packet to MN. The packet is delivered to S-GW/P-GW/LMA first. Then the S-GW/P-GW/LMA forwards the packet to the eNB/MAG serving MN, and eventually to the MN.

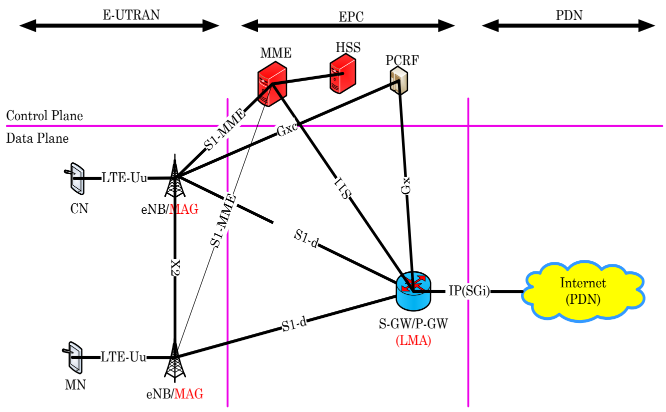

Fig. 1 Network model of EPMIP-SAE

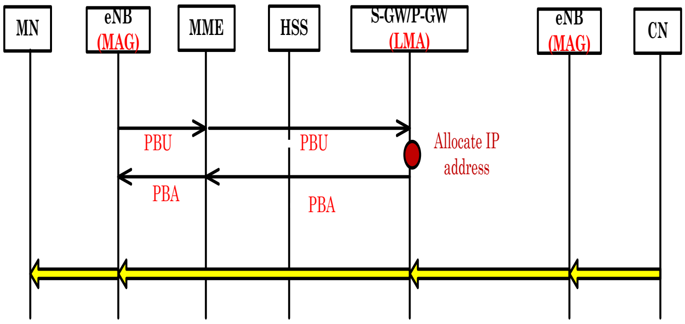

Fig. 2 Registration and data delivery

III. PROPOSED EPMIP-SAE-LR SCHEME

A. Network Model

We consider the network model of Fig. 1 to illustrate our proposed scheme, denoted as EPMIP-SAE-LR. Differently from the existing EPMIP-SAE, our scheme supports packet delivery through the optimal route between MN and CN when they are in the same domain. To this end, we use Localized Routing Initiation (LRI) and Local Routing Acknowledgment (LRA) messages as in the PMIP-LR [5].

B. Registration and Data Delivery

Fig. 3 shows the registration and data delivery procedures of our proposed scheme. Actually, the registration procedure of our EPMIP-SAE-LR is exactly same with that of EPMIP-SAE. However, the data delivery procedure can be very different.

When CN has a data packet for MN, the CN hands in the packet to its serving eNB/MAG. The eNB-MAG then delivers the packet to S-GW/P-GW/LMA. The S-GW/P-GW/LMA forwards the packet to the eNB/MAG serving MN, and further to the MN. After that, S-GW/P-GW/LMA exchanges *LRI* and *LRA* messages with both eNB/MAGs involved, for route optimization. Now, CN and MN can use the optimized route between their serving eNB/MAGs for data delivery.

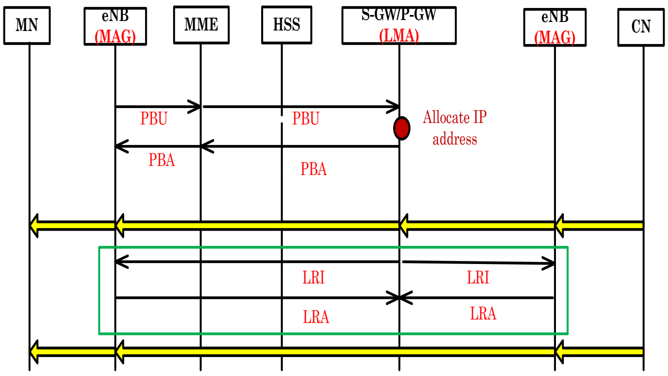

Fig. 3 Registration and data delivery procedures of EPMIP-SAE-LR

C. Benefits of our EPMIP-SAE-LR

The benefits of EPMIP-SAE-LR can be summarized as follows:

1. **Optimal route:** With LRI and LRA messages, CN and MN can use the optimized route for data delivery.

2. **Reduced end-to-end delay:** The shorter routing distance is, the smaller end-to-end delay is.

3. **Throughput:** As the end-to-end delay is reduced, throughput can be improved also.

IV. PERFORMANCE ANALYSIS

For performance analysis, we compare the packet delivery cost, tunneling overhead and throughput of the two candidate mobility schemes, i.e., EPMIP-SAE, EPMIP-SAE-LR. We consider a network topology of Fig. 4, and provide the summary of notations used in analysis in Table 1.

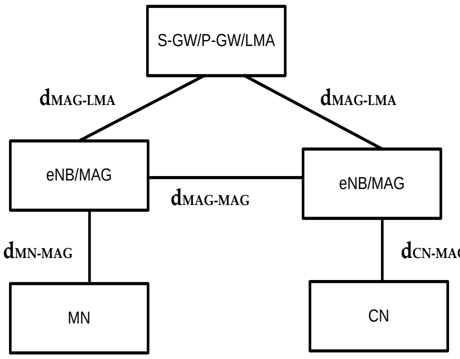

Fig. 4 Network model for performance analysis

Table1. Parameters used for analysis

Parameters	Description
S_d	Size of data packets (bytes)
B_w	Wired link bandwidth (Mbps)
B_{wl}	Wireless bandwidth (Mbps)
L_w	Wired link delay (ms)
L_{wl}	Wireless link delay (ms)
d_{x-y}	Hop count between node *x* and *y* in the network
L_T	Size of IP header

A. Packet Delivery Cost (PDC)

Packet delivery cost is defined as the transmitted data packet size multiplied by routing hop distance, for a given arrival rate and session duration time.

Albeit MN and CN reside in same domain, they can be served by the same eNB/MAG with probability q and by different eNB/MAGs with probability $1-q$. In EPMIP-SAE, if MN and CN are connected to different eNB/MAGs, all the data packets should be routed through LMA. Accordingly, the Packet Delivery Cost (PDC) of EPMIP-SAE can be represented as follows.

$$\mathrm{PDC}_{\mathrm{EPMIP-SAE}} = \lambda_s(1/\mu_s)\,\mathrm{E}(N)(2q + (1-q)D_{NOR}),$$

where λ_s is the average session arrival rate, $1/\mu_s$ is the average session duration time, and $\mathrm{E}(N)$ is the number of packets in a session. D_{NOR} denotes the routing hop distance through the non-optimized route via LMA. It can be written as

$$D_{NOR} = 2 + 2d_{MAG-LMA}.$$

On the other hand, in EPMIP-SAE-LR, some packets of each session can be routed through the non-optimized route initially. However, the route is optimized soon and most of the packets are routed through the direct path between the involved eNB/MAGs. We denote the portion of the initial packets routed via LMA as ω. Then, PDC of our proposed EPMIP-SAE-LR can be written as

$$\mathrm{PDC}_{\mathrm{EPMIP-SAE-LR}} = \lambda_s(1/\mu_s)\,\mathrm{E}(N)\,(2q + (1-q)(\omega D_{NOR} + (1-\omega)D_{OR})$$

where D_{OR} denotes the routing hop distance through the optimized route between eNB/MAGs, and can be written as

$$D_{OR} = 2 + d_{MAG-MAG}.$$

B. Tunneling Overhead (TO)

The tunneling overhead equation is obtained by only considering the traffic overhead. It can be given by the product of IP tunneling header length and traveled routing distance. Tunneling Overhead (TO) for the considered schemes can be represented as follows.

$$\mathrm{TO}_{\mathrm{EPMIP-SAE}} = \lambda_s(1/\mu_s)\,\mathrm{E}(N)(1-q)\cdot 2d_{MAG-LMA}\cdot L_T$$

$$\mathrm{TO}_{\mathrm{EPMIP-SAE-LR}} = \lambda_s(1/\mu_s)\,\mathrm{E}(N)\,(1-q)(2\omega d_{MAG-LMA} + (1-\omega)d_{MAG-MAG})\cdot L_T.$$

C. Throughput (TH)

Let $T_{x-y}(S)$ denote the transmission delay of a packet with size S from node x to y via a '*wireless*' link. Likewise, $T_{x-y}(S,H)$ denotes the transmission delay of a packet with size S from node x to node y via H hop of '*wired*' links. It is straightforward to see that $T_{x-y}(S) = \frac{S}{B_{wl}} + L_{wl}$ and $T_{x-y}(S,H) = \frac{S}{B_w} + L_w$.
We then obtain the average packet delivery times of EP-MIP-SAE and EPMIP-SAE-LR as follows, assuming the packet size is S_d.

$$T_{\mathrm{EPMIP-SAE}} = q\big(T_{CN-MAG}(S_\mathrm{d}) + T_{MN-MAG}(S_\mathrm{d})\big) + (1-q)\tau_{NOR},$$

$$T_{\mathrm{EPMIP-SAE-LR}} = q\big(T_{CN-MAG}(S_\mathrm{d}) + T_{MN-MAG}(S_\mathrm{d})\big) + (1-q)(\omega\tau_{NOR} + (1-\omega)\tau_{OR}),$$

where τ_{NOR} and τ_{OR} denote the average packet delivery times via non-optimal route and optimal route, respectively. The average packet delivery times can be written as

$$\tau_{NOR} = T_{CN-MAG}(S_\mathrm{d}) + 2T_{MAG-LMA}(S_\mathrm{d} + L_T, d_{MAG-LMA}) + T_{MN-MAG}(S_\mathrm{d})$$

$$\tau_{OR} = T_{CN-MAG}(S_\mathrm{d}) + T_{MAG-MAG}(S_\mathrm{d} + L_T, d_{MAG-MAG}) + T_{MN-MAG}(S_\mathrm{d})$$

Conclusively, referring to [6], we obtain the throughput as

$$TH_{EPMIP-SAE} = \frac{E(N)S_d}{T_{EPMIP-SAE}\cdot\sigma(E(N)-1)},$$

$$TH_{EPMIP-SAE-LR} = \frac{E(N)S_d}{T_{EPMIP-SAE-LR}\cdot\sigma(E(N)-1)}$$

V. Numerical Results and Discussion

In this section, we provide numerical results based on the analysis of Section IV. Default values of parameters are set as $d_{MAG-LMA}$ =8, $d_{MAG-MAG}$ =4, S_d=1000 bytes, B_w =100 Mbps, $B_{wl} = 11$ Mbps, $L_{wl} = 0.5$ ms, $L_w = 0.2$ ms, $E(N) = 10$, λ_s =0.01, μ_s =0.0033, σ = 1 ms, ω =0.5, and L_T =40 bytes, respectively, referring to [6].

Fig.5 shows that the variation of ω seriously affects the packet delivery cost of both the candidate scheme. EPMIP-SAE-LR gives better performance from EPMIP-SAE. This is because in EPMIP-SAE-LR the LMA is used for the first few data packets, then LMA will perform the localized initiation and then the optimized path will be used for the rest of the data packets.

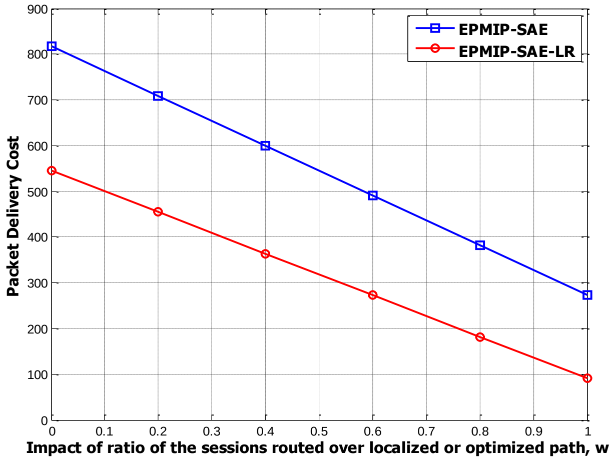

Fig. 5 Impact of ω on packet delivery cost

Fig. 6 shows the impact of ω on tunneling overhead. From the figure, we can see that the tunneling overhead decreases, as ω gets larger, for both the candidate scheme. It is shown that the proposed scheme gives better performance than the existing schemes. This is because the proposed scheme uses optimized path.

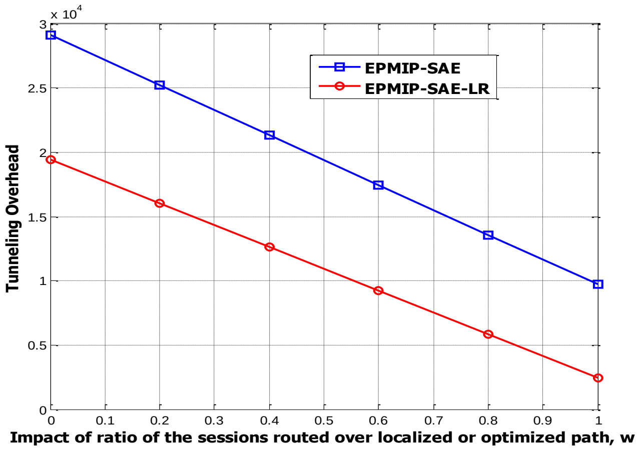

Fig. 6 Impact of ω on tunneling overhead

Fig. 7 and 8 compares the throughput for different ω and E(S).It is shown in figure 7 that the throughput linearly increases, as ω gets larger, for both the candidate scheme. We can see that the proposed scheme gives the best performance among the candidate schemes. This is because of optimized route. In Fig.8, both the schemes are quite sensitive to the increase of E(S). However, the proposed scheme can give better performance than the existing scheme.

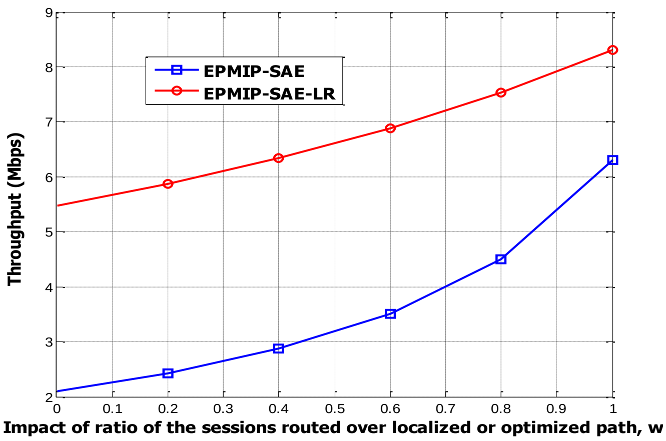

Fig. 7 Impact of ω on throughput

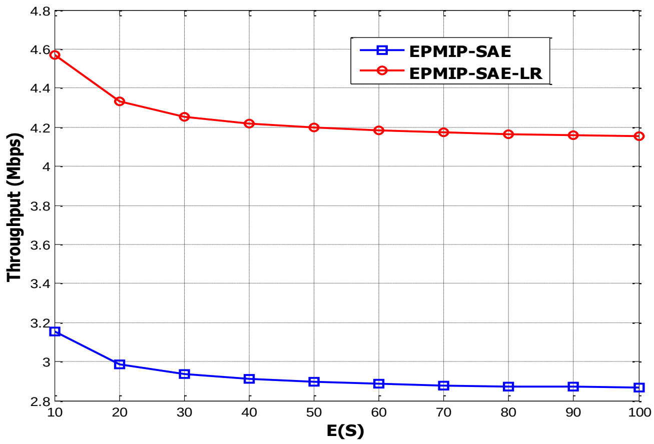

Fig. 8 Impact of E(S) on throughput

VI. Conclusions

In this paper, we give extension of localized routing to EPMIP-SAE based mobile networks by using Localized Routing Initiation (LRI) and Local Routing Acknowledgment (LRA) messages. By numerical results, proposed scheme provides better performance than the previous schemes in terms of the packet delivery cost, tunneling overhead, and throughput.

References

[1] S. Gundavelli, *et al.*, Proxy Mobile IPv6, IETF RFC 5213, August 2008.

[2] Julien Laganier, *et al.*, "Mobility Management for All-IP Network," NTT DOCOMO Technical Journal, Vol. 11, No. 3, September 2009.

[3] 3GPP TR 23.402, Technical Specification Group Services and System Aspects: Architecture Enhancements for Non-3GPP Accesses, V10.7.0, March 2012.

[4] Moneeb Gohar, *et al.*, "Enhanced Mobility Management Scheme in PMIP-SAE based Mobile Networks,", IEEE Communications Letters, Vol. 20, No. 6, June 2016.

[5] S. Krishnan, et al., "Localized Routing for Proxy Mobile IPv6," IETF RFC 6705, September 2012.

[6] Seil Jeon, *et al.*, " Comprehensive Performance Evaluation of Distributed and Dynamic Mobility Management Routing Strategy," Computer Networks, Volume 79, Pages 53-67, 14 March 2015.