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Advanced Connection Manager for Interworking between 3GPP and Non-3GPP Networks

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Abstract*:Smart phones and handheld devices equip with multiple radio access technologies capabilities e.g. cellular and Wi-Fi now a days. It is observed that seamless session and service continuity is a difficult task while device is roaming across different radio access technologies. Connection Manager, ANDSF and Traffic Steering Algorithms are mainly used to address such switching requirements. Radio access selection decision is usually based upon various parameters like network capabilities, availability, quality, subscription and policies. This research compares network quality of all available networks for the duration and then connection manager's decision support system ranks all suitable networks to select most appropriate access network. This paper investigates about new input parameters to be included in connection manager's enhanced decision support system for the smarter decision of access network selection.

***Keywords*: LTE, Heterogeneous Networks, Connection Manager, IWLAN, ANDSF**

I. INTRDUCTION

Cellular and Wi-Fi radio technologies have been evolved from two different objective and developments. Fundamental objective of Cellular radio technology was to make telephony mobile. Wi-Fi was evolved to serve data communication primarily. There is convergence in these technologies and user is able to use data and voice communication altogether in smart handheld devices. Data communication over cellular network and voice over data communication network in form of VOIP are also possible communications. There are few known difficult tasks e.g. seamless session and service continuity, while device is roaming across different radio access technologies[1]. Connection Manager, ANDSF and traffic steering algorithms are mainly used to address these requirements. Connection Manager is software component which manages the radio access connections of the device. It decides on various inputs e.g. pre-configured or user preferences, operator preferences, network conditions etc.

This paper tries to explain the role of connection manager in heterogeneous network environment. Multiple parameters are being suggested to take decision about radio access network selection. Along with other parameters; based upon network quality measurement for defined duration grading of available networks, is also considered to analyze for helping in choosing most suitable access network.

The rest of this paper is organized as follows: Section II describes mobility requirement in heterogeneous network environment. Section III describes network selection decision parameters. Section IV presents requirement of more suitable network selection procedure for better user experience and proposal of new parameter. Section V includes conclusions and future work.

II. LTE – WLAN INTERWORKING

IETF and 3GPP studied and standardized cellular – WLAN interworking scenarios (see Table I). 3GPP SAE / LTE architecture provides secure service and cellular - WLAN interworking. 3GPP LTE and WLAN have distinguished feature set.

TABLE I. LTE and Wi-Fi

	LTE	Wi-Fi
Standard	3GPP	IEEE802.11, Wi-Fi Alliance
Standard Entity		STA, AP, AP Controller, AAA
User Authentication	EPS-AKA	EAP-AKA/SIM EAP-TLS, WBA, etc.
User Data Security	Encryption	Encryption and integrity protection in EAP based authentication
QoS Support	Yes	WMM
User Mobility Support	Yes	Yes, but AP controller required
Tunnelling Protocol	GTP	Vendor Specific
Frequency Interference	None	Yes [ISM band]
Frequency Band	800MHz, 1.8GHz, 2.1GHz, etc.	2.4GHz, 5GHz

A. IETF Mobility Solutions

Internet protocols for information packet transportation among IP (Internet Protocol) Devices have been developed by IETF (Internet Engineering Task Force). IETF worked towards interworking cellular and Wi-Fi networks. Mobile-IP standards have been developed by IETF to address this challenge[2]. Mobile-IP standards are classified in two categories, Client based solutions and Network based solutions.

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Seamless mobility to moving devices is one of the primary goals of these Mobility protocols. Mobile IP (MIP) protocol, Dual-Stack Mobile IP (DSMIPv6) architecture are main standards for client based mobile IP solution. Proxy Mobile IP (PMIP) protocol is main standard for network-based solution[3][4].

EAP (Extensible Authentication Protocol) is a generic framework solution for user authentication[5].

B. 3GPP Efforts to Integrate Wi-Fi

GSMA (GSM Association) formed a taskforce to study Wi-Fi and cellular integration; this group has proposed six different levels of interworking including loose integration, tight integration, and session continuity. These standards are known as IWLAN ((Integrated/Interworked WLAN) and EPC standards. IWLAN standards (3GPP Technical Report, TR 23.234) mentioned following interworking scenarios:

- *Common Billing and Customer Care*
- *3GPP system based Access Control and Charging*
- *Access to 3GPP system PS based services*
- *Service Continuity*
- *Seamless services*
- *Access to 3GPP CS Services*

3GPP standards TS 23.234, TS 23.327, and TS 23.261 cover these scenarios[6][7][8]. No user intervention for authentication is one of the main objectives of IWLAN solutions. Mobility between interworking WLAN and 3GPP networks has been defined in 3GPP standard TS23.327. There are two major issues exists in these solutions. First advanced policy and QoS based management of the IWLAN-3GPP mobility and second is that UE to have only a single radio connection at any given time, namely either to the WLAN or 3GPP radio interface. EPC standards 3GPP TS 23.401 and TS 23.402 overcome these obstacles and came up with new solution. The EPC standards for 3GPP and Non-3GPP interworking introduce a new class of non-3GPP access networks, namely Trusted Non-3GPP Networks, with the word “trust” referring to trust by the operator (and not necessarily by the user). Trusted Wi-Fi Networks imply that the Trusted Wi-Fi access points are deployed and managed by the Operator, so that UE can connect to the Wi-Fi Network directly using the radio interface without requiring any additional security measures[9][10].

3GPP supports interworking with WLAN in the core network and current studies are focusing on RAN level integration between cellular and WLAN to improve user Quality of Experience (QoE), reduced battery power consumption and coordinated radio resource management.

III. SERVICE DISCOVERY AND CONNECTION MANAGEMENT

ANDSF (Access Network Discovery and Selection Function) and Hotspot 2.0 policy specifications are used for policy based user equipment management. 3GPP standard TS23.402 defines the ANDSF as a framework which allows user equipment to know where, when and how to choose a non-3GPP access network and for specifying and delivering access network policies to user equipment. The ANDSF contains data management and control functionality necessary to provide network discovery and selection assistance data as per operators' policy[11]. OMA (Open mobile Appliance) developed device management procedures and operator policies transfer to user equipment through S14 interface using communication procedures based upon OMA’s device management procedures[12]. ANDSF has three components i.e. ANDSF server, ANDSF management Object (MO)and S14 interface for communication. ANDSF provides following information:

- *UE location*
- *Access Network Discovery Information*
- *ISMP (Inter-System Mobility Policy)*
- *ISRP (Inter-System Routing Policy)*
- *IARP (Inter APN Routing Policy)*
- *WLANSP (WLAN Selection Policy)*
- *VPLMNs with preferred WLAN Selection Rules*
- *Preferred Service Provider List*

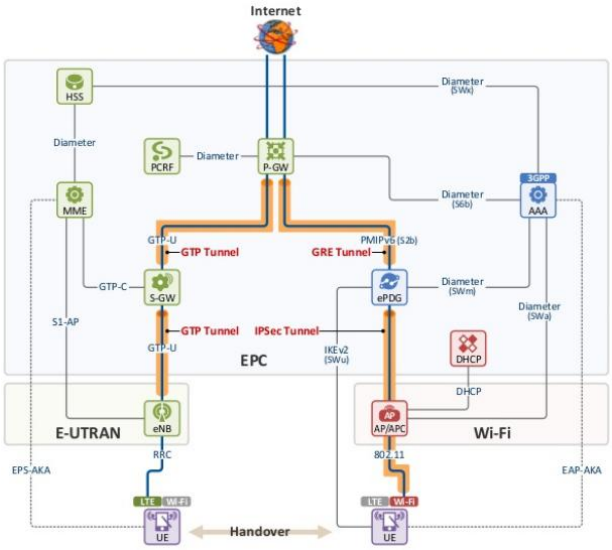

Fig. 1.LTE– WLAN interworking – Network Reference Model[13]

User equipment with valid 3GPP subscription credentials i.e. USIM and WLANSP policies can perform WLAN selection based upon these policies. User preferences have precedence over WLANSP policies “Fig. 2”.

ANDSF provides 3GPP user equipment information about available networks and policies for selecting and using such networks. Primary function is selecting non-3GPP access networks which include WLAN, 3GPP2 networks, WiMax etc. ANDSF is relatively static and not responsive to real time network conditions currently. It is basically a service discovery protocol.

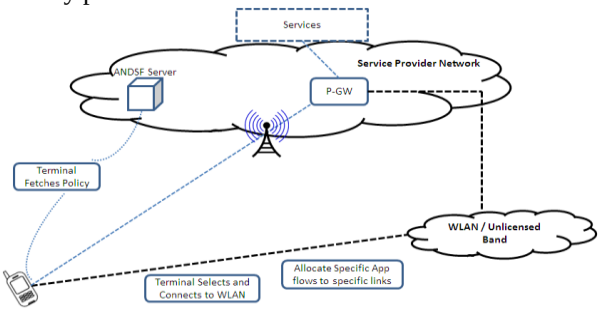

Fig. 2.ANDSF (Cellular – WLAN use case)

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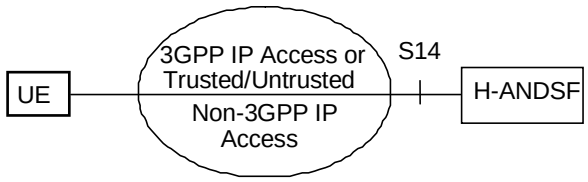

Fig. 3.ANDSF (Non-Roaming Architecture)[9]

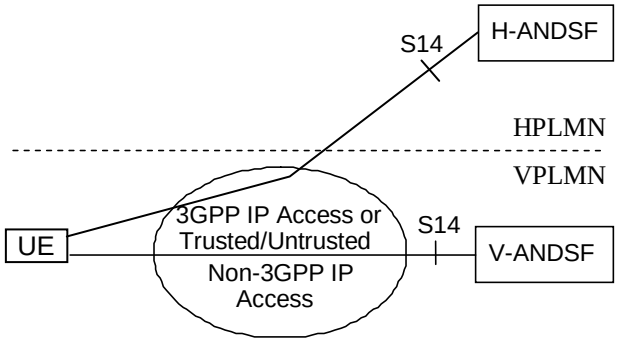

Fig. 4.ANDSF (Roaming Architecture)[9]

A Connection Manager is an application that manages different network connections based on user profiles associated with these connections. Connection manager own responsibilities to discover networks and establish connection. Connection manager may find multiple access networks in vicinity and to choose best and appropriate network to user is based upon multiple parameters[13][14].

- *Network capabilities*
- *User defined preferences*
- *Roaming scenarios*
- *Subscription credential & operator policies*

Connection managers are adapting few other following parameters for betterment of decision making processes; connection manager are using few other parameters:

- *Adaptation to connection conditions*
- *Adaptation to limited information on the connection*
- *Reducing negative impacts*

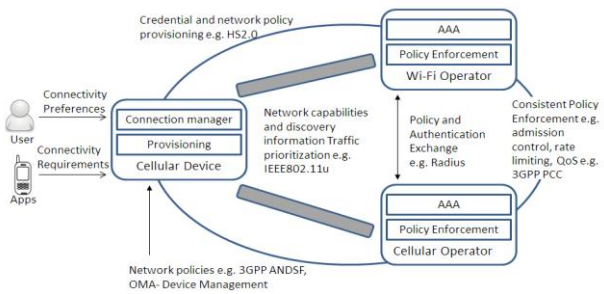

Fig. 5.Connection Manager

OMA's (Open Mobile Alliance) and IETF are working to stabilized and standardize connection management features under projects Connection Management Access Point Interface (OMA-CMAPI) and IETF Multiple Interfaces Working Group (MIF) respectively. Objective of these groups is to provide common and additional functionalities to applications, network operators and users to manage the network connections of the user equipment in optimized manner, network discovery and selection services, optimize power management, location management, contacts handling, service handling, security authentication and single sign on[15].

The most satisfactory user experience can only be achieved if radio access network selection decisions are based on information available from both the 3GPP and Wi-Fi networks, which includes user-equipment mobility and location information, loading on networks and link rates estimation in each network.

IV. NETWORK SELECTION DECISION – QOS GUARANTEE

The ANDSF responds to UE requests for access network discovery information (pull mode operation) and may be able to initiate data transfer to the UE (push mode operation), based on network triggers or as a result of previous communication with the UE. WLANSP (WLAN Selection Policy) is a set of operator-defined rules that determine how the UE selects and reselects a WLAN access network. User equipment sends location area code, cell identification, geometric co-ordinates, & WLAN SSID etc. information to ANDSF. ANDSF send discovery information (e.g. network access area, WLAN SSID etc.), ISMP (Inter-System Mobility Policy) information (e.g. validity area: location area code, cell identification, geometric co-ordinates, WLAN SSID etc.), ISRP (Inter-System Routing Policy) information (e.g. in this validity area: location area code, cell identification, geometric co-ordinates etc.). Based upon user preferences, ANDSF parameters, WLANSP parameters and other information connection manager choose access network for connection establishment[16][17].

The main focus of this research is to include additional mechanism to connection manager for smarter decision making process. This mechanism may improve the possibility of quality of service on new access network. This research proposes estimation of quality of service on all available access networks for duration and ranking of all qualifying access networks. In this research it is observed that based upon policy and user preference qualification top ranked network ensures better quality of service than other available networks. All available access networks must check for the required network capabilities, qualification for user defined preferences, suitable roaming agreements, and operator subscription and policy qualifications. Connection manager run a pilot software program for small quantum of time 't' on all qualifying access networks and ranks these access networks based upon estimated QoS parameters e.g.

QCI, ARP, GBR, MBR, APN-ABMR, and UE-ABMR etc. These parameters and other vital parameters i.e. ANDSF, WLANSP and user preferences are input to decision support system of connection manager. Finally DSS ensures that connection manager has chosen best available access network which has been tested and estimated for best possible quality of services. In the final note the research conclude with an enhanced user experience drawn on the following artefacts-

- *Increase user Quality of Experience (QoE)*
- *Reduce possibilities of unhealthy choice*
- *Reduce possibilities of service degradation*
- *Better throughput*

V. CONCLUSION

Access network discovery selection function framework and policy specifications are used for policy based user equipment management. User equipment receives & sends specific information which is used by connection manager's DSS to decide selection of most appropriate access network. In this research a new mechanism of enhanced decision making process by connection manager is introduced. It includes additional input parameter i.e. estimation of quality of service on all available networks for better user experience. Further the new mechanism can be optimized with link rate estimation and quality of service estimation on available networks. Other existing parameters e.g. ANDSF, WLANSP, user preference, must be considered as vital parameters. This additional quality of service estimation based ranking will helpful for better user experience. This work can be taken further by optimizing quality of service estimation model on available networks.

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