Localization and Mobility Management for Heterogeneous Wireless Networks based on ANDSF

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1 Introduction

Wireless communication technology is evolving to realize a ubiquitous network in which multiple wireless access such as 3GPP (GSM, EDGE, UMTS, LTE), IEEE (802.11, 802.16, 802.3...) and 3GPP2 (CDMA 2000, EVDO) coexist. It allows realizing a vision of a human centric network in which the user's devices can automatically select an optimum wireless network corresponded to user's demands such as transmission rate, quality of service (QoS), communication charges, policy, etc. In this network, the users can smoothly and seamlessly handoff between available access networks without experiencing any service disruption. This trend of network evolution is becoming more and more apparent today with the exponential growth of smartphones, tablets or other gadgets which are equipped with multiple interfaces such as 3G, Wi-Fi, WIMAX and LTE. On top of that operators are craving for taking advantage of Wi-Fi, Pico-cell or other low cost wireless networks to offload for their overloaded cellular network due to the surging demand for data traffic and mobile internet.

The integration of non-3GPP access technologies and legacy 3GPP networks into the Evolved Packet Core (EPC) which is the core network designed for 3GPP's next generation mobile network poses both new opportunities and challenges relating to inter-system handover and mobility management. Therefore, 3GPP currently proposes a new optional entity for EPC so-called Access Network Discovery and Selection Function (ANDSF). The ANDSF designed to provide policy and information for detecting and selecting the most suitable target network based on user reference and operator handoff (HO) policies to minimize the latency incurred by the intersystem handover. One of use cases of ANDSF is to provide always-best-connected service for the mobile station (MS). As aforementioned, in heterogeneous networks, the MS will be encompassed by various access networks with different data rate plan, QoS and communication costs at a particular location. The MS must automatically detect and select the optimal network at its location. However, as far as I concerned, the current immature ANDSF has not supported such scenario due to some deficiencies such as MS localization and Mobility management issues when MS moves around different access networks are not considered in this standard. Therefore, in this paper, we propose two enhancements for current ANDSF standard to support above use case. Our first proposal is an additional procedure to manage UE's mobility across multiple access networks and the second one is a method to Localize MS based on available Wi-Fi's APs information (SSID, BSSID, and RSSI). We also implement our proposed extensions to ANDSF server and client in a real working system at KDDI R&D laboratories.

2 Background

2.1 Access Network Discovery and Selection Function

ANDSF is a new entity proposed by 3GPP to resolve the complexity in handover across multiple access technologies of next generation mobile network. The ANDSF was introduced as an optional component for Evolved Packet Core (EPC) in the

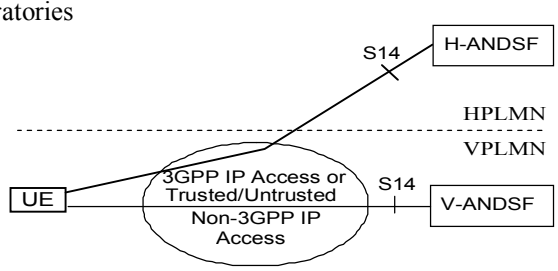


Fig. 1. ANDSF Architecture (Src TS 23.402)

3GPP standard TS 23.402[1], TS 24.312[2] to exchange discovery information and network selection policies with the User Equipment (UE) to facilitate HO in heterogeneous network and meet operator requirements. The ANDSF is accessible for UEs either through any 3GPP or non-3GPP access technologies that are interconnected through the EPC and IP connection. The ANDSF can provide three types of information:

- Intersystem mobility policy (ISMP).
- Access network discovery information.
- Inter system routing policy (ISRP).

The architecture of ANDSF is shown in Fig 1, ANDSF integrated with the EPC which can be accessible by the UE through S14 interface. S14 is an IP-based interface which is independent to access technology. OMA DM (Device Management) is used to manage to manage Inter-System Mobility Policy (ISMP) and Inter-System Routing Policy (ISRP) as well as access network discovery information stored in UE. If the UE has access network discovery information, inter-system mobility policies or inter-system routing policies valid at its current location indicating that there is an access network in its vicinity with higher priority than the currently associated access network(s), the UE should perform HO procedures to switch to the higher priority access network. However, the ANDSF is still in the initial state of its standardization process. There are still several issues need to be addressed before it can be deployed in the real network. One of the major issues is how to detect MS's location. Identifying MS location is very important to provide corresponded ISMP and ISRP policies. Another issue is mobility management when MS moves from one access network to the others. In this paper we try to resolve these two issues.

2.2 Localizing Mobile Station based on Wi-Fi access points and macro cells

As we mentioned above, identifying MS location is crucial for ANDSF system since all of its provisioned ISMP, ISRP policies and discovery function are based on MS specific location. In order to identify MS location, the most typical and easiest way is to use GPS (Global Positioning System). However, GPS may not suitable for this kind of situation. As the matter of fact, not all of mobile device are equipped with GPS receiver. In addition, GPS cannot work in indoor environment. Furthermore, ANDSF does not need very high accuracy to provide information of Wi-Fi APs. Therefore, we propose an alternative method to identify MS's location in which we take advantage of the cell IDs of cellular network along with Wi-Fi

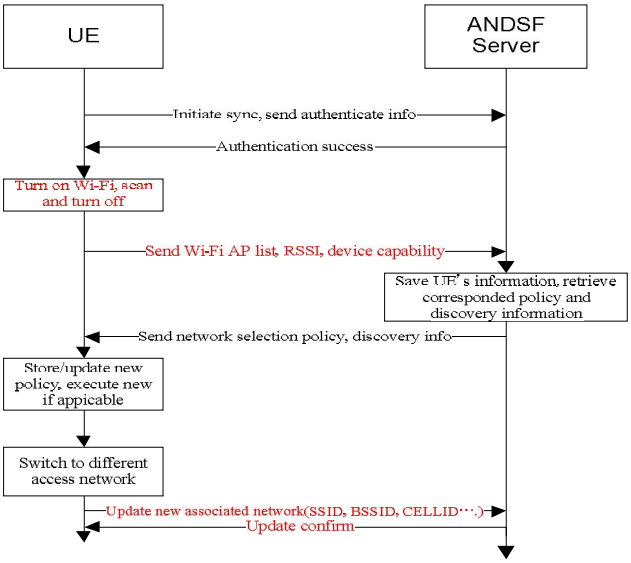


Fig. 2. Identifying location based on Wi-Fi APs

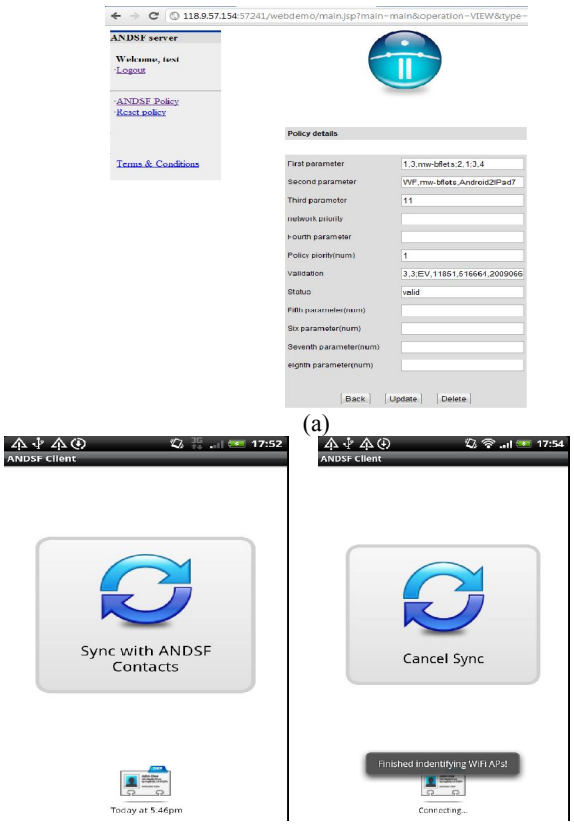
APs information such as SSID, BSSID, and RSSI. As shown on Fig 2, we propose an additional procedure (in red color) when UE retrieves information from ANDSF server. The MS can turn on its Wi-Fi interface to collect information of Wi-Fi APs in its vicinity and turn off again to save power. The Wi-Fi information includes SSID and BSSID which can identify a unique AP. The more number of APs can collect the higher accuracy we can achieve. Subsequently, the information can be forwarded to ANDSF server to calculate MS' location based on the pre coordinated survey database.

2.3 Additional primitives for mobility management

The ANDSF server has to keep track of the associated network to which the MS is associated. According to latest release of TS 23.402[1] the ANDSF server does not have any interface or connection to other nodes in EPC. It relies on the provisioned policies and information to operate, therefore its functionality is very limited and cannot be used for load-balancing or preventing congestion between different access networks. In this paper, we propose an extended procedure for ANDSF in which the MS is required to update its associated access network to the ANDSF whenever it switches to other access network or cells. As shown in Fig 2, after retrieving new policy from ANDSF server, in case that a new access network available with higher priority, the MS will attempt to handoff to that network. When the HO process completes successfully, the MS will send information of its current associated network to ANDSF. Therefore, the ANDSF can keep track of mobile associated network. Thank to this new procedure, the ANDSF server can monitor the payload of the network, if it detects that one Cell or Wi-Fi AP of the network is overloaded, it will change the policy to instruct the MS to switch to another access network or cell. This extension has two advantages. One advantage is that it does not require any modification from existing network infrastructure or adding new interfaces. The second is that it is independent of access network technology as long as the MS can connect to ANDSF server through the access network.

3 Implementation and result

We have implemented our proposed enhancements as well as ANDSF server and client into a real working system at KDDI's laborites using an open source code [3]. This open source code is originally developed for synchronizing Personal Information such as contact, calendar, email. etc. from the mobile handset to a centralized server. We have developed the ANDSF Management Object (MO) according to TS 24.312 [2] specifically for intelligent detecting and selecting Wi- Fi, WiMAX PoSs when they are available at MS location. We also implemented our proposals into this demo system.



(a)

(b) (c)

Fig. 3. The ANDSF server and client

As shown in Fig 3, figure 3(a) is the GUI of Our ANDSF server running on a server powered by Ubuntu 10.4 OS. Figure 3(b), (c) are our client running on a mobile handset (HTC EVO) powered by Android 2.3 OS which supports WiMAX, Wi-Fi, 3G. the mobile can turn on its Wi-Fi interface to collect nearby Wi-Fi APs and turn off again. It will send this information to ANDSF server to identify its location. The figure 2.(b) describes the MS retrieves new policy corresponded to MS location from ANDSF server. Afterward, MS can automatically turn on Wi-Fi interface and tries to connect to available Wi-Fi access point or WiMAX using the information retrieved from the server. Figure 2.(c) illustrates that after successfully handoff to Wi-Fi, the MS updates the ANDSF to report its new associated network.

4 Conclusion

In this paper, we proposed two enhancements for current ANDSF standard. The first proposal is MS localization based on Wi-Fi and Cell-ID information. This method can achieve the accuracy good enough for detecting Wi-Fi access point which is best suitable for our experience scenario. We also proposed any additional primitive for ANDSF system to help the ANDSF server to keep track of associated point of server without any modification to the existing network's infrastructure and independent to the access network technology. Your future research is to evaluate our proposal and implementation in bigger scale in which we deploy multiple Wi-Fi access points and WiMAX. We want to evaluate the effectiveness of our proposal in term of power saving for mobile device and load-balancing and preventing congestion in heterogeneous networks.

References

[1] Architecture enhancements for non-3GPP accesses, 3GPP TS 23.402, V11.0.0 Release 11, Sep 2011.

[2] Access Network Discovery and Selection Function, 3GPP TS 24.312, V11.0.0 Release 11, Sep 2011.

[3] "Funambol", Funambol, Inc, http://www.funambol.com/