ALL IP ARCHITECTURES FOR CELLULAR NETWORKS

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ABSTRACT

There are several organisations developing specifications for "All IP" cellular networks; i.e., fully IP protocols based networks. The specification work is on going in established standard developing organisations such as 3GPP, 3GPP2, and IETF, as well as in different industry forums such as 3G.IP and MWIF.

In this paper we will introduce the most important forums involved in All IP development and describe the All IP concepts discussed in different forums. We will discuss on differences and similarities of the architectures of these forums.

INTRODUCTION

Currently there are several ongoing efforts to define cellular network architectures that would enable fully IP based service delivery; i.e., not only data, but also speech service would be provisioned over IP bearer. Such network architectures are usually referred as *All IP* networks.

First look over different architectures might leave reader very confused; it is quite challenging to compare the concepts without deeper knowledge on the ideas behind the architectures. Thus, we try to give reader short introduction to different proposed architectures and discuss how the concepts discussed in different forums relate to each other.

In this paper, we first give brief overlook of different organisations involved in All IP development. After getting familiar with the organisations, we describe different architectures discussed in these organisations and analyse the commonality and differences of the All IP architecture proposals. Finally, we will conclude the paper with brief overlook to the future of All IP.

ORGANISATIONS

The organisations discussing All IP development can be divided to informal industry forums and formal Standard Developing Organisations (SDO). The most important All IP related industry forums are introduced below:

3G.IP. 3G.IP is an operator-driven initiative, which "actively promote a common IP based wireless system third generation mobile communications technology" as stated in forum's mission statement [1]. The 3G.IP has defined reference architecture for All IP network architecture based on evolution of UMTS.

Mobile Wireless Internet Forum (MWIF). MWIF is another operator-driven industry association, which "drive acceptance and adoption of a single mobile wireless and Internet architecture" as stated in the MWIF homepage [2]. The MWIF has specified an access independent All IP network architecture.

The industry forums discussed above do not aim to write full specifications for All IP network, but rather define reference architectures and drive All IP development. The actual standards are done in SDOs, which are introduced below.

3rd Generation Partnership Project (3GPP). 3GPP is a global SDO that was formed between Chinese, European, Japanese, Korean, and North American national SDOs to specify GSM based 3rd Generation cellular system, often referred as UMTS. Currently 3GPP is working on UMTS evolution to All IP network. The All IP specifications will be part of 3GPP Release 5.

3rd Generation Partnership Project 2 (3GPP2). 3GPP2 is an SDO that was formed between Chinese, Japanese, Korean, and North American national SDOs to specify IS-41 based 3rd Generation cellular system, often referred as cdma2000. Currently, 3GPP2 is working on All IP network specifications for cdma2000 networks.

Internet Engineering Taskforce (IETF). IETF is community of people "concerned with the evolution of the Internet architecture and the smooth operation of the Internet" as defined in IETF homepage [3]. IETF is not actually concerned All IP architectures as such, but is has specified and is assumed to specify, several protocols that will be essential for All IP networks.

ARCHITECTURE PROPOSALS

In this chapter, we describe the All IP network architecture proposals on table in 3GPP, 3GPP2, and MWIF. The reader should note that the work is still on going in all these forums. Thus, the architectures presented here are subject to change before the specifications are completed.

3rd Generation Partnership Project (3GPP)

The All IP architecture agreed in 3GPP is illustrated in Figure 2. The architecture is described in 3GPP TR 23.922 [4] and functionality of the network is further elaborated in 3GPP TS 23.228 [5]. As the reader familiar with UMTS network may easily see, the 3GPP All IP network contains several similar parts than 3GPP Release 99 network.

The network architecture can be split in to several domains: Radio Access Network (RAN), General Packet Data Service (GPRS) network, IPT core network, Gateways, and Databases. Naturally, there is also User Equipment (UE); i.e., Mobile Terminal (MT) and Terminal Equipment (TE).

There are actually two different RAN options in the 3GPP Rel. 5 specifications: UTRAN and GERAN. The former is WCDMA based and the latter is GSM TDMA based RAN. The RAN and GPRS network together provide IP bearers from the UE to the IPT core.

The GPRS network in 3GPP Rel. 5 architecture is straight evolution from GSM and UMTS GPRS network; i.e., the main network elements are Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). The GPRS network is responsible for controlling IP bearer service; the main tasks include user authentication, authorisation, accounting, mobility management inside GPRS network, and controlling Radio Access Bearers (RAB).

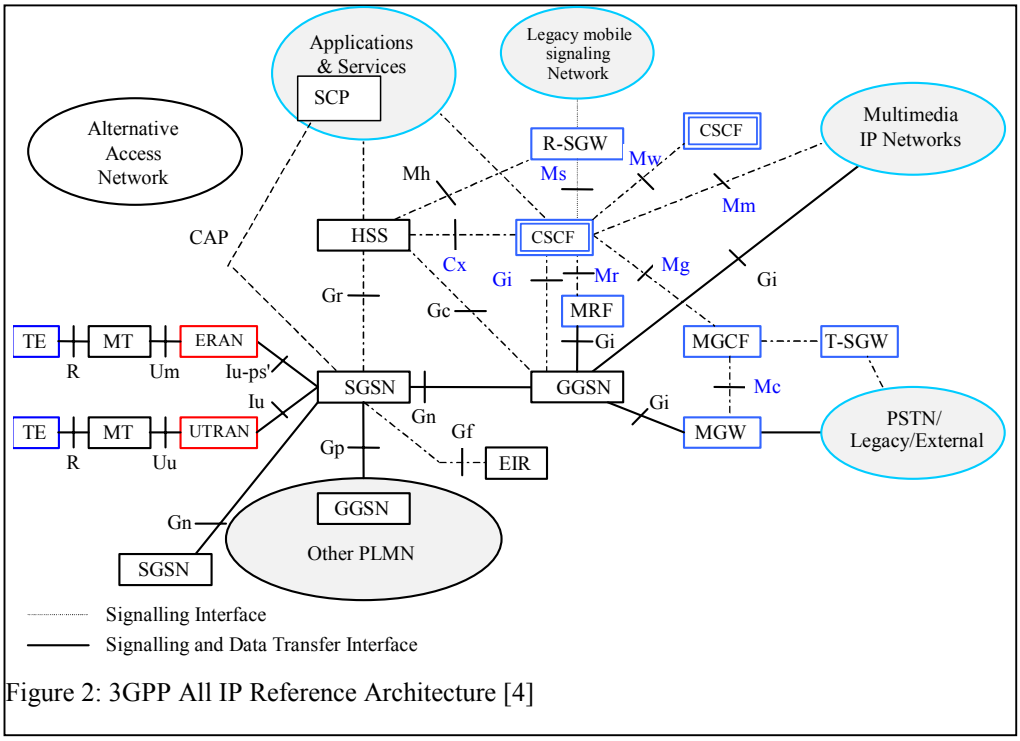

Figure 2: 3GPP All IP Reference Architecture [4]

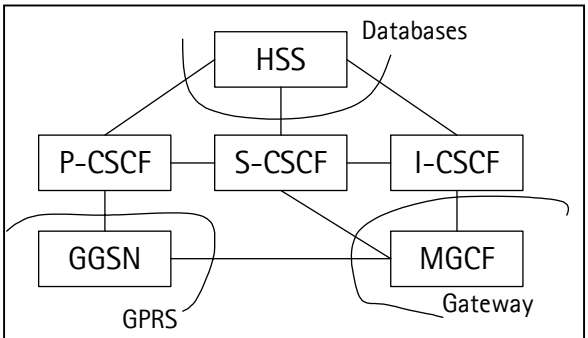

Figure 1: CSCFs in 3GPP IPT Core Network

In Figure 2, the IPT core part of the architecture is reduced into Call State Control Function (CSCF) and Media Resource Function (MRF). The former manages all call (or session) control related procedures. The latter handle media management related operations, e.g., conferencing. However, that is not the whole truth; there are actually three different kind of CSCFs, which are shown in Figure 1.

Proxy CSCF (P-CSCF) is the contact point for the UE towards IPT core. Basically, the P-CSCF behaves like SIP proxy as defined in RFC2543 [6]. In addition to basic proxy functions, the P-CSCF may complete information provided by terminal; e.g. the P-CSCF may perform number analysis and convert local numbering plan numbers to global addresses.

Serving CSCF (S-CSCF) performs session control related operations. The S-CSCF maintains session state for each ongoing session. The S-SCSF may invoke session related value-added services based on subscriber profile download into the S-CSCF during registration.

Interrogating CSCF (I-CSCF) is the contact

point for all connections destined to subscriber of the particular network where the I-CSCF is located. Further, all connections towards inbound roamers on that network are routed via I-CSCF. The main task of I-CSCF is to aid routing of session control messages to appropriate S-CSCF.

The 3GPP Rel. 5 architecture contains two types of Gateways: Roaming Signalling Gateway (R-SGW) and PSTN Gateway. The former handles signalling conversions required for roaming to legacy networks. The latter handles interworking with PSTN and other switched circuit networks (SCN). The PSTN gateway is further decomposed into Media Gateway Control Function (MGCF), Transport Signalling Gateway (T-SGW), and Media Gateway (MGW).

The Databases in 3GPP architecture are condensed into Home Subscriber Server (HSS). The HSS has two distinct functions: Home Location Register (HLR) and User Mobility Server (UMS). The former is equivalent of the HLR in 3GPP Release 99 (UMTS) specifications, which holds subscriber profile information needed in GPRS part of the network. The latter stores subscriber profiles required in the IPT core network.

Also in 3GPP2 the SCM has several identified roles: Interrogating SCM (I-SCM), Serving SCM (S-SCM), and Visited SCM (V-SCM). The roles of those are practically the same than respective CSCFs of the 3GPP.

While the 3GPP has incorporated all databases into HSS, the 3GPP2 architecture has block called "Databases". The different databases of the 3GPP2 architecture in turn have similar functionalities than the HSS of the 3GPP.

While in 3GPP the QoS management functionalities are incorporated into RAN and GPRS network entities, in 3GPP2 architecture we can see separate QoS management functions. The Subscription QoS manager (SQM) makes policy decisions on QoS allowed for user sessions based in subscriber profile and current QoS allocations for the user. On the other hand, Core QoS manager (CQM) makes decisions on use of the QoS resources within one core network.

The 3GPP All IP architecture relies on Mobile IP (MIP) infrastructure for roaming between different access gateways. Thus, MIP Home Agent and Foreign Agent are introduced in the reference architecture.

3rd Generation Partnership Project 2 (3GPP2)

The All IP architecture currently discussed in the 3GPP2 is illustrated in Figure 3. The architecture is described in 3GPP2 Network Architecture Model (NAM) document [7]. The basis of architecture is in the evolution of the cdma2000 specifications. Like the 3GPP architecture, also 3GPP2 All IP network architecture can be divided into almost similar domains.

Access Network and Access Gateway together equals roughly to combination of RAN and GPRS of the 3GPP architecture; they provide IP bearers from Mobile Station to IPT core network. However, the functional split is slightly different; e.g., user authentication and authorisation is done in the cdma2000 Access Network, while in 3GPP those are GPRS network functionalities.

Session Control Manager (SCM) and Media Resource Function (MRF) of the 3GPP2 have very similar functionality than the CSCF and MRF of the 3GPP.

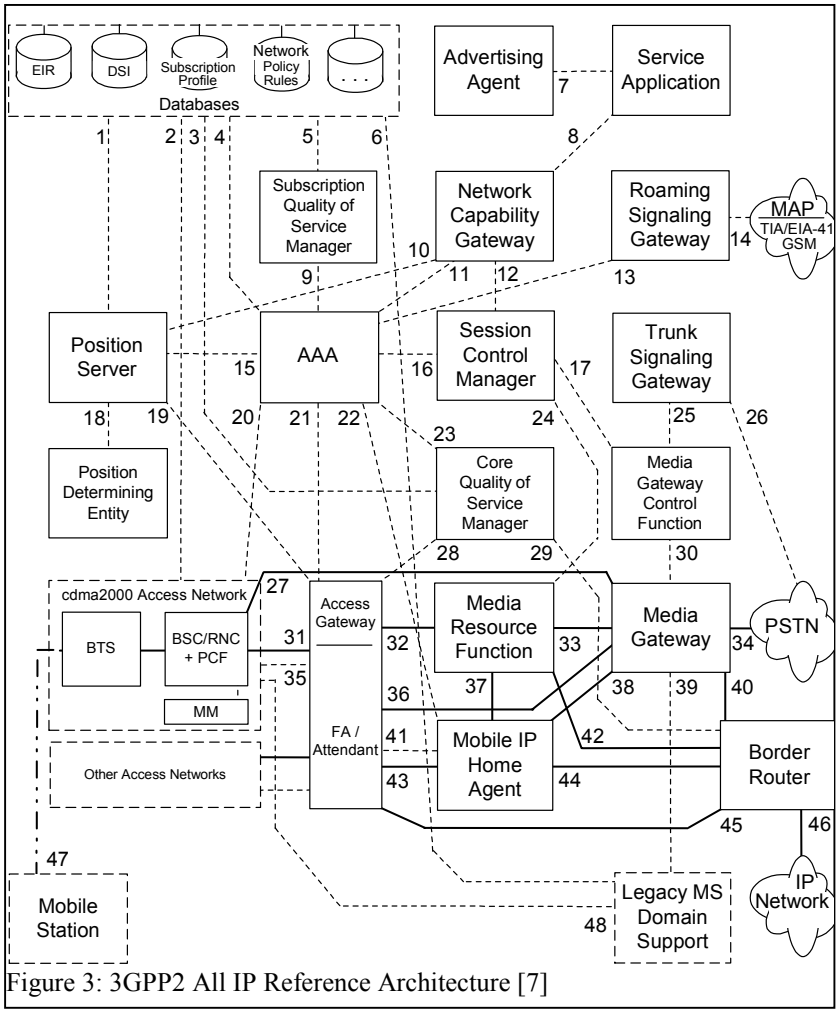

Figure 3: 3GPP2 All IP Reference Architecture [7]

The Gateways of the 3GPP2 resemble very much the Gateways of the 3GPP. Media Gateway Control Function, Media Gateway, and Trunk Signalling Gateway of 3GPP2 have similar functionalities than MGCF, MGW, and T-SGW of 3GPP respectively. However, 3GPP2 introduces also Network Capability Gateway (NCGW), which main task is to authorise servers' use of the network resources. In 3GPP architecture functionality of NCGW is embedded into CSCF.

Mobile Wireless Internet Forum (MWIF)

The MWIF has created a comprehensive All IP network reference architecture, which is described in MTR-004 [8]. Figure 4 illustrates the reference architecture of MWIF. The MWIF architecture resembles quite a bit the architecture of 3GPP2, but the network is divided into smaller functional elements.

Very similar domains than in the 3GPP and 3GPP2 architectures can be found also from the reference architecture of the MWIF; there are databases, gateways, access gateway and network, and session control managers. However, the MWIF architecture does not state anything on the functionalities of the access network, while 3GPP and 3GPP2 have also RAN architecture described in their network architecture documents.

Subscriber profile and policy management is covered in detail in the MWIF architecture. There are distinct servers for authentication, authorisation, and accounting as well as there are four distinct directory servers: location server, global name server, policy server, and profile server.

Protocols and exact functionalities for most of the interfaces in MWIF architecture are still open. However, the reference architecture is a good abstraction of the functionalities required in each All IP network.

CONCLUSIONS

To conclude, all three architectures have some common elements. Each of the architectures has a separate access network connected to some kind of gateway; 3GPP has SGSN and GGSN while 3GPP2 and MWIF have node called Access Gateway. Also connection to the other networks, e.g., PSTN, is organised via dedicated gateways. Furthermore, the core of the All IP network, i.e., the call or session management entities are more or less clearly separated from access network and Gateways.

The biggest differences between the architectures are in the access network, including access gateways, and in the organisation of the user databases and subscription profile management, especially QoS management. Moreover, there are some differences in mobility management. In 3GPP network the GPRS network hides mobility from All IP core and Gateways. In 3GPP2 network the Mobile IP (MIP) is adopted as integral part of the architecture; MIP is used for mobility across Access Gateways and 3GPP2 proprietary protocol is used for mobility within one Access Gateway's area.

Since the network domains of every architecture are at least somewhat independent of each other, it is possible that those domains evolve separately. While also general functionality of the core All IP network is pretty similar in all architectures, there is good possibility that the different architectures start to consolidate towards one architecture.

It is likely that consolidation of the architecture happen in the domains of core All IP network, Databases, and Gateways to external networks, where there are not so large installed base of legacy equipment. In the domains of RAN and Access Gateways seems to be more difficult to achieve common architecture, since there are different radio access technologies and the equipment is already in use.

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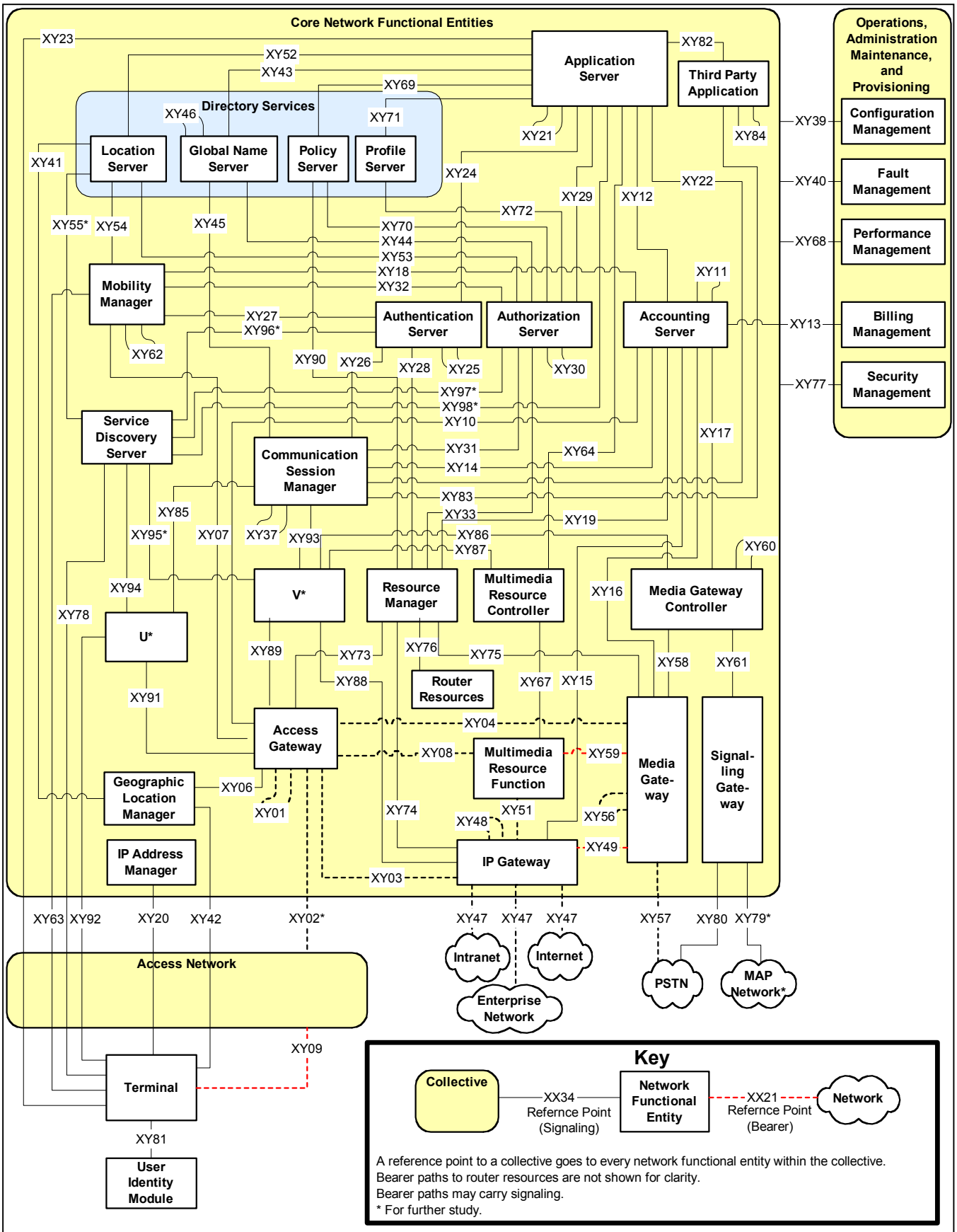

Figure 4: MWIF All IP Reference Architecture [MWIF]