INTELLIGENT NETWORK ARCHITECTURE FOR FIXED–MOBILE CONVERGENCE SERVICES

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ABSTRACT

Recenly, competition in telecommunications markets is increasing rapidly. In order to survive in the competitive telecommunication markets, service providers and network operators have to reform their marketing and service delivery strategies. The Fixed-Mobie Convergence (FMC) is an evolution from both the technological and network provision point of view. FMC can generally be achieved at the intelligent network level. Supporting both fixed and mobile services on the intelligent network architecture, will bring a number of benefits to operators and customers. In this article, we propose Fixed-Mobile Converged Intelligent network architecture between fixed network and mobile network via existing ADSL(Asymmetric Digital Subscriber Line) technology. This article consists of convergence trends, IP access architecture, mapping mechanism for IP over other technology, 3GPP user plane protocol architecture, and technology forecasting.

Keywords: FMC, FMS, Fixed-mobile convergence network, intellignet network

1 INTRODUCTION

Fixed-mobile convergence (FMC) is the trend towards seamless connectivity between fixed and wireless telecommunications networks. The term also describes any physical network that allows cellular telephone sets to function smoothly with the fixed network infrastructure. The ultimate goal of FMC is to optimize transmission of all data, voice and video communications to and among end users, no matter what their locations or devices. In the near future, FMC means that a single device can connect through and be switched between fixed and mobile networks. FMC is sometimes seen as a way to reverse the trend towards fixed-mobile substitution (FMS), the increasing tendency for consumers and businesses to substitute cellular telephones for hard-wired or cordless landline sets.

Consumers prefer mobile phones for several reasons. The most often mentioned factors are convenience and portability. With mobile service, it is not necessary for the user to locate and remain bound to a hard-wired phone set or stay within the limited range of a cordless base unit. Most mobile service providers offer packages in which there is no extra charge for roaming or long-distance calling. Another factor in the acceleration of FMS is the fact that as mobile telephone repeaters have proliferated, the per-minute cost of the services has been declining while coverage has been improving. FMS at the consumer and enterprise level translates to the industry as a whole, offering a major opportunity to mobile companies and threatening the continued existence of traditional telecommunications companies. A number of companies are offering or developing devices that can connect to both traditional and wireless telecom networks as a means of slowing the overall trend to FMS.

The FMC is an evolution from both the technological and marketing points of view. From the technological point of view, convergence can generally be achieved at one of three levels: the terminal level, the intelligent network level, or the switch level. However, incumbent operators and new entrants find that they cannot easily integrate all the current switches. The only level where significant progress has been achieved is the intelligent network level. Solutions based on the intelligent network exactly fit the market demands for flexible, innovative services and fast introduction to the market. Therefore, adoption of an intelligent network solution by mobile operators and implementation of wireless access solutions (with limited mobility) by fixed network operators are the current key drivers toward FMC [1, 2].

Support of both fixed and mobile services on intelligent network architecture brings a number of benefits to operators and customers, helping them to become or remain competitive.

Consumers using GSM and WCDMA phones

will now be able to use their mobile phones at home, with the price advantages offered by fixed-line and internet phones. Intelligent network solution includes home base station that is, in itself, the world's smallest mobile base station. The home base station is compatible with GSM and WCDMA phones and also includes Wi-Fi and ADSL. This solution enables the operator to offer a "home-area" tariff to all the people living in a household. Home base station is connected, plug-and-play, to any existing IP backhaul network (e.g. ADSL), and the user's mobile phone will switch to the indoor home base station automatically as they walk through the door.

The remains of this article are as follows: We investigate current FMC/FMS trends including activities of FMCA which is an organization for convergence products and service. There are different approaches to FMC around different operators and vendors. Section 3 presents IP access architecture model referred from ITU-T standardization, and 3GPP user plane protocol architecture. In section 4, intelligent network architecture for FMC services and proposed protocol architectures are described. Section 5 addresses the future mobile technologies. Finally, we conclude this article.

2 Convergence trend for FMC/FMS

Today, customers are increasingly using mobile phones to replace fixed phones, due to mobile phones' convenience and greater functionality. With this trend, Fixed to Mobile Convergence (FMC), currently one of the crucial strategic issues in the telecommunications industry is the way to connect the mobile phone to the fixed line infrastructure. With the convergence between the mobile and fixed line networks, telecommunications operators can provide services to users irrespective of their location, access technology, and terminal. In addition, it is expected that by 2010 mobile service penetration levels of almost 90 percent will be achieved in international market. These trends are stimulating operators and vendors to provide the same services over both fixed and mobile networks, developing a converged intelligent network Fig. 1.

Fixed-mobile converged intelligent network can provide seamless location, roaming and hand-off of voice calls between indoor network and outdoor network using one mobile phone with a single number. Applicable to data and video services as well, this capability will enable providers to deliver multimedia services to a range of different devices and maintain service continuity and Quality of Service (QoS) across a range of access networks for users at work, at home, or on the road. The intelligent network can dynamically deliver these services over the most efficient and highest quality network without subscribers having to take action or even acknowledge that any change took place. This results in greater subscriber satisfaction and enhanced customer loyalty.

Fig. 2 shows network development roadmap which describes the convergence paths from today's second-generation wireless system to the third-generation wireless system. There are 3 convergence paths that converge to all IP network: mobile, wireless, and the fixed network.

In the past, the mobile network's data transmission rate was 14.4Kbps to 64Kbps by using PCS (IS-95A) or IS-95B. This was suitable for messaging and short file transfer, but not convenient for Web browsing and multimedia services. In the early 2000, the data transmission rate was enhanced from 144Kbps to 2.4Mbps with newly introduced technologies, CDMA2000 and 1X EVDO. This High-speed data technology allows real-time video communication or large file transfer.

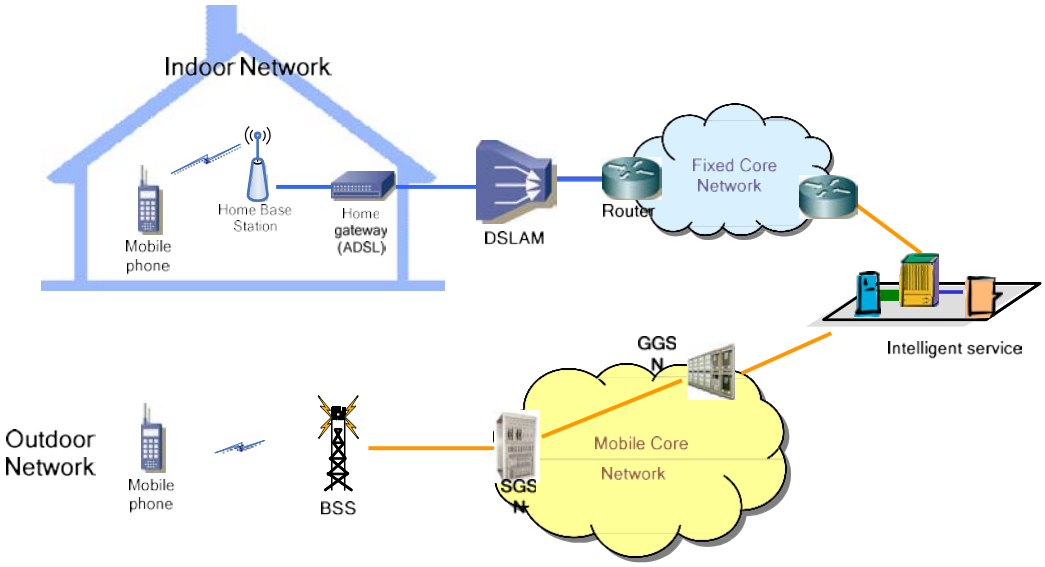

Figure 1: The Fixed-Mobile Converged Intelligent network

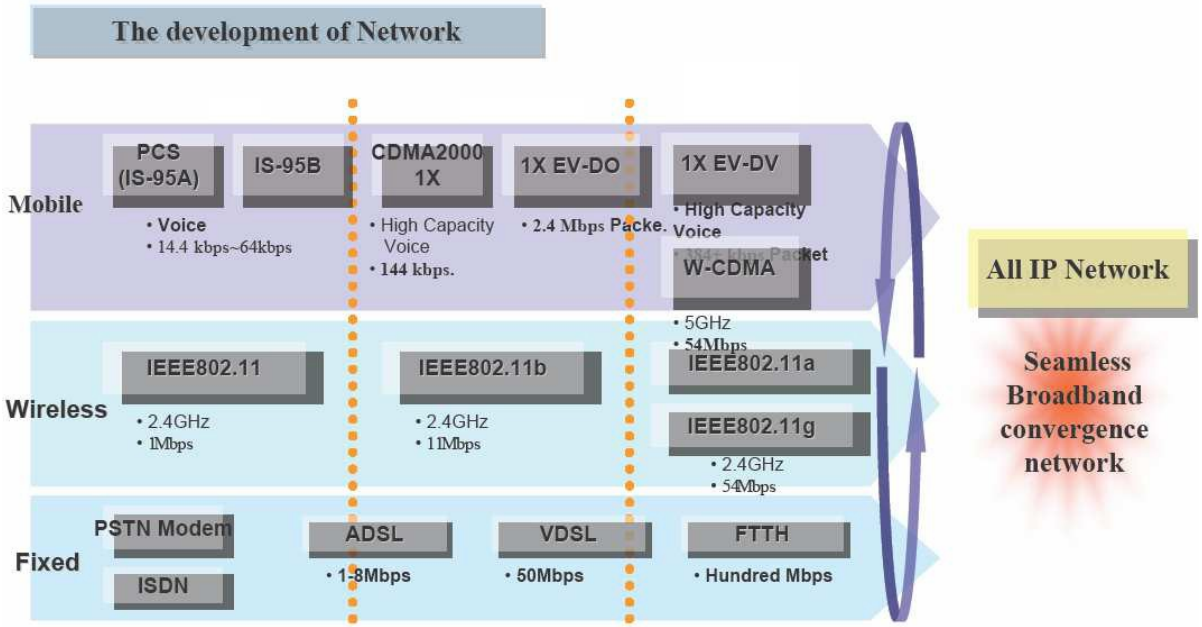

Figure 2: Network development roadmap

The convergence path of wireless network, which started with IEEE802.11 technology, was initially provided 1Mbps data rate. However, after several years later, the IEEE802.11b technology was developed and the data transmission rate became 11Mbps. currently the data rate is 54Mbps using IEEE802.11a/g, and expect to be increased within several years. The Fixed network also has developed from the utilization of the PSTN modem to optical technology. From the ISDN, the ADSL technology with 1 to 8Mbps data rate was widely deployed and soon the VDSL with 50Mbps data rate was adopted. Now, the FTTH which provides hundreds of Mbps is being used. This improvement will be accelerated and converged to all IP networks.

2.1 Fixed-Mobile Convergence Alliance

We briefly introduce the activities of 2.1Fixed-Mobile Convergence Alliance (FMCA) which is an organization for converged products and services.

The FMCA [3] was formed in June 2004 and incorporated as a non-profit trade association under New York law in August 2006. The FMCA is therefore managed by Bylaws and operating policies and governed by the laws of the state of New York, USA.

As a market driven organization, the FMCA benefits from a number of Priority Programs focused on making Convergence products and services seamless and easy to use, no matter what access technology is employed, for the benefit of the customer.

Its global membership base of leading operators, representing a customer base of over 850 million customers, or 1 in 3 of the world's telecoms users, collaborates with member vendors towards the accelerated development and availability of Convergence products and services in areas such as terminals, access points and home access gateways, roaming and innovative applications.

In order to accomplish its goals, the FMCA has developed close relationships with leading Standards Development, Specification & Certification Organizations (SDO/Fora), actively contributing towards the delivery of existing and emerging service requirements.

Its worldwide membership represents the organizations that are thought leaders in Convergence and deeply involved in the implementation of Convergence technologies and services.

As a global organization, they are working together to provide today's and tomorrow's Convergence customers with high-quality, seamless and easy to use products and services.

Through their members' collaborative work, they are ensuring that devices, access points, applications and underlying networks interoperate to deliver the best user experience possible.

The FMCA published Release 2.0 of the FMCA Product Requirement Definitions (PRDs). The FMCA PRDs, centered on the key Convergence Technologies (Bluetooth CTP, Wi-Fi GAN/UMA and Wi-Fi SIP), are created by senior technical and product development professionals across the FMCA membership base and reflect common operator requirements for Convergence products and services in areas such as Service Capabilities, Handset, Access Point & Gateway, Network Architecture and Roaming. (May, 2006)

- FMCA Convergence Application Scenarios
- Convergence Services over Wi-Fi GAN (UMA)
- Convergence Services using SIP over Wi-Fi
  - Access Point & Gateway Requirements
  - Network Architecture Document
  - Service Capabilities Document
  - Technical Handset Requirements
  - Terms and Definitions Document

This milestone reflects the phased evolution of the FMCA PRDs and the FMCA's commitment to collaborating with leading standards development and certification organizations in areas which require operator-led input. The documents have also received input from the Wi-Fi Alliance, the leading worldwide certification body for WLAN technology actively focused on the certification of Convergence products, with which the FMCA has a strategic relationship.

In order to understand the technology implication of convergence, various service scenarios have been created. Typical examples of converged service scenarios are as follows [3,4]:

- One-number service, a basic FMC service, typically offered to residential and small office/home office (SOHO) customers who can be reached by means of enhanced IN functionality. One-number service enables pricing flexibility, such as charge splitting for incoming calls between the called and calling parties. Furthermore, it enables charging options according to subscriber locations. For instance, calls performed within the home tariff zone can be priced according to lower fixed network charging, while calls performed outside this zone can be priced according to mobile network charging.
- Personal Multimedia, a service which provides secure access to the user's multimedia content (stored at home and/or in the network) from any terminal. It allows the user to upload or download content from any device anywhere at any time. The service will take care of ensuring that the right network is used dependent on the nature of the content, e.g. music and video content may only be downloaded when in range of a high speed network such as a Wi-Fi hotspot. The service allows the user to subscribe to media feeds which are automatically delivered to the device over the best network.
- Combinational Services, Services based on the availability of multiple connections (circuit and data) also on a fixed-mobile convergent network during the same communication session. Using more than one connection in the same session allows the combination of media/data flow and different devices to create new services. The fixed-mobile convergent network solution guarantees that the customer experience is seamless to the end user, independent from the network access used, and with different services and devices available in the two environments during a voice call:
  - Outdoor - environment where only the GSM/UMTS network is present;
  - Indoor - environment where the Wi-Fi/Bluetooth/Ethernet networks and the GSM/UMTS networks are available.

The customer can choose the best network (xDSL /Wi-Fi /UMTS /GSM…) for a communication connection in every situation (outdoor/indoor, in office at home, in public hot spot)

3 SOLUTION APPROACHES FOR FMC SERVICES

3.1 IP access network architecture

This section describes the high-level IP network architecture and models for the IP services referred from ITU-T Recommendation [5]. We describe the access types and interfaces to be supported by the IP access network, the IP access network capabilities and requirements, and the IP access network functional models and possible arrangements.

3.1.1 General network architecture of IP network

Fig. 3 shows general network architecture of IP network. In Fig. 3, the lines between various rectangles and ellipses represent connections that are bidirectional, that may be asymmetrical in bit rate, and that may be of differing media in the two directions. The reference points (RPs) which were illustrated are logical separation between the functions and may not correspond to physical interfaces in certain network implementation. In certain network implementations, access and core networks may not be separable

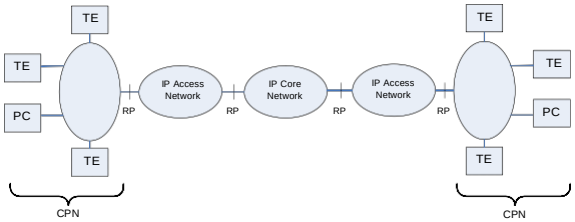

Figure 3: General network architecture of IP network

3.1.2 The functional requirements for IP Access

Possible IP access functions are as follows:

- Dynamic selection of multiple IP service providers
- Dynamic allocation of IP access using PPP
- NAT

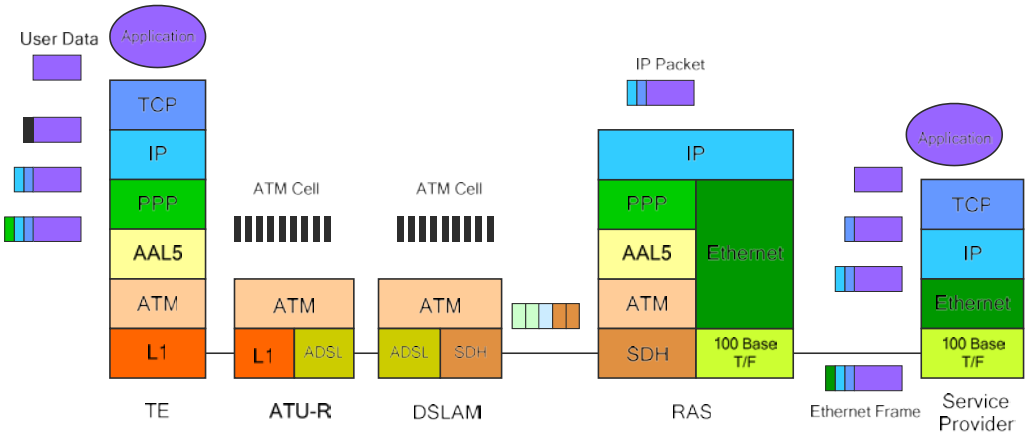

Figure 4: PPP over ATM

- Authentication
- Encryption
- Billing usage metering and interaction with AAA server.

3.1.3 Examples of IP mapping mechanism

The following diagrams show protocol stacks for IP on various transmission systems.

- IP over PPP over ATM

ATM AAL5 protocol is designed to provide virtual connections between end stations attached to the same network. The PPP layer treats the underlying ATM AAL5 layer service as a bit synchronous point-to-point link. In this context, the PPP link corresponds to an ATM AAL5 virtual connection.

Fig. 5 shows IP over PPP over ATM mapping mechanism. [6]

IP
PPP (RFC 1661/RFC 2364)
Encapsulation Header (RFC2684)
AAL5
ATM
PHY

Figure 5: Mapping mechanism for IP over PPP over ATM

- IP over PPP over Ethernet

The Point-to-Point Protocol (PPP) provides a standard method for transporting multi-protocol datagrams over point-to-point links. PPP over Ethernet (PPPoE) provides the ability to connect a network of hosts over a simple bridging access device to a remote Access Concentrator. With this model, each host utilizes it's own PPP stack and the user is presented with a familiar user interface. To provide a point-to-point connection over Ethernet, each PPP session must learn the Ethernet address of the remote peer, as well as establish a unique session identifier. PPPoE includes a discovery protocol that provides this.

Fig. 6 shows IP over PPP over Ethernet mapping mechanism. [7]

IP
PPP (RFC 1661/RFC 1662)
Encapsulation Header (RFC2516)
MAC
PHY

Figure 6: Mapping mechanism for IP over PPP over Ethernet

3.2 3GPP user plane protocol architecture

This section introduces overviews WCDMA impacts on the protocol architecture as well as on element functionalities. The architecture can be defined as the user plane part handing user data, and the control plane part. The overall user plane protocol architecture is shown in Fig. 8.

The Packet Data Convergence Protocol (PDCP) has its main functionality header compression which is not relevant for circuit-switched services. Radio link control (RLC) handles the segmentation and retransmission. The medium access control (MAC) layer in Release 99 focuses on mapping between the logical channels and handling the priorities, as well as selection of the data rates is being used – i.e., selection of the transport format (TF) being applied. Transport channel switching is also MAC layer functionality.

3.3 Intelligent network protocol architecture for Fixed-Mobile Convergence Services

Mobile operators increasingly perceive a threat from the convergence of WCDMA, Wi-Fi and fixed telephony within the home, and are seeking a way to increase their share of the residential calls market.

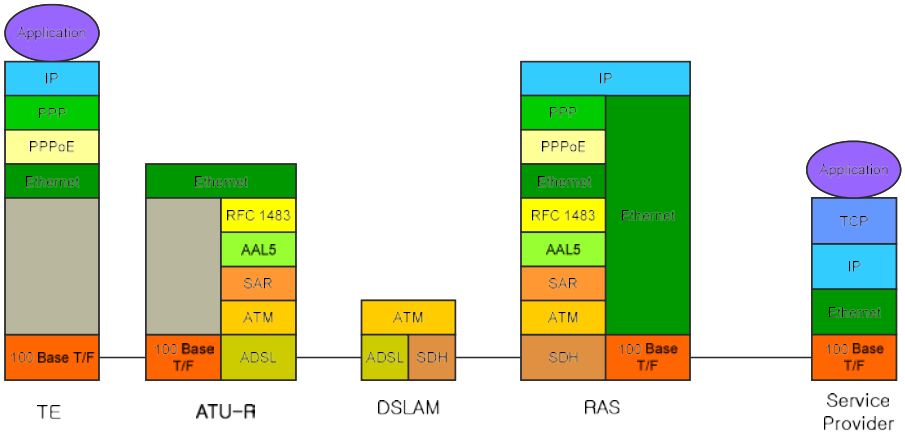

Figure 7: PPP over Ethernet

The home base station or femtocell supports cellular calls locally, and then uses broadband, typically xDSL or cable modem, to carry traffic to the operator's core network. Crucially, as a standard 3G base station, it operates with all existing handsets rather than requiring customers to upgrade to expensive dual-mode devices. This provides cellular carriers with an effective means of countering the threat of VoIP, UMA or VoWi-Fi, by using proposed Fixed-Mobile Converged Intelligent network. As the same handset is used for all calls, it improves customer loyalty and reduces churn, as barriers to changing operators increase. An additional benefit is that network coverage and capacity are increased in a cost-effective manner, exactly where they are most needed by the end user.

From the customer's perspective, a home base station offers the benefit of using a single mobile handset with a built-in personal phonebook for all calls, whether from home or elsewhere. This eliminates user frustration caused by changing between handsets with different interfaces and functionality.

As a result, intelligent network architecture can provide following benefits both customers and network operators.

- Customers can use single mode terminal everywhere
- Low price for using mobile station at home.
- No need other terminal (e.g. fixed telephone)
- No need to upgrade expensive dual mode terminal.
- Economic feasibility of investment
- Cheap price of equipment and construction expenditure
- Reduction of operational expenditure
- Creation of new market
- Application of specialized product for targeted customers

4 TOWARD MOBILE TECHNOLOGIES OF THE FUTURE

4.1 IMS (IP Multimedia Subsystem)

IMS is defined by 3GPP/3GPP2 as a new core and service 'domain' that allows the service provider to combine wired and wireless applications in the same session, and allows sessions to be dynamically modified on the fly, for instance add video to a voice call, or transfer a cell phone call to your landline seamlessly. This makes possible "blended" services such as video telephony, push-to-talk, chat, broadcast TV using multicast IP video streams, video-on-demand, video surveillance, and other applications. IMS carries signaling and bearer traffic over IP and acts as a session controller application that matches user profiles with the appropriate call/session-handling servers and then routes the call or session to the appropriate destination.

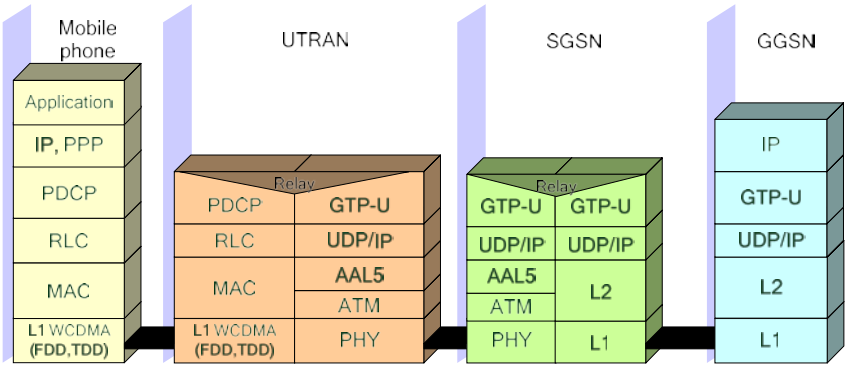

Figure 8: 3GPP User Plane protocol architecture

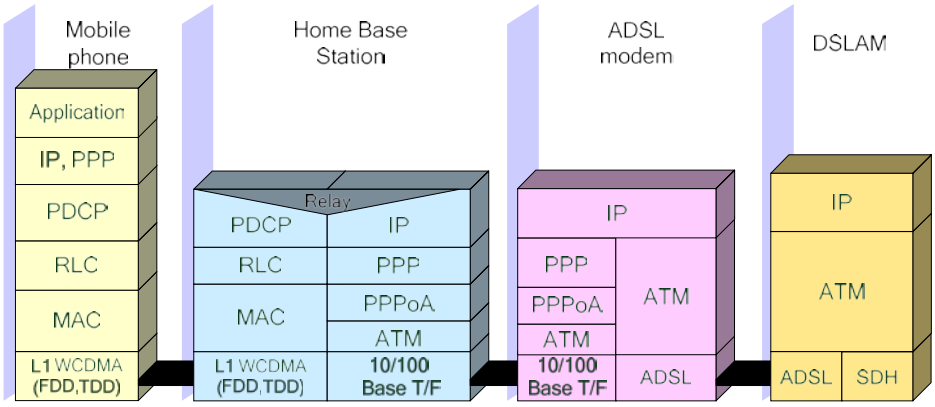

Figure 9: Intelligent network protocol architecture for Fixed-Mobile Convergence service

4.2 ITU-T FMC Working Group [8]

The ITU Telecommunication Standardization Sector (ITU-T) coordinates standards for telecommunications on behalf of the International Telecommunication Union (ITU). FMC working group, in ITU-T SG13, describes principles and requirements for convergence of fixed and mobile networks (Fixed-Mobile Convergence, (FMC)). This convergence of fixed and mobile networks enables mobile users to roam outside the serving area of their mobile networks and still have access to the same set of services outside their network boundaries as they do within those boundaries, subject to the constraints of physical access and commercial agreements.

The origin of NGN is within fixed networks and their evolution. However, increasingly mobility services are demanded by the user and the operators. Therefore the support of several aspects of mobility is a feature to be provided by NGN. This shall also include “discrete mobility” which can be offered even based on fixed line access technologies. In addition, there is the requirement for fixed-mobile-convergence which includes convergence of the services, convergence of the basic architecture of NGN and Mobile Networks etc. These requirements are the basis of this Question.

This should enable the ITU-T to provide value by rapidly enhancing the NGN recommendations to provide elements of mobility and extend the mechanisms to fully suit the requirements on NGN.
Study items:

- Service convergence and interoperability between fixed and mobile networks
- Architecture convergence between fixed and mobile networks
- Nomadicity (discrete mobility) within the NGN and possible roaming between fixed and mobile networks.

The high level architecture of the FMC scenarios that are studied in this recommendation is depicted in Fig. 10. The architecture assumes a common IMS service platform for the delivery of services over fixed and mobile networks.

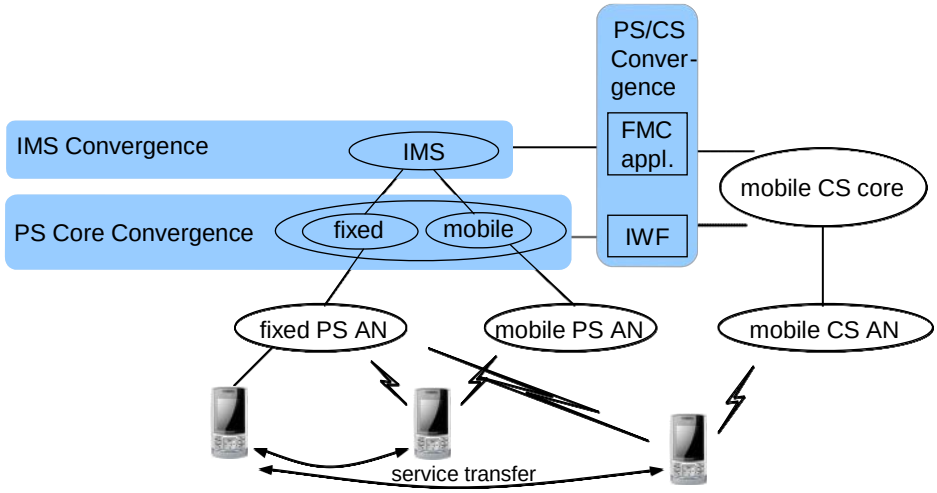

Figure 10: IMS based FMC architecture

4.3 802.21 (MEDIA INDEPENDENT HANDOVER)

Roaming across heterogeneous access technologies such as CDMA, WiMAX, and 802.11 as well as wired access networks such as xDSL and cable will become a requirement of future networking devices rather than an additional feature. However, supporting seamless roaming between heterogeneous networks can be challenging since each access network may have different mobility, QoS and security requirement. One of the latest standards committees, 802.21 is developing protocols that cover both 802-type wireless networks and mobile telephony. [9] This group is creating a framework that defines a media independent handover function that will help mobile devices to seamlessly roam across heterogeneous access network.

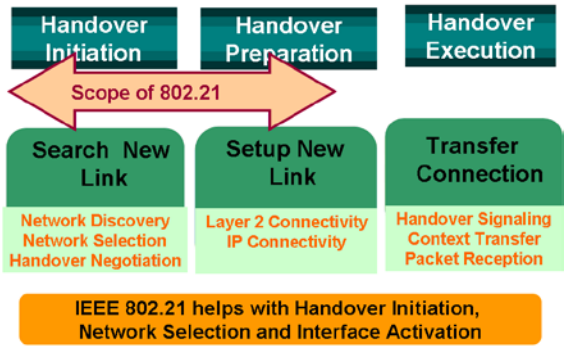

Figure 11: Genesis for 802.21

MIH Reference Model for Mobile Stations with Multiple Protocol Stacks is intended to provide methods and procedures that facilitate handover between heterogeneous access networks.[10] These handover procedure can make use of information gathered from both the mobile terminal and network infrastructure to satisfy user requirements There are several factors that may determine the handover decision. Typically these include service continuity, application class, quality of service, network discovery and selection, security, power management and handover policy. This reference model facilitates the network discovery and selection process by exchanging network information that helps mobile devices determine with networks are in their current neighborhoods. This network information could include information about the link type, the link identifier, link availability and link quality etc. of nearby network links. This process of network discovery and selection allows a mobile to connect to the most appropriate network based on certain mobile policies.

5 Conclusion

In order to succeed in competitive telecommunication markets, network operators and service providers have to develop new markets, enlarge their range of services and provide services at a quicker pace and at more competitive prices.

The integration of wired and wireless technologies to create a single telecommunications network foundation has quickly captured the collective imagination of the telecommunication industry. FMC is set to obliterate some of the physical barriers that now prevent telcos from reaching all of their potential consumers with all types of services.

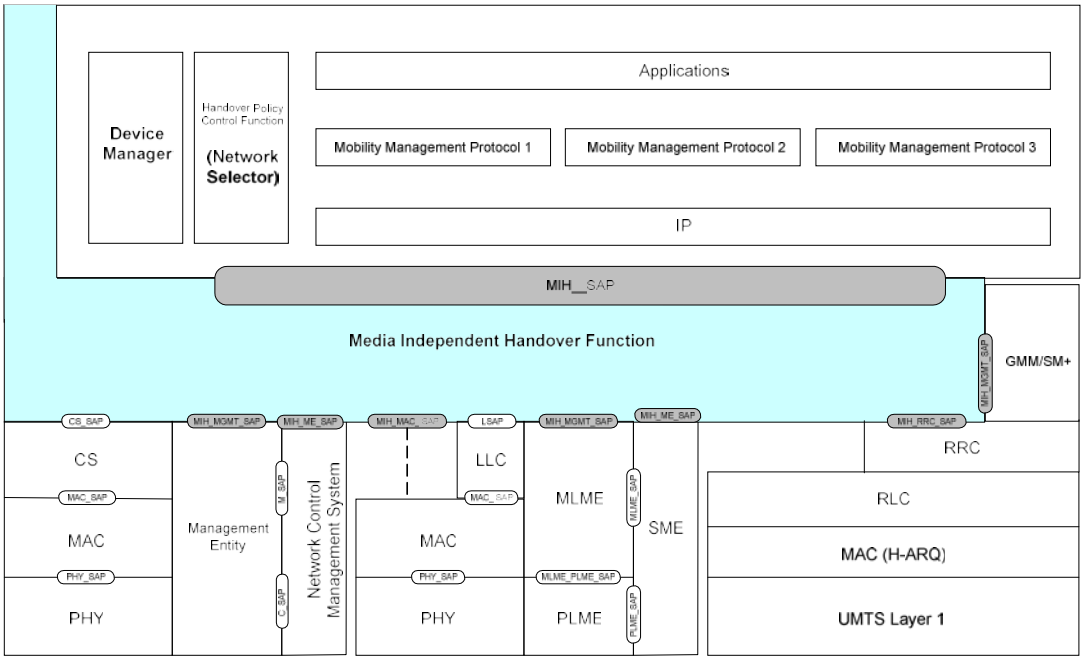

Figure 12: MIH Reference Model for Mobile Stations with Multiple Protocol Stacks

Thus, they have to eliminate operational and service constraints imposed by different technologies. An emerging solution is a removal of the barrier between various networks by converging fixed and mobile services. Using the fixed-mobile convergence approach, operators and service providers will be able to enhance customer services, and increase their own competitiveness and revenues. This can be done in a cost-effective way by upgrading the existing technologies and developing FMC strategies toward third-generation wireless technologies.

Furthermore, the comparative analysis of wireless technologies shows that by implementing GPRS technology some operators may upgrade their GSM networks and begin offering wireless data services now, while waiting for WCDMA technology in the next century. In other words, using GPRS, they can start making a profit from wireless data services, thus creating a milestone toward achieving the vision of ubiquitous personal communications. Other operators, however, may choose to develop their TDMA networks toward EDGE, which they will use as a 3G network. Customers can be attracted by these intermediate solutions, which could provide them with attractive services from new content and service providers. Manufacturers and operators therefore need to keep abreast of all competitive technologies, since currently there is no technology in the leading position.

ACKNOWLEDGEMENT

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