The 3GPP and 3GPP2 Movements Towards an All IP Mobile Network

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1 Introduction

Today's wireless core network is based on a circuit switched SS7 architecture similar to that found in wireline telecommunication networks. With the advent of IP technologies and the tremendous growth in data traffic, the wireless industry is evolving their core networks toward IP technology.

Wireless telecommunications started as an offshoot of wireline telephony and with the absence of global standards resulted in regional standardization. Two major mobile telecommunication standards have dominated the global wireless market, namely, TDMA/CDMA developed by TIA in North America and GSM developed by ETSI in Europe. As we move toward 3rd generation wireless, there is a need to develop standards, which are more global and collaborative. Recently, the global wireless industry has created two new partnership projects to address this issue:

- *3rd Generation Partnership Project (3GPP)* [1] ,which is developing 3G standards for GSM based systems. The consortium includes ETSI, T1 (North America.), ARIB/TTC (Japan), TTA (Korea) and CWTS (China). The North American TDMA community is participating and contributing in 3GPP as ANSI-41 based TDMA systems evolve towards 3G architecture based on EDGE and GPRS.
- *3rd Generation Partnership Project 2 (3GPP2)* [2], which is developing 3G standards for IS-95 based CDMA systems. The consortium includes TIA (N.A.), ARIB/TTC, TTA and CWTS.

The limited data capabilities of 2G systems, motivated the PPs to start work on 3G wideband radio technologies that can provide higher data rates. This work resulted in 3G wireless radio technologies that will provide data rates of 144 kb/s for vehicular, 384 kb/s for pedestrian and 2 Mb/s for indoor environments and meet the ITU IMT-2000 requirements [3]. Now that the radio technology standards to support higher data rates have been developed, the PPs are focussing on development of standards for all IP networks.

In this short article, we discuss the genesis of 3GPP and 3GPP2 IP work outlining the important architectural differences by the two groups. Currently, 3GPP and 3GPP2 offer divergent proposals that need to be harmonized if convergence toward an IP-based mobile telecommunications networks is to become a reality. Note that this provides a snapshot at present, since the work in both forums is progressing rapidly.

2 3GPP Network Architecture

In evolving to an IP core network, 3GPP has decided to base it on GPRS (General Packet Radio Service) [4]. While the GPRS based approach provided packet data access in 3GPP some operators felt that the work towards an all IP network was not moving rapidly. Hence in early 1999, a group of wireless operators invited a group of leading vendors to work in a focus group called 3G.IP to address the requirements for an all IP wireless network architecture. The intent was to formulate fast track technical solutions that would be introduced into 3GPP.

Shortly after 3GPP formed an hoc group to perform feasibility study for an all IP network based on 3G.IP inputs. The group developed requirements for network architecture based on an all IP network. The IP based architecture would have to support both stream and best effort services. The implication of this is that the mobile terminal would include IP based clients. The group also agreed to base the access mobility on

GPRS. The feasibility study has resulted in a draft architecture for an all IP network. Figure 1 shows a simplified version of the 3GPP architecture [5].

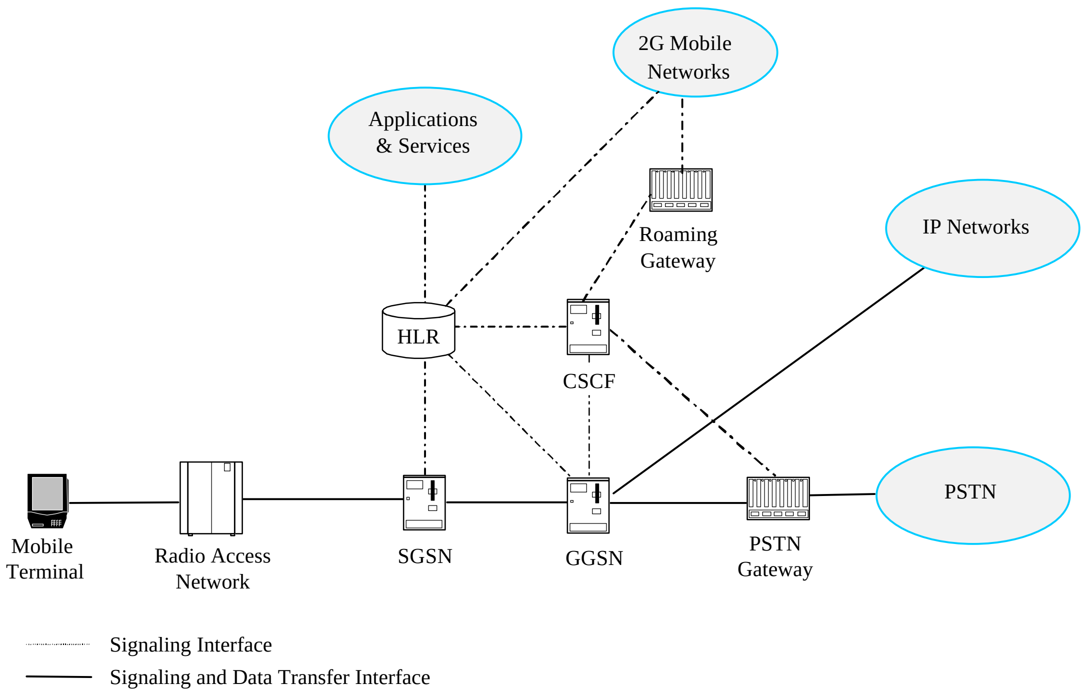

Figure 1: 3GPP IP Reference Architecture

An essential principle of the framework was to provide separation of service control from connection control. 3GPP essentially started with GPRS as the core packet network and overlaid it with call control and gateway functions required for supporting VoIP and other multimedia services. The functions are provided via IETF developed protocols to maintain compatibility with the industry direction in all IP networks..

To support VoIP, call control function analogues to call control in a circuit switched environment are provided by the CSCF (Call State Control Function). The mobile terminal communicates with the CSCF via SIP or H.323 protocols that support Voice over IP. The CSCF performs call control functions, service switching functions, address translation functions, and vocoder negotiation functions. For communication to PSTN and legacy networks PSTN gateways are provided. For supporting roaming to 2G wireless networks, roaming gateway functions are also provided.

The GPRS serving node, SGSN uses existing GSM registration and authentication schemes to verify the identity of the data user. This makes the SGSN access technology dependent. The GPRS Home Location Register (HLR) is enhanced for services that use IP protocols. The data terminal makes itself known to the packet network by doing a GPRS attach. The IP address is anchored in the GPRS gateway node GGSN during the entire data session. This limits the mobility of the data terminal to within GPRS based networks. To provide mobility with other networks a Foreign Agent (FA) as per the Mobile IP architecture [7] can be incorporated in the GGSN.

3GPP has accepted IP technology for its new work items in year 2000. Up to this point in time, the 2000 work has consisted primarily of framework discussions, so the detailed solutions are not finalized.

3 3GPP2 network architecture

3GPP2 has created a new packet data architecture building upon the CDMA 2G and 3G air interface data services. 3GPP2 has taken advantage of 3G high data rates and existing work in IETF on Mobile IP [7] to enhance the network architecture to provide IP capabilities. For additional details of the Mobile IP application in 3GPP2 architecture, see [6]. One advantage of using globally accepted IETF protocols is the ease interworking and roaming with other IP networks. The other major advantage is that it can provide private network access (Virtual Private Networking) via Mobile IP tunnel with IP security [6].

3GPP2 has undertaken the work to enhance the IP architecture for multimedia services (including voice). The idea is to capitalize on the synergies of Internet technologies and using one single network for all services. Figure 2 shows an interpretation of the all IP network (actual requirements are currently being developed).

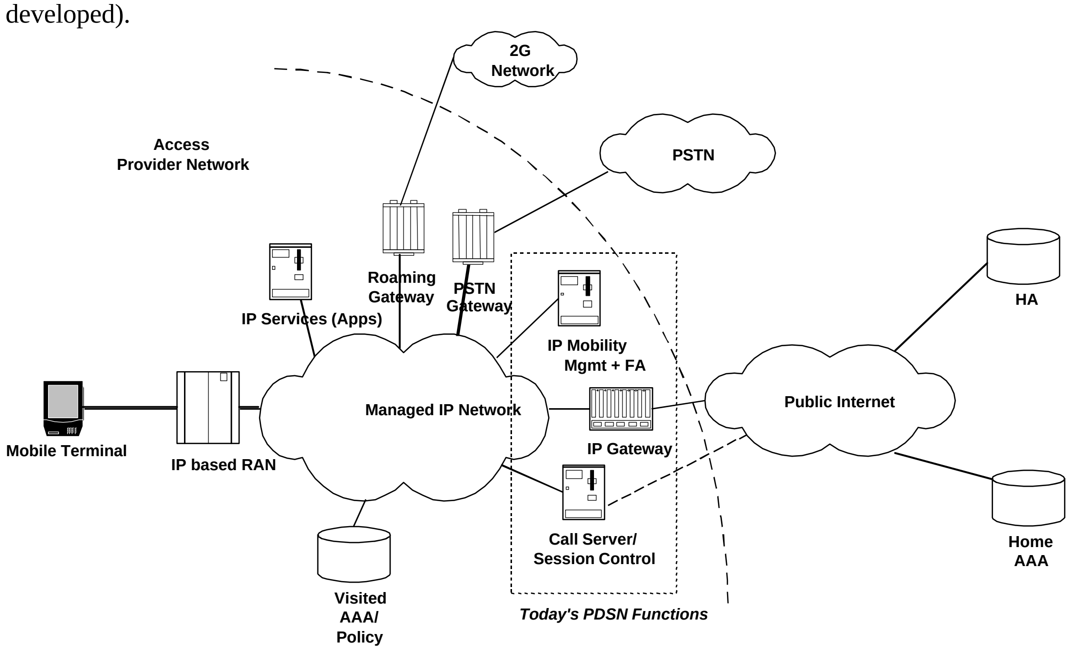

Figure 2: 3GPP2 Future IP Architecture

The essential attributes of an all IP network are End to End IP connectivity, distributed control and services and gateways to legacy networks. In the 3GPP2 architecture, IP connectivity reaches all the way to the Base station Transceiver (BTS). Both BSC and BTS are contained in the "IP based RN" node in the figure above. This means that the BSC will be a router based IP node containing some critical radio control functions (e.g., power control, soft handoff frame selection, etc). The remaining control functions, such as call/session control, mobility management, and gateway functions are moved out into the managed IP network. This allows distributed and modular control architecture. The functions of the PDSN (Packet Data Serving Node) in the 2G architecture [6] are distributed as shown in Fig. 2. Since much of the communication will be between wireless terminals and legacy terminals, gateway functions are provided for roaming to 2G wireless networks and interworking with PSTN.

In the 3GPP2 architecture, the Mobile Terminal uses Mobile IP based protocols to identify itself. The PDSN (Packet Data Serving Node) contains Foreign Agent (FA) functionality as per the Mobile IP architecture [7]. When the Mobile Terminal attaches to the FA, the FA establishes a Mobile IP tunnel to the Home Agent (HA) and sends registration message to the HA. . The HA accesses the AAA (Authorization, Authentication, Accounting) server to authenticate the Mobile Terminal. The IP address of the Mobile Terminal is now anchored in the HA for the duration of the data session. The data device connected to the Mobile Terminal can be handed over to any other access device that supports Mobile IP. Thus, this approach can provide mobility across different access networks (wireless, wireline etc.). However since it essentially uses address translation to provide mobility, it can not do fast handoff due to the latency of address updates from distant agents. There has been considerable research to address the latency issue via schemes such as Cellular IP [8], Hawaii [9] and TeleMIP [10]. Essentially all of them propose some form of hierarchy with local/gateway routers, which can reduce latency by reducing updates from the remote Home Agent. These schemes could be used to optimize Mobile IP application in 3GPP2.

4 Convergence of the two approaches

In provision of mobility for IP sessions, the 3GPP and 3GPP2 architectures are different because of the underlying base networks and evolution strategies. In 3GPP, GPRS based mobility was already defined and so the IP network enhancements were considered on top of GPRS. On the other hand 3GPP2 needed to develop a mobility mechanism for packet data since one did not exist previously. 3GPP2 has decided to use Mobile IP as the basis for packet data mobility. To illustrate the similarities and differences of the two approaches, mobility needs to be separated into three levels: Air Interface mobility, Link Level Mobility and Network level mobility. Air interface mobility supports cell to cell handoff within a radio access network. Link level mobility maintains a PPP context across multi radio access networks. Network level mobility provides mobility across networks.

In both of the approaches, the air interface mobility is handled in the Radio Access Network. The air interface mobility is specific to the radio technologies and so harmonization of the two would depend on the harmonization efforts that are underway for global CDMA. In 3GPP, link level mobility is handled by GTP (GPRS Tunneling Protocol) [4]. GTP is used to provide mobility to other 3GPP defined networks. The 3GPP architecture also provides an option in which a Foreign Agent may be located in the GGSN. This allows roaming from GPRS based networks to other IP access networks. In 3GPP2, link level mobility is provided by defining a tunneling protocol as an extension of Mobile IP. The Mobile IP architecture allows the mobile to have a point of presence and roam across any IP network. Registration and authentication in the 3GPP architecture for access and data network are integrated and use the schemes used for wireless. In the 3GPP2 architecture, the registration and authentication for access and data networks are performed separately. For data network, authentication and registration AAA as defined in Mobile IP [7] is used. Hence, the data architecture is access independent.

A common set of IP Mobility protocols are needed to provide network level mobility between different access networks including wireless. IETF is developing a suite of protocols (Mobile IP) to achieve such mobility. Mobile IP based protocols could provide a good approach for network level mobility. A new forum MWIF [11] started recently by major global CDMA carriers intends to drive a single open mobile wireless internet architecture that enables seamless integration of mobile telephony and internet services and is independent of the access technology. It intends to influence both 3GPP and 3GPP2. Hopefully cross forum discussions between 3G.IP, MWIF, 3GPP and 3GP2 results in achieving the objectives set by MWIF. This will be to the benefit of the global wireless industry.

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