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Performance Technique of Location Registration in System Architecture Evolution

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Abstract: Next generation mobile network is composed of several networks that interconnected into one common core network called as a heterogeneous network. In this heterogeneous network, the different operators will have different access networks. Therefore, there is a need to have a technique to interconnect between these different access networks. The objective of this research was to develop a new location registration technique for System Architecture Evolution (SAE) in order to support interworking between different access networks. Under the developed technique, the authentication between different networks which may not have service level agreement between them is carried out. A signaling message is developed to evaluate the performance of the registration technique. A generalized equation is formulated to investigate the location registration performance. In the simulation results, it was found that the developed technique reduces the latency and signaling cost for location registration. Therefore, this technique had improved the network performance for SAE.

Key words: Heterogeneous, location registration, authentication, service level agreement, latency

INTRODUCTION

In next generation mobile network, various wireless access networks will be connected to one common core network by anchor entity and form a heterogeneous network (Akyildiz *et al*., 2004) are to enable the mobile terminal to be connected anytime and anywhere (Salem *et al*., 2011; Viswacheda *et al*., 2007). Being able to prioritize the traffic and allocate a minimum bandwidth guarantee for each user is crucial in this environment (Noor and Edward, 2011; Al-Nabhan *et al*., 2006; Ghazizadeh *et al*., 2009; Eshanta *et al*., 2009). To meet this demand, a new architecture is required to integrate these different wireless networks which belong to different operators that may not be willing to provide registration with information about the access network (Sasikala and Srivatsa, 2006). Most of the research requires agreements between the operators who own different interworking access networks to be established (Mohanty, 2005). SAE has been developed by 3 GPP under Release 8 as the interworking architecture for the next generation mobile network. The signalling message for location registration needs to be designed to integrate any number of wireless systems of different operators who may not have direct service level agreements among them (Agrawal and Bedekar, 2007). In this study, a new location registration technique is developed for SAE. The generalized equation is formulated for the signaling cost and latency of location registration. The numerical results are provided to analyze and compare the proposed technique.

There have been many proposals to propose a new heterogeneous architecture. Dahlman *et al*. (2005) has developed some changes to the 3G radio network architecture. To achieve the performance and to decrease packet loss and latency, Dahlman *et al*. (2005) has proposed a radio network architecture that only have some network nodes in order to decrease the number of processing and interfaces, therefore reduce interoperability testing cost.

Ekstrom *et al*. (2006) also proposed some solutions for the Radio Access Network (RAN) and radio access. In the developed Long Term Evolution (LTE) architecture, the Rel-6 entity Radio Network controller (RNC), Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN) are combined into a single entity called as the Access Core Gateway (ACGW). The ACGW function are to transferred the user and control planes for the User Equipment (UE) and controls the core network functions provided by the SGSN and GGSN in Release 6. The control plane protocol for the UE is same to the Radio Resource Control (RRC) in Release 6.

In order to support interworking between different access networks, SAE has been developed by 3 GPP. Figure 1 shows the SAE that has been developed to provide access for different types of networks.

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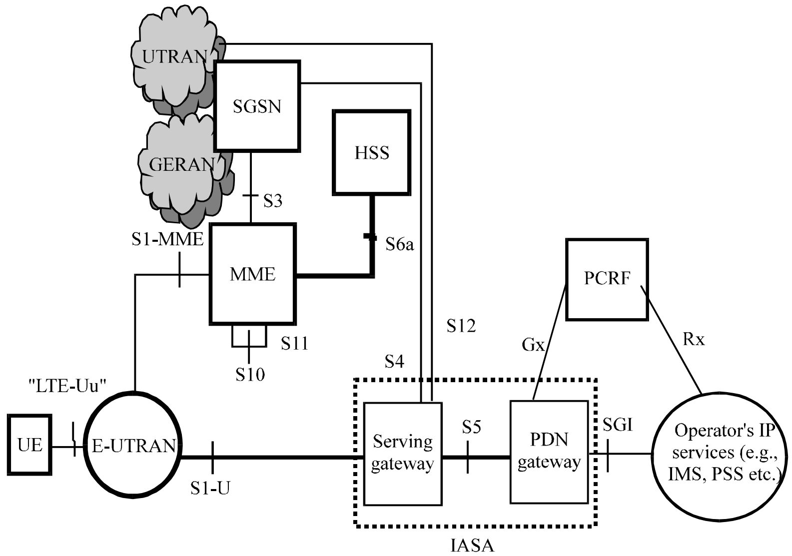

Fig. 1: System architecture evolution (SAE)

As a conclusion, each architecture has its merit and demerits but neither alone indicates the complete requirements for next generation mobile network. Among all the architecture discussed, the SAE has been chosen as the best architecture for next generation mobile network. In this research, a new location registration technique is proposed for SAE. A numerical results are provided to evaluate and compare the proposed technique.

SYSTEM ARCHITECTURE EVOLUTION

SAE is simplified all-IP architecture, focusing on the packet switch domain. In this architecture, the E-UTRAN only composed of one network element that is enhanced Node B (eNodeB) which are interconnected with each other by the X2 interface in order to allow for efficient handoffs. All eNodeBs are connected to at least one Mobility Management Entity (MME) over the S1-MME interface. The MME handles all the Long Term Evolution (LTE) related signaling, including mobility and security functions. The MME is connected to the Home Service Subscriber (HSS) over the S6a interface. The Home Service Subscriber (HSS) manages storing and updating the database containing all the user subscription information. The Inter Access System Anchor (IASA) is in charge of mobility between different access systems. The traffic from all the networks is gathered in the IASA making the access technology transparent to other parties involved in the service provisioning. It is composed of a 3 GPP Anchor that executes mobility between 3 GPP access systems and a SAE Anchor that handles mobility between 3 GPP and non-3 GPP access systems. The SAE Anchor does not take any decision regarding mobility, it just executes it (Li and Salleh, 2007; Li *et al*., 2009). It is the User Equipment (UE) that takes this decision.

A new location registration technique: As discussed before, the number of entity would be decreased and reduced costs as the system architecture has been simplified. Therefore, in this research a new location registration technique is developed to analyze the latency and signaling cost of location registration for the SAE.

From the location registration procedure proposed by http://www.3 GPP.org, it can be seen that the technique does not described in detailed how the authentication between different access networks having different Internet Protocol (IP) is described. The interaction between the Home AAA Server (AAAH) and the HSS is not explicitly presented in the location registration technique proposed by 3 GPP. After a UE has successfully been authenticated by the AAAH, the AAAH registers its address to the HSS, unless already done. The HSS should store the address of the registered AAAH for the given user and mark the user as registered in the AAAH. Then, the HSS returns user profile data. This process is not explained in the location registration technique proposed by 3 GPP. Therefore, in this research a modification of location registration for different access system is proposed for SAE to reduce overhead of signaling costs.

The modification is done by combining the 3 GPP procedure as described above and project done (Mohanty, 2005). The author proposed a security architecture called as Architecture for ubiquitous Mobile Communications (AMC) by including AAAH in the location registration procedure. However, the proposed architecture introduces extra signaling overhead by adding nodes called Network Interworking Agent (NIA) and Interworking Gateway (IG) to the system. Therefore, in this proposed procedure two new entities proposed by Mohanty (2005), is removed and the location registration procedure proposed by 3 GPP is modified based on SAE. One major change is that the NIA is eliminated. In these SAE heterogeneous networks, the network domains will be owned by different operators. Therefore, for a user who are roaming or traveling outside of the home service area, there is a need to have subscription information and authentication on the networks. The networks operate independently of each other and requiring direct service level agreements to support non-3 GPP access types. However, since the UE has no subscription with non-3 GPP access, 3 GPP AAA server needs to be linked to the HSS for registration. 3 GPP AAA server acts as an interworking unit between the 3 GPP and non-3 GPP world. Its purpose is to allow registration between the 3 GPP and non-3 GPP access network. For that reason, the 3 GPP AAA server has an access to the HSS through the Wx interface, so as to retrieve user related subscription information and 3 GPP authentication vectors.

Information technology journal: AAAH is needed to authenticate the UE when the user roams to a Foreign Network (FN). The AAAH must communicate with the designated HSS to select a suitable home address for the UE and to deliver to the HSS the necessary configuration parameters. Therefore, in this research, AAAH is presented as one entity in the location registration procedure to show in detailed how the registration process is carried out.

Assumptions and parameters: The following parameters were defined in order to present and evaluate the performance of the signaling procedure. a_h is the HSS access cost, a_e is the evolved RAN access cost, a_a is the AGW access cost, a_{ah} is the AAAH access cost and a_i is the IASA access cost. The average service time is $1/\mu_h$ for HSS, $1/\mu_e$ for Evolved RAN, $1/\mu_a$ for AGW, $1/\mu_{ah}$ for AAAH and $1/\mu_i$ for IASA. The system time is indicated by s_h, s_e, s_a, s_{ah} and s_i for the HSS, Evolved RAN, AGW, AAAH and IASA, respectively. The waiting times are represented as w_h, w_e, w_a, w_{ah} and w_i.

Overhead of signaling cost: The signaling cost is derived based on the calculation of the total cost proposed by Wang and Akyildiz (2001). Based on the proposed procedure, the signaling cost associated with transmission cost is α $(6c_1+3c_2+3c_3+2c_4)$ and the cost related to the databases is $\beta(a_e+a_{a+}a_{ah}+a_{i+}a_h)$. So, the total cost of the proposed procedure is then formulated as $T = \alpha\ (6c_1+3c_2+3c_3+2c_4)+\beta(a_e+a_{a+}a_{ah}+a_{i+}a_h)$.

Latency of location registration: The latency of accessing each database, s(.), can be formulated as:

$$s(.) = 1/\mu_{()}+w_{()} \quad (1)$$

where, (.) shows the number of a signaling message and $1/\mu_{()}$ indicates the average service time for Evolved RAN, AGW, AAAH, IASA and HSS. $w_{()}$ is used to represent the waiting time for all databases. The average waiting time, w_h is calculated by Kleinrock (1975):

$$w_h = \varsigma_h \times \mu_h^2+\varsigma_h \times \sigma_h^2 / 2(1- \varsigma_h/\mu_h) \quad (2)$$

where, σ_h^2 is the HSS variance processing time. The latency of involving the HSS, s_h can be formulated from:

$$s_h = 1/\mu_h+w_h = 1/\mu_h+\varsigma_h(\mu_h^2+\sigma_h^2) / 2(1- \varsigma_h/\mu_h)) \quad (3)$$

where w_h is the result from (2). The latency of the Evolved RAN, AGW, AAAH and IASA can be calculated by using Eq. 3. Hence, the latency of registration is $L = s_e+s_a+s_{ah}+s_i+s_h$.

NUMERICAL RESULTS

The numerical results are showed to compare the performance of location registration by Mohanty (2005) and proposed proposal. Table 1 shows all parameters used in the simulation analysis (Chan *et al*., 1997; Zeng and Lei, 1999).

Figure 2 shows the comparison of location registration. Three categories of α = 0.4, 0.5 and 0.7 are compared to evaluate the location registration cost as indicated in Fig. 2a and c. In all cases, the proposed proposal shows less location registration cost than (Mohanty, 2005) as given in Fig. 2a and c. Sixteen percent improvements shown for the same alpha. When the operation completion probability is small, the location registration cost is dominated by only involving less databases access. If the operation completion probability is high, the registration cost is dominated by accessing more databases, resulting in higher cost. Figure 2c shows the comparison of location registration cost when α = 0.7. Figure 3 indicates that the registration cost reduced for each category in SAE proposal. Therefore, the location registration cost of SAE proposal is much lower than Mohanty (2005) because of the simplified architecture.

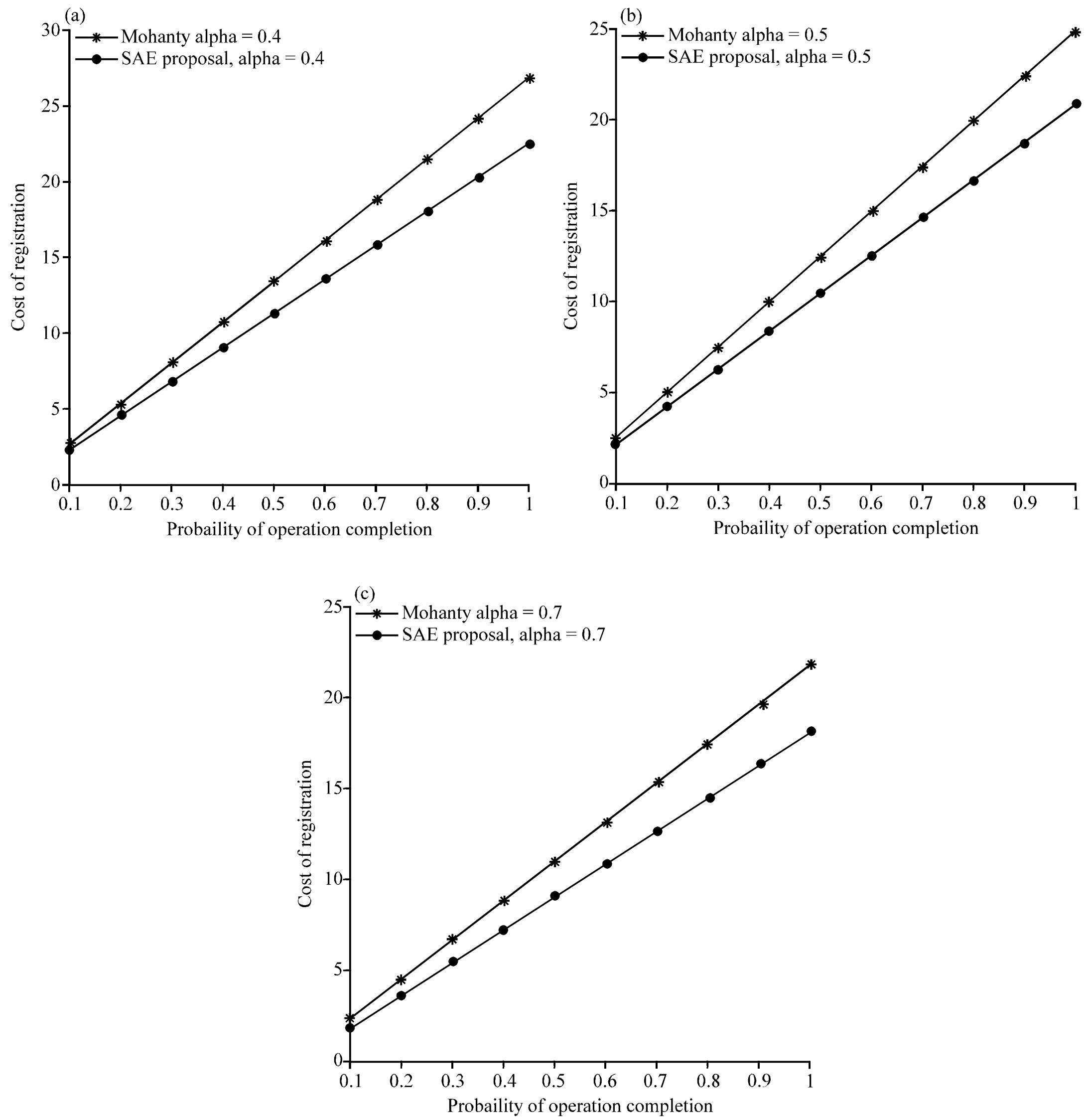

Fig. 2(a-c): Cost of registration for (a) alpha = 0.4, (b) alpha = 0.5 and (c) alpha = 0.7

Table 1: Simulation analysis parameters

Parameters	Result
Database access cost	$a_h = 8$, $a_e = 5$, $a_m = 5$, $a_{ah} = 5$, $a_i = 5$, $a_{fa} = 5$, $a_{ig} = 5$, $a_{nia} = 5$, $a_{ah} = 5$, $a_{auc} = 5$, $a_{ha} = 8$
Average arrival rate (m sec^{-1})	$\varsigma_h = 0.001$, $\varsigma_e = 0.001$, $\varsigma_m = 0.001$, $\varsigma_{ah} = 0.001$, $\varsigma_i = 0.001$, $\varsigma_{fa} = 5$, $\varsigma_{ig} = 0.001$, $\varsigma_{nia} = 0.001$, $\varsigma_{ah} = 0.001$, $\varsigma_{auc} = 0.001$, $\varsigma_{ha} = 0.001$
Average service time (m sec^{-1})	$1/\mu_h = 1$, $1/\mu_e = 0.5$, $1/\mu_m = 0.5$, $1/\mu_{ah} = 0.5$, $1/\mu_i = 0.5$, $1/\mu_{ha} = 1$, $1/\mu_{fa} = 0.5$, $1/\mu_{ig} = 0.5$, $1/\mu_{nia} = 0.5$, $1/\mu_{ah} = 0.5$, $1/\mu_{auc} = 0.5$, $1/\mu_{ha} = 1$
Variance of processing time (m sec^{-1})	$\mu^2_h = 0.04$, $\mu^2_e = 0.01$, $\mu^2_m = 0.01$, $\mu^2_{ah} = 0.001$, $\mu^2_i = 0.\ 01$, $\mu^2_{fa} = 5$, $\mu^2_{ig} = 0.01$, $\mu^2_{nia} = 0.01$, $\mu^2_{ah} = 0.01$, $\mu^2_{auc} = 0.01$, $\mu^2_{ha} = 0.04$
Signaling transmission cost	$c_1 = 1$, $c_2 = 1$, $c_3 = 1$, $c_4 = 1$, $c_5 = 1$
Weighting factors	$\alpha = 0.4$, $\beta = 0.6$

Figure 4 shows the latency of SAE proposal causes less delays up to 29% than Mohanty (2005). When operation completion probability is small, the registration delay is mainly determined by accessing less databases while it is dominated by accessing more databases when operation completion probability is high. Therefore, SAE proposal reduces the latency and registration costs for location registration so that it is more suitable for roaming cases.

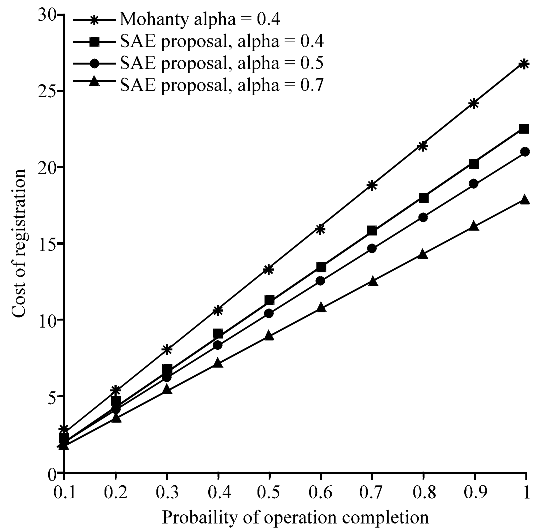

Fig. 3: Comparison cost of registration for different alpha for SAE proposal

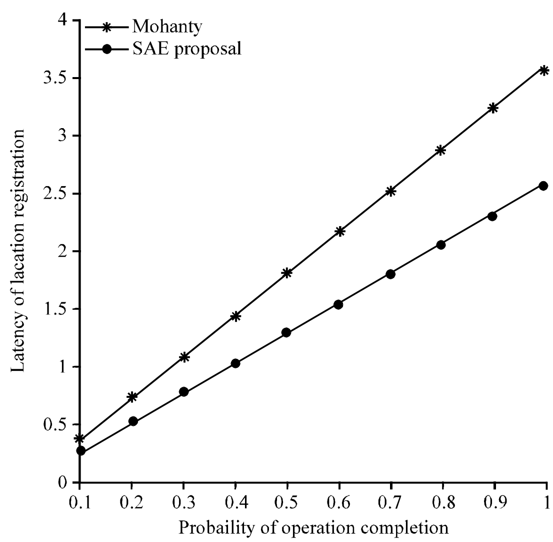

Fig. 4: Latency of location registration

CONCLUSION

In this research, SAE was proposed as the best architecture in order to support interworking between different access networks. The detailed location registration technique is developed based on the SAE. To analyze the latency and signaling cost of registration, the generalized equation for the latency and signaling cost of registration were formulated. In conclusion, the numerical results indicated that the proposed location registration technique result in significant performance improvements for SAE. As a future scope, simulation work for detailed performance analysis with respect to packet loss is under processing.

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