NEXT GENERATION NETWORKS FIXED MOBILE CONVERGENCE INTEGRATION FEATURES

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Abstract: An essential integration features in Fixed Mobile Convergence are discussed in this paper. The growing user requirements for consistent set of services and facilities are the main reason for the evolution of mobile networks nowadays. Convergence with fixed IP networks is the destination field to respond employees’ and customers’ needs. An overview of protocols and systems providing convergence is presented. The features of the convergence between next generation wireless networks and existing Ethernet platforms are described.

Keywords: FIXED MOBILE CONVERGENCE, LONG TERM EVOLUTION, CORE NETWORK, IMS, SIP

1. INTRODUCTION

Data applications are leading the business and people’s life in the 21st century. The need of fast networking technology is already known and accepted as essential worldwide. User requirements for device, service and network convergence are growing facing new opportunities of contemporary life such as traveling all around the world for business meetings, fast responding to a given task, working in a team on- and offline, etc. Such new challenges to the busy personnel ask for new way of service delivery and real time Quality of Service ensured.

The Fixed Mobile Convergence technologies give a new perspective to the existing networking platforms. FMC is a technology trend toward seamless connectivity between fixed and wireless telecommunications networks [18]. Having the quality of fixed networks and the comfort of mobile networks users explore exiting way of giving their best for business task developing and project finishing in time.

Fixed Mobile Convergence is essential to industry, business and enterprises having the ability to reduce cost expenses, ensuring reliability and opportunity for any service working with any device. FMC assumes device, service, network and industry convergence working in common environment with efficiency, productivity and customer satisfaction improved.

2. NEXT GENERATION FIXED AND WIRELESS NETWORKS OVERVIEW.

An interesting subject defining the need of FMC is that employees never want to miss an important business call. There is also a benefit when calls between groups of users are free; the voice mail is one and the same in the mobile device and in the stationary telephone in the office. Having an ability of call recording, call transfer and forwarding are also benefits provided by FMC. When FMC is offered from a network operator, the service-level benefits are developing a new revenue stream, customers are been retained and acquisition costs of new customers are reduced. The network level benefits are capital cost savings, combining functionality of multiple technologies into single element and also single management system.

Important feature of FMC is allowing customers to access a consistent set of services from any fixed or mobile user equipment via any enhanced compatible access point. Roaming can be pointed as extension of this principle avoiding link loss between different networks.

The Fixed Mobile Convergence is a previously discussed problem and some solutions were already offered. The future challenge is the convergence of broadband access networks with fast speed Ethernet core networks. The Long Term Evolution - Advanced (LTE - Advanced) network pretends to be 4th Generation cellular network (4G) and WiMAX is next generation Wireless standard. The future needs determine that the best combination is between 4G Cellular Networks/Wireless networks and Optical Core Networks. The goal is achieving convergence for faster than ever data rates. To achieve the symbiosis between different networks, integration of variable key technologies is needed. It includes fixed and wireless broadband, IP multimedia subsystem (IMS) and deployment of Session Initiation Protocol (SIP) and Packet Data Convergence Protocol (PDCP).

2.1. LTE

The LTE standard upgrades Global System for Mobile Communications (GSM) and Universal Mobile Telecommunications System (UMTS) standards, commonly called 2G and 3G. Voice transfer was the first application in use, after which data transfer was added as extra service. Mobility and seamless handoff were requirements from the start, as was a requirement for central management of all nodes. LTE assumes a full IP network architecture and is designed to support voice in the packet domain [18]. LTE speeds will be equivalent to what today’s user might see at home on a fast cable modem [2]. The LTE standard is designed to enable 150 Mbps downlink and 50 Mbps uplink over a wide area. While 150 Mbps is LTE’s theoretical top uplink speed, each user’s bandwidth will depend on how carriers deploy their network and available bandwidth. As a matter of Fixed Mobile Convergence, the LTE physical and MAC layers are the object of view. The physical layer has the modulation of data in asymmetrical way. The operation is in full-duplex, with simultaneous transmission and reception. The radio is optimized for downlink performance, without regarding the consumption power during transmission. On the uplink consumption is optimized for battery power saving. The communication between the user equipment (UE) and the enhanced base station – eNode B (eNB) can be established either directly (i.e., one hop) or over two hop via Radio Network (RN). Relaying should happen only when it can improve the throughput or enhance the coverage with sophisticated relaying strategies. The targets of this new technology are increased coverage, higher data rates, better QoS performance and fairness for different users [5].

![Fig. 1 LTE Architecture](image-url)
In figure 1 the LTE Architecture overview is shown. Mobility Management Entity (MME) and System Architecture Evolved (SAE) play the role of Evolved Packet Core Network Gateways. Base stations communicate with each other through interface X2 and each base establishes connection to the gateway by interface S1. The enhanced base stations, and the User Equipment such as smartphones and tablets, form an Evolved Universal Terrestrial Radio Access Network (E-UTRAN). The design of the LTE architecture is for operation in full duplex using paired spectrum.

The downlink channel of LTE operates as a continuous stream and there is no relation between the air interface—transmitted frames on the air and the actual service data unit (SDU) packets that are coming from the top of the protocol stack. A resource block stands as foundation in the concept of LTE. Each resource block consists of 12 sub-carriers in one time slot and a transport block is a group of resource blocks with common modulation [2]. The physical interface is a transport block which is formed from the data carried in a period of time dedicated to a given user equipment. Each radio subframe lasts 1 millisecond (ms), and each frame lasts 10 milliseconds. One transport block is able to service multiple UEs on the downlink at any particular time. The MAC controls what to send in a given time.

The other evolved technology for wireless networks – WiMAX, operates in half duplex transmitting in one direction at a time. WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to ~50 Mb/s in a 20 MHz channel. Moreover, WiMAX maintains end-to-end QoS on a per-connection (flow) basis [9]. Its sub-channelization and MAP-based signalling capability provide flexibility of optimally scheduling space, frequency and time-based packet access slots in each Orthogonal Frequency Division Multiplexing (OFDM) frame, which enables easy bandwidth allocation and QoS for each service flow.

2.2 WiMAX

The WiMAX standard (IEEE 802.16) shows features like employing advanced physical layer transmission techniques and coding and modulation techniques. WiMAX can support a peak downlink data rate up to ~70 Mb/s and a peak uplink data rate up to ~50 Mb/s in a 20 MHz channel. Moreover, WiMAX maintains end-to-end QoS on a per-connection (flow) basis [9]. Its sub-channelization and MAP-based signalling capability provide flexibility of optimally scheduling space, frequency and time-based packet access slots in each Orthogonal Frequency Division Multiplexing (OFDM) frame, which enables easy bandwidth allocation and QoS for each service flow.

WiMAX also employs optimized handover schemes to ensure latencies less than 50 ms, thereby enabling delay-sensitive services such as VoIP [7]. Five types of services with different QoS levels are supported by WiMAX, including Unsolicited Grant Service (UGS), Real-Time Packet Service (rtPS), Extended Real-Time Packet Service (ertPS), and Best-Effort Service (BE). WiMAX allocates bandwidth to each SS based on a poll/request/grant mechanism responding to the requirements of these service types.

2.3 Fiber-optic core network

The most efficient wired network in data throughput point of view is the Fiber-optic Network. The evolved laser technology and optical fiber cables provide the highest bandwidth available for wired data networks. A passive optical network (PON) is a point-to-multipoint, Fiber-to-the-premises (FTTP) network architecture. PON is built with network devices that do not use electricity. Power-independent optical splitters are used to enable a single optical fiber to serve multiple premises [10]. Optical line terminal (OLT) at the service provider’s central office interconnected by a passive fibre network with number of optical network units (ONUs)
near end users builds the topology of PON. The most common physical topology of an EPON is a tree. One benefit of PON is the reduced amount of fiber and central office equipment required in comparison with point-to-point architectures. A passive optical network is a form of fiber-optic access network ATM Passive Optical Network (APON) has the destiny to be the first technology for fast WAN access. In 2013 the domination of Ethernet technology is with no doubt which brings that Ethernet Passive Optical Network (EPON) is one type of ON technique. In EPON, single trunk fiber is used which extends from a central office to a passive optical splitter pointing to multiple optical drop fibers [11]. Any component in the network is energy independent (doesn’t use electricity) and that’s where the name “passive” comes from. One variant of passive optical network is Gigabit Ethernet Passive Optical Network (GEPON). EPON operates in Time Division Multiplexing (TDM) mode, enabling each ONU to flexibly share the bandwidth of a system. Wavelength division multiplexing (WDM), with one wavelength for downlink and another for uplink on a single non-zero dispersion-shifted fiber (ITU-T G.652) is used in PON.

**3. CONVERGENCE TECHNOLOGIES AND PROTOCOLS.**

Next generation networks provide the roadway to evolution. With technologies like IP Multimedia Subsystem (IMS) with Session Initiation Protocol (SIP), Multi Protocol Label Switching (MPLS), combination of Private Bank Exchange (PBX) boxes, special dedicated Home Subscriber Servers (HSS) and convergence protocols, the goal of seamless operation of all kinds of applications is achieved.

![Fig. 6 Service and network convergence](image)

Figure 6 shows the concept of service and network convergence using SIP deployment and common IP network backbone. Different network technologies are combined with one IP-based platform which ensures cooperative operation in variable networking environment. The service layer manages all applications through different servers in the backbone network. Users can be any of the following networks: xDSL, WiFi, LTE or WiMAX customers. Next generation networks as WiMAX and LTE ensure mobility with high data rates.

To present a Fixed Mobile Convergence different protocols are used. One known protocol is Packet Data Convergence Protocol (PDCP). PDCP has functionalities as header compression, in-sequence delivery and retransmission of Session Data Units (SDUs) as acknowledgment at handover, duplicate detection, and encrypted protection. The Packet Data Convergence Protocol (PDCP) layer is illustrated by the PDCP block in Figure 2. In earlier versions of GSM and 3GPP standards, the PDCP was only used for the packet data bearers, and the circuit switched bearers connected directly from the host to the RLC layer. Because LTE is all-packet, this is now a place for higher-layer functions that sit above the encapsulation in the RLC. PDCP functions in the user plane include decryption, ROHC header decompression, sequence numbering and duplicate removal [2]. PDCP functions in the control plane include decryption, integrity protection, sequence numbering and duplicate removal. There is one PDCP instance per radio bearer. The radio bearer is similar to a logical channel for user control data.

The challenge in PDCP is the header compression for limiting the network load. Header compression is important because VoIP is a critical application for LTE. All voice signals in LTE must be carried over IP due to the lack of circuit switching. Efficiency requirements for real-time applications are crucial and various standards are being specified for use in profiles for robust header compression (ROHC). This provides a tremendous savings in the amount of header that would otherwise have to go over the air. Protocols like PDCP and SIP are designed to work with the packet loss that is typical in wireless networks with higher error rates and longer round trip time. ROHC is defined in IETF RFC 3095, RFC 4815, and RFC 3843 [2] and SIP in RFC 2543 and RFC 3261.

The Session Initiation Protocol (SIP) is an application-layer control protocol that can establish, modify and terminate multimedia sessions or calls [13]. These multimedia sessions include multimedia conferences, distance learning, Internet telephony and similar applications. The SIP protocol is able to invite persons and "robots", such as a media storage service. Media and participants can be added to an existing session. These sessions include Internet multimedia conferences, Internet telephone calls and multimedia distribution. Members in a session can communicate via multicast or via a mesh of unicast relations, or a combination of these [13]. The methods which SIP operates with are: invite; ack, options, bye, cancel and register. Sessions are created using SIP invitations which carry session descriptions allowing participants to agree on a set of compatible media types. SIP supports user mobility by proxying and redirecting requests to
the user’s current location which can be registered. SIP is designed to be independent of the lower-layer transport protocol and can be extended with additional capabilities. SIP uses proxy servers to help the requests routed toward user’s current location. SIP authenticates and authorizes users for services, implements provider call-routing policies, and provides features to users. SIP also provides a registration function that allows users to upload their current locations for use by proxy servers [14]. SIP operates above several different transport protocols. The Session Initiation Protocol works by enabling Internet endpoints (called user agents) to discover one another and to agree on a characterization of a session they would like to share. For locating prospective session participants, and for other functions, SIP enables the creation of an infrastructure of network hosts (proxy servers) to which user agents can send registration, invitations to sessions, and other requests. SIP uses proxy servers to help sessions that works independently of underlying transport protocols and without dependency on the type of session that is being established.

It can be said that the SIP protocol is the main IP Multimedia Subsystem or IP Multimedia Core Network Subsystem (IMS) building block. IMS is an architectural framework for delivering IP multimedia services. It was originally designed by the wireless standards body 3rd Generation Partnership Project (3GPP), as a part of the vision for evolving mobile networks beyond GSM. Its original formulation (3GPP Rel-5) represented an approach to delivering “Internet services” over GPRS. This vision was later updated by 3GPP, 3GPP2 and ETSI TISPAN by requiring support of networks other than GPRS, such as Wireless LAN, CDMA2000 and fixed lines. To ease the integration with the Internet, IMS uses IETF protocols wherever possible, e.g., SIP. According to the 3GPP, [15] IMS is not intended to standardize applications, but rather to aid the access of multimedia and voice applications from wireless and wireline terminals, i.e., to create the fixed-mobile convergence (FMC). This is done by having a horizontal control layer that isolates the access network from the service layer. From a logical architecture perspective, services need not have their own control functions, as the control layer is a common horizontal layer. However in implementation this does not necessarily map into greater reduced cost and complexity. Alternative and overlapping technologies for access and provisioning of services across wired and wireless networks include combinations of Generic Access Network, soft switches and “naked” SIP. Since it is becoming increasingly easier to access content and contacts using mechanisms outside the control of traditional wireless/fixed operators, the interest of IMS is being challenged. IMS refers to a functional architecture for multimedia service delivery, based upon Internet protocols. Its aim is to merge Internet and cellular worlds, in order to enable rich multimedia communications [16]. The IP Multimedia Core Network subsystem comprises all Core elements for provision of multimedia services. This includes the collection of signaling- and bearer-related network elements. IP multimedia services are based on an IETF defined session control capability which, along with multimedia bearers, utilizes the IP-Connectivity Access Network [17].

In order to achieve access independence and to maintain a smooth interoperation with wire line terminals across the Internet, the IP multimedia subsystem attempts to be conformant to IETF “Internet standards”. Being conformant, IMS enables a carrier to understand a SIP call routing information and switch the call to a user through the carrier’s infrastructure instead of his own. The IP multimedia core network (IM CN) subsystem enables operators to offer their subscribers multimedia services based on and built upon Internet applications, services and protocols. The intention is that such services will be developed by PLMN operators and other third party suppliers including those in the Internet space using the mechanisms provided by the Internet and the IM CN subsystem. The IM CN subsystem should enable the convergence of, and access to, voice, video, messaging, data and web-based technologies for the wireless user, and combine the growth of the Internet with the growth in telecommunications [17]. The complete solution for the support of IP multimedia applications consists of terminals, IP-Connectivity Access Networks (IP-CAN), and the specific functional elements of the IM CN subsystem described in this technical specification. An example of IP-Connectivity Access Network is the GPRS core network with GERAN and/or UTRAN radio access networks.

![Fig 7. Converged network concept](image)

Figure 7 shows concept of different networks, converging through devices like Signaling Gateway (SGW), Media Gateway (MGW), Soft Switches and IP Private Bank Exchange (PBX) units. All of those implement specific technologies in response of today’s needs. The backbone presented is an IP network and the end users enjoy mobility with seamless handover of applications. This means that everybody can have his own application working independently of the network that he is using. For best performance, the core network is recommended to be optical fiber and access networks being Next Generation wireless networks offer best solutions in mobility and traffic bandwidth.

4. BENEFITS OF FIXED MOBILE CONVERGENCE.

The key to Fixed Mobile Convergence realization is to have common networking platform capable of maintaining plenty of protocols and therefore variety of services. The above described next generation networks and technologies provide best solutions in application services. The benefits are coming from the successful convergence between different protocols in the horizontal and vertical hierarchy. Protocols like DPCP and SIP operating in different reference model layers are the key to successful service operations. For example mobile calls through one company’s PBX use Wi-Fi where available instead of Cellular improving cost efficiency. With the Wi-Fi to Cellular handoff and FMC appliance some benefits can be cheaper international calls, reducing mobile airtime costs and the usage of smart phones instead of desk phones. A full IP PBX integration offers wide variety of applications for the enterprise enabling Fixed Mobile unification. The Fixed Mobile Unification enables the phone to be converted into SIP endpoint at the level of the mobile network. The FMU SIP endpoint is then connected to the company PBX VoIP server, and also FMU enabled cell phone acts as a standard SIP phone. This gives the opportunity never to miss an important business call. By deploying FMC customers get full PBX integration and agile service creation with services like push to talk (PTT), instant messaging (IM), video telephony, presence, and other combinational services. IPTV & IMS appear to be seamless internetworking. FMC integration offers free calls between users, call transfers and forwarding, one voice mail, call recording and only one number for fixed and wireless telephone access. A customer never understands the transition from one kind of network to another while in motion during workdays.
5. CONCLUSION.

There are many applications of the Internet that require the creation and management of a session, where a session is considered an exchange of data between an association of participants. The implementation of these applications is complicated by the practices of participants: users may move between endpoints, they may be addressable by multiple names, and they may communicate in several different media - sometimes simultaneously. Numerous protocols have been authored that carry various forms of real-time multimedia session data such as voice, video, or text messages [14].

There are many companies in the market offering FMC already. Multi service access platforms converge voice, video and data traffic onto a single network infrastructure with download speeds now faster up to 150 Mbps. It is a matter of company’s financial strategy to accept the new technology of FMC to present to its employees and customers better attendance. One network for all services: Internet access, TV broadcasting and voice, all this through one converged network, gives convenience for customers, one bill only and reduced traffic costs. It appears that FMC will continue to develop in all telecommunications companies facilitating more and more customers all over the “one big village” world.

6. REFERENCE.

1. Anritsu, Understanding LTE-Advanced Carrier Aggregation, issue 1, 02/2013, www.anritsu.com
2. Long term evolution protocol overview, white paper, doc. No.: LTEPTCLOVWWP, Freescale™ semiconductor
3. Y. Luo, et al., “Integrating optical and wireless services in the access network,” NTHG1, OFC’06
17. 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; IP Multimedia Subsystem (IMS); Stage 2 (Release 12) - 3GPP TS 23.228 V12.0.0 (2013-03)
18. 3G Americas.org
20. 10G EPON IEEE working group (WG); http://www.ieee802.org/3/av/index.html. [Online on September 18, 2007]