

A Schema Based Approach to Access Network Discovery and Selection in EPS

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Abstract – Access Network Discovery and Selection Function (ANDSF) defined in the architecture of the Evolved Packet System (EPS) allows the operator to control the user choice of access technology if several non-3GPP access networks are available. The 3GPP specifications define the management objects that can be used by ANDSF and the user equipment (UE), but do not define the structure and format of user capabilities that the UE may provide in order to support the rules generation by the ANDSF. The paper provides a structural approach to definition of the information that the UE may send to the ANDSF. The information is defined using XML schemes.

Keywords – Evolved Packet System, Access Network Discovery and Selection, User equipment capabilities.

I. INTRODUCTION

Evolved Packet System (EPS) is the name for the evolution of mobile networks [1]. EPS covers the radio access, the core network and the user equipments that comprise the overall mobile system. Along with the high-speed 3GPP radio access networks, EPS supports also non-3GPP accesses such as WLAN, WiMAX and wired access.

When a user equipment (UE) is registered in the home network and when both 3GPP and non-3GPP accesses are available, or when multiple non-3GPP accesses are available, the EPS network may provide the UE with assistance data/policies about available accesses. The EPS network allows the operator to influence the access that the UE shall handover to (when in active mode) or re-select (when in idle mode). The architecture that may be used for access network discovery and selection is based on a new network element called Access Network Discovery and Selection Function (ANDSF). The ANDSF contains data management and control functionality necessary to provide network discovery and selection assistance data as per operators' policy [2].

ANDSF is in an initial stage of standardization. Only the minimal interface to the mobile equipment is defined [3]. The definition on how the ANDSF should work is limited and there are no connections between ANDSF and other entities. Further, the ANDSF relies only on its own information for decisions. The following extensions are proposed in [4]. First, the ANDSF decisions should be based on subscription. Second, the ANDSF decisions should use dynamic access network information and the ANDSF should support from the always-best-connected enabler towards the services. Third, the ANDSF should provide the means to integrate femto-accesses for network discovery and selection.

The idea of using dynamic access network information is

developed in [5], [6] and [7]. In [5], the authors propose a solution that combines ANDSF and MIH (Media Independent Handover (MIH) Service standard 802.21 from IEEE) for improving the inter-system handover behavior. In [6], the authors propose novel access reselection procedures which enable a network provider to optimize the allocation of the users on the different access networks available using as central concept that handovers can and should be triggered by the modifications on the resources required by the mobile devices in order to optimize the overall usage of the wireless environment. A multilink architecture with evolved ANDSF and Policy and Charging Rule Function is suggested in [7].

3GPP defines management objects that can be used by the ANDSF and the UE [3]. The Management Object (MO) is compatible with the OMA Device Management (DM) protocol specifications, version 1.2 and upwards. It is defined using the OMA DM Device Description Framework (DDF) as described in the Enabler Release Definition OMA-ERELD-DM-V1_2 [8]. The MO consists of relevant parameters for inter-system mobility policy and access network discovery information that can be managed by the ANDSF.

In this paper, we propose a structural approach to definition of information that the UE may send to the ANDSF in order to support the ANDSF decisions. The proposed information structure is based on the MO information for UE location as defined in [3] and on UE capabilities. The definitions are presented using XML schemes.

The paper is structured as follows. Section II provides an analysis on required information about UE capabilities and defines the respective XML schemes. In Section III, XML schemes are defined for the information related to UE location. Section IV presents an example of the content of a client initiated session alert message of code "Generic Alert" which UE may use to initiate the information provision by the ANDSF.

II. UE CAPABILITIES INFORMATION STRUCTURE

The UE needs to provide to the ANDSF information about its capabilities and its location. The UE capabilities describe the supported access technologies and the routing capabilities. The related XML scheme is shown in Fig.1.

The UE may obtain IP connectivity by attaching to 3GPP access technologies, 3GPP2 access technologies and non-3GPP access technologies. The UE may support more than one access technologies.

Each access technology is designed to operate in particular frequency bands. The UE routing capabilities define the mechanism for routing of different IP flows. The UE is classified in a given category depending on the supported

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maximum data rates. The 3GPP access technologies that may be supported by the UE include GSM/GPRS, WCDMA/HSPA and LTE. The 3GPP technologies that may be supported by the UE include 1xRTT and HRPD. The non-3GPP2 technologies that may be supported by the UE include WiMAX and WLAN. Fig.3 shows the related XML scheme.

```
<xs:element name="UE">
  <xs:complexType>
    <xs:element name="capabilities">
      <xs:complexType>
        <xs:element name="technologies"
          type="supportedTchnologies"/>
        <xs:element name="routingCapabilities"
          type="routingCapabilitiesType"/>
      </xs:complexType>
    </xs:element>
    <xs:element name="UELocation" type="UELocationType"/>
  </xs:complexType>
</xs:element>
```

Fig.1 XML scheme for UE information

The XML scheme related to UE supported technologies is shown in Fig.2.

```
<xs:complexType name="supportedTechnologies">
  <xs:sequence>
    <xs:element name="supportedTechnology"
      type="supportedTechnologyType" minOccurs="1"
      maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="supportedTechnologyType">
  <xs:sequence>
    <xs:element name="technology" type="technologyType"/>
    <xs:element name="bands" type="bandsInfo"/>
    <xs:element name="category" type="xs:positiveInteger"/>
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="technologyType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="WCDMA/HSPA"/>
    <xs:enumeration value="GSM/GPRS"/>
    <xs:enumeration value="LTE"/>
    <xs:enumeration value="WiMAX"/>
    <xs:enumeration value="WLAN"/>
    <xs:enumeration value="1xRTT"/>
    <xs:enumeration value="HRPD"/>
  </xs:restriction>
</xs:simpleType>
```

Fig.2 XML scheme for UE supported access technologies

IFOM (IP Flow Mobility) capable UE is an UE that is capable of routing different IP flows to the same PDN (Packet Data Network) connection through different access networks. The IFOM capable UE may simultaneously connect to 3GPP access and WLAN and exchange different IP flows belonging to the same PDN connection through different accesses.

Non-seamless WLAN offload capable UE is an UE that is capable of non-seamless WLAN offload. An UE supporting non-seamless WLAN offload may, while connected to WLAN access, route specific IP flows via the WLAN access without traversing the Evolved Packet Core (EPC).

MAPCON (Multi Access PDN Connectivity) capable UE is a UE that is capable of routing different simultaneously active PDN connections through different access networks.

A UE that is not capable of routing IP traffic simultaneously over multiple radio access interfaces (e.g. a non-IFOM or non-MAPCON capable UE, or an UE that has such a capability disabled, or an UE not capable of non-seamless WLAN offload) selects the most preferable available access network for inter-system mobility based on the received/provisioned inter-system mobility policies and user preferences and disregards the inter-system routing policies it may have received from the ANDSF. The XML scheme related to routing capabilities is shown in Fig.3.

```
<xs:simpleType name="routingCapabilities">
  <xs:restriction base="xs:string">
    <xs:enumeration value="IFOM"/>
    <xs:enumeration value="NonSeamlessOffload"/>
    <xs:enumeration value="MAPCON"/>
    <xs:enumeration value="NoInter-systemRouting"/>
  </xs:restriction>
</xs:simpleType>
```

Fig.3 XML scheme for routing capabilities

The access technology operating bands define the frequency allocation for uplink and downlink as well as the duplex mode of operation. The UE may support more than one frequency bands. The related XML scheme is shown in Fig.4.

```
<xs:complexType name="bandInfo">
  <xs:sequence>
    <xs:element name="low" type="xs:decimal"/>
    <xs:element name="high" type="xs:decimal"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="bandType">
  <xs:sequence>
    <xs:element name="bandID" type="xs:positiveInteger"/>
    <xs:element name="uplink" type="bandInfo"/>
    <xs:element name="downlink" type="bandInfo"/>
    <xs:element name="duplex" type="duplexMode"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="bandInfo">
  <xs:sequence>
    <xs:element name="low" type="xs:numeric"/>
    <xs:element name="high" type="xs:numeric"/>
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="duplexMode">
  <xs:restriction base="xs:string">
    <xs:pattern value="FDD|TDD"/>
  </xs:restriction>
</xs:simpleType>
```

Fig.4 XML scheme for UE supported operating bands information

III. UE LOCATION INFORMATION

The UE location node acts as a placeholder for location description; an UE therefore inserts information regarding all of the access networks that it can discover into this node. If the UE is aware of its geographical position, it shall insert the coordinates of its position in this GeoLocation element. Fig.5 shows the XML scheme related to UE location.

```
<xs:complexType name="UELocationType">
  <xs:sequence>
    <xs:element name="3GPPLocation" type="3GPPLocations"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="3GPP2Location"
      type="3GPP2Locations" minOccurs="0" maxOccurs="1"/>
    <xs:element name="WiMAXLocation"
      type="WiMAXLocations" minOccurs="0" maxOccurs="1"/>
    <xs:element name="WLANLocation" type="WLANLocations"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="GeoLocation" type="GeoLocationType"
      minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
```

Fig.5 XML scheme for UE location information

For 3GPP networks, the access network information includes: PLMN-id, Tracking Area Code, Location Area Code and Cell Global Identity. The PLMN-id is defined by Mobile Country Code and Mobile Network Code. Fig.6 shows the XML scheme for UE location information in 3GPP access.

```
<xs:complexType name="3GPPLocations">
  <xs:sequence>
    <xs:element name="location" type="3GPPLocationType"
      minOccurs="1" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="3GPPLocationType">
  <xs:sequence>
    <xs:element name="PLMN" type="xs:string"/>
    <xs:element name="TAC" type="xs:unsignedShort"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="LAC" type="xs:unsignedShort"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="GERAN_CI" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="UTRAN_CI" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="EUTRA_CI" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
```

Fig.6 XML scheme for 3GPP location

For 3GPP2 1xRTT networks, the SID (System Identification code), NID (Network Identification code) and Base ID (Base Station Identification code) for one particular 3GPP2 1xRAT location are used to indicate UE position. For 3GPP2 HRPD networks, the Sector_ID (Sector Identification code), Netmask (Netmask code) for one particular 3GPP2 HRPD RAT location are used to indicate UE position. Fig.7 shows the XML scheme for UE location information in 3GPP2 access.

For WiMAX networks, UE Location includes: NAP-ID and BS-ID. The NAP-ID (Network Access Provider) and BS-ID (BS identifier) for a particular WiMAX network are used to provide access network information. For WLAN networks, HSSID, SSID and BSSID are captured. Fig.8 shows the XML scheme for UE location information in non-3GPP access.

The GeoLocation node acts as a placeholder for one or more UE geographical location descriptions. Fig.9 shows the related XML scheme.

In order to illustrate the usage of the proposed information structure, the following section presents an example.

```
<xs:complexType name="3GPP2Location">
  <xs:sequence>
    <xs:element name="1xLocation" type="1xLocations"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="HRPDLocation" type="HRPDLocations"
      minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="1xLocations">
  <xs:sequence>
    <xs:element name="location" type="1xLocationType"
      minOccurs="1" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="1xLocationType">
  <xs:sequence>
    <xs:element name="SID" type="xs:hexBinary"/>
    <xs:element name="NID" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="Base_ID" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="HRPDLocations">
  <xs:sequence>
    <xs:element name="location" type="HRPDLocationType"
      minOccurs="1" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="HRPDLocationType">
  <xs:sequence>
    <xs:element name="Sector_ID" type="xs:hexBinary"/>
    <xs:element name="Netmask" type="xs:hexBinary"/>
  </xs:sequence>
</xs:complexType>
```

Fig.7 XML scheme for 3GPP2 location

```
<xs:complexType name="WiMAXLocations">
  <xs:sequence>
    <xs:element name="location" type="WiMAXLocationType"
      minOccurs="1" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="WiMAXLocationType">
  <xs:sequence>
    <xs:element name="NAP-ID" type="xs:hexBinary"/>
    <xs:element name="BS-ID" type="xs:hexBinary"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="WLANLocationType">
  <xs:sequence>
    <xs:element name="BSSID" type="xs:hexBinary"/>
    <xs:element name="SSID" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
    <xs:element name="HESSID" type="xs:hexBinary"
      minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
```

Fig.8 XML scheme for non-3GPP location

```
<xs:complexType name="GeoLocationType">
  <xs:sequence>
    <xs:element name="AnchorLongitude" type="xs:decimal"/>
    <xs:element name="AnchorLatitude" type="xs:decimal"/>
  </xs:sequence>
</xs:complexType>
```

Fig.9 XML scheme for UE geographical location

IV. EXAMPLE OF USER DATA PROVIDED TO ANDSF

The UE may initiate information provisioning from the ANDSF, using a client initiated session alert message of code "Generic Alert". The "Type" element of the OMA DM generic alert message shall be set to "urn:oma:at:ext-3gpp-andsf:1.0:provision-multiple-if" as we assume that the UE is configured for IFOM. In our example, the UE supports both LTE and WiMAX access network technology. For LTE, the UE supports operating bands of 1447.8 MHz -1462.9 MHz for uplink and 1495.9 MHz -1510.9 MHz for downlink and FDD mode. For WiMAX the UE supports operating bands of 3527.5MHz -3562.5 MHz and TDD mode. The UE category in LTE is 5, that means that UE supports 4x4 MIMO, data rates of 300 Mbps for downlink and 75 Mbps for uplink, and the supported modulation format is 64QAM. The UE location in LTE access network is identified by PLMN-id of 28402, tracking area code of 0xD34F and E-UTRA cell identity of 0xAF52D10<EUTRA. In WiMAX, the UE location is identified by NAD-ID of 0xF4700A and BS-ID of 0xCA9912.

Fig.10 shows the XML description of information about UE capabilities and location used in the example for access network discovery and selection.

V. CONCLUSION

The paper provides a structural approach to definition of information that an UE may send to the ANDSF in order to support the decision for access network discovery and selection. The suggested information contains both UE capabilities and location. The UE capabilities include information about supported access network technologies and routing capabilities. The XML schemes defining this information can be used to express a set of rules to which the UE provided information must conform in order to be considered 'valid' according to that schema. The suggested XML schemes are designed with the intent that determination of the UE provided information validity would produce a collection of information adhering to specific data types.

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```

<UE>
  <capabilities>
    <technologies>
      <supportedTechnology>
        <technology>LTE</technology>
        <bands>
          <band>
            <bandID>21</bandID>
          </band>
        </bands>
        <uplink><low>1447.9</low><high>1462.9</high></uplink>
        <downlink><low>1495.9</low><high>1510.9</high></downlink>
        <duplex>FDD</duplex>
      </supportedTechnology>
      <supportedTechnology>
        <technology>WiMAX</technology>
        <bands>
          <band>
            <bandID>2</bandID>
          </band>
        </bands>
        <uplink><low>3527.5</low><high>3562.5</high></uplink>
        <downlink><low>3527.5</low><high>3562.5</high></downlink>
        <duplex>TDD</duplex>
      </supportedTechnology>
    </technologies>
    <routingCapabilities>IFOM</routingCapabilities>
  </capabilities>
  <UELocation>
    <3GPPLocation>
      <location>
        <PLMN>28402</PLMN>
        <TAC>0xD34F</TAC>
        <EUTRA_CI>0xAF52D10</EUTRA_CI>
      </location>
    </3GPPLocation>
    <WiMAXLocation>
      <location>
        <NAP-ID>0xF4700A</NAP-ID>
        <BS-ID>0xCA9912</BS-ID>
      </location>
    </WiMAXLocation>
  </UELocation>
</UE>
    
```

Fig.10 An example of UE capabilities and location required for access network discovery and selection