WiMAX integration in NGN network, architecture, protocols and services

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Abstract: - With growing demands for fast provision of new and complex services, imposed by life and business dynamic in general, service providers are forced to adopt open technologies and advanced business models in their solutions. These enable a fast response to market demands and maximum utilization of the network. A big challenge for operators today is how to deliver broadband services in rural areas. Today, the broadband services in urban areas are served by DSL and cable modems. However, it is too difficult and very expensive for operators to deploy wired network in rural areas. BWA technology can overcome this problem. Today, the most popular BWA technology is WiMAX (commonly referred as IEEE 802.16), which supports fixed, nomadic, portable, and mobile operations. WiMAX is based on IP network. As a result, many operators around the world are interested to integrate WiMAX in existing networks to facilitate the move to an all IP.

Key-Words: - Integration, WiMAX technology, NGN network, protocols, security

1 Introduction

Data transmission and broadband access using wireless technology, enables the usage of all Internet services in the regions without developed infrastructure and at the same time enables the extra competition in places where broadband services over wired networks are present.

WiMAX technology is the most promising technology for offering broadband services. Integrating this technology in NGN network is an ideal solution for offering broadband services. This paper tends to illustrate integration of WiMAX technology in NGN network, including protocols, security and QoS in this integrated technology. The Next Generation Network (NGN) is a packet-based network, able to provide telecommunication services and able to make use of multiple broadband, QoS enabled transport technologies.

To integrate WiMAX into NGN core network the new hardware and software solution are needed in order to provide QoS control for subscriber services, especially VoIP telephony. Integration of WiMAX in NGN will provide the coverage in the areas that are difficult to cover with wireline. This approach is forced by real business needs as well as license obligation for network coverage and QoS. The main advantages using WiMAX in NGN network are higher bandwidth and secure transmission.

In this paper we will describe shortly NGN network, protocols and services offered. Also we will describe the WiMAX technology, main standards, routing metrics and integration of WiMAX technology into NGN network.

2 NGN network

NGN is a safe technology for the future. Nowadays market demands always change. Customers require different services with high quality. In order to fulfill those requirements is developed NGN network with an advanced platform. Next Generation Networks as a platform is able to offer ubiquitous connectivity and intelligent interfaces for human and machine communication as well as pervasive services access, bringing value to human life for its improvement and new experiences [1]. It is proved that NGN network offers more services compared to PSTN network. NGN network needs lower investments to achieve the same functions. By creating dedicated virtual communication environment, NGN is able to disappear distance

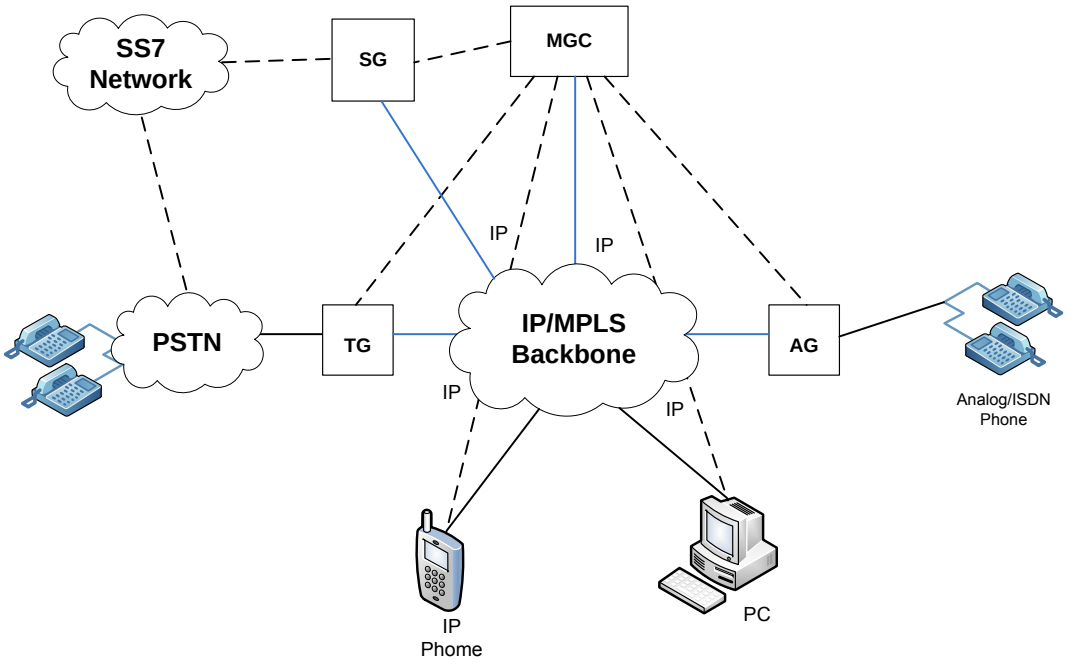

Figure 1: NGN network architecture

barrier between two users, handover problems etc. NGN is packet based network, so it is oriented in VoIP services. The main features of NGN network are: packet based transmission; broadband capabilities with end-to end QoS, fixed-mobile convergence as well as wide range of services.

Two international organizations as the IETF and ITU propose two different NGN network models, each one having its own set of features and protocols. According to IETF, NGN network topology model is based in Softswitch model which consists of:

- **Media Gateways (MG)**: the role of media gateway is conversion of voice message from circuit format into packet format.
- **Media Gateway Controllers (MGC)**: the main role of MGC is to manage different connections in a certain packet network. Also, has the feature for call control.
- **Signaling Gateway (SG)**: it is the interface between packet network and signaling network nº 7 (SS7) of the switched circuit network.

Whereas, the ITU defines the NGN network topology based on H323 standards. This ITU model includes:

- **Gateway (GW)**: it is the interface between the IP network and switched circuit network.
- **Terminal**: may be any end-point of the network able to establish duplex communications in real time with any other H.323 terminal or any Gateway.
- **Gatekeeper (GK)**: the Gatekeeper manages an H323 zone, thus providing address translation of terminals within one H323 zone.

NGN network is designed to become more than ISP (internet service provider). NGN network brings change in service network architecture and service network management [1].

One of the main equipment that offers voice application in NGN network is Softswitch. The Softswitch main role is to provide call control functions for VoIP calls. Softswitch enables integration of different protocols within NGN network. Call details for billing are generated in Softswitch also. Another important function is interface creation with existing telephony networks PSTN (Public Switched Telephone Network) through Signaling gateway and Media gateway. Figure 2 illustrates the distributed architecture of Softswitch. This model separates packet switched hardware from call control, service logic and creation of new services. This distribution enables high hardware flexibility. The lower layer is considered to be the transport layer, which physically transports voice and data.

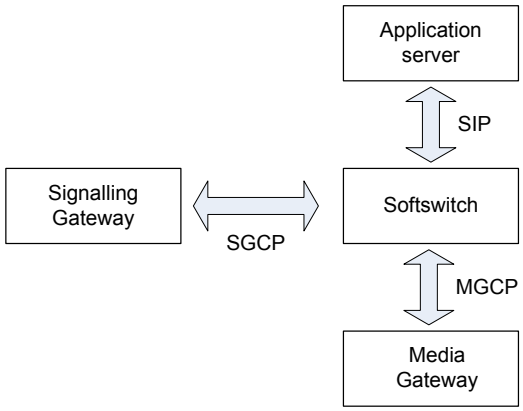

Fig.2. Components of Softswitch architecture

The main advantages of Sofswitch against traditional switches are: new services, flexibility in operation and maintenance, easy integration of different components and networks, low cost etc. This technology enables connection between internet, wireless networks, cabling networks and traditional telephony network, which results in one convergent network.

3 Protocols used in NGN network

NGN is considered as converged network aggregating different functionalities of existing network with common IP/MPLS backbone [2]. NGN network offers interoperability using multiple protocols. The main feature of NGN architecture is separation of service, transport and control layers, which are interconnected by open interfaces and use standards protocols as below: [3]

- **MEGACO** is protocol which is sponsored from IETF and ITU. It is used inside one MGC (media gateway controller) for controlling media gateways (MG-s). This protocol allows the MGC to tell to the MG-s when to send and receive information towards/from different addresses. This protocol also is useful for sending all information to the MGC from MG-s regarding with detected events such is: on – hook, off hook etc. The equivalent protocol of MEGACO according to ITU is H248.
- **SIP**-Session Initiation protocol: is protocol that resides into application layer and is signaling protocol. SIP plays a very important role for session creation for audio/videoconferences, interactive games and for call orientation towards IP network. SIP is IETF standard which supports traditional telephony services within IP domain such are: routing, identification, call establishment and other services.
- **H323 protocol**: this protocol is for multimedia conferences, including here: voice, video and data in packet switched networks. H323 standard can be applied in networks that which offers different services: IP telephony, networks for offering voice and data, video and data etc. The main components of H323 protocol are: terminals, Multipoint Control Units (MCUs), Gateways, Gatekeeper, Border Elements / Peer Elements.
- **Real time protocol**: this protocol offers end-to-end voice transmission in real time. Whereas H323 is used for data transmission in IP based networks, the RTP protocol is used for data transmission in User Datagram Protocol (UDP). RTP together with UDP offers functionality to the transport protocol. The RTP protocol identifies the type of load, enumerates sequences, measures time etc.
- **Real Time Control protocol (RTCP)**: is a copy of RTP which offers control services. The main function of RTCP is identification of transport level for one RTP source

Services offered in NGN network

There are a lot of services offered from NGN network. The services in NGN network are divided in: supplementary services and intelligent services:

Some of supplementary services are:

- Call forwarding services, Fixed Announcement Presentation services, Call screening, Outgoing call barring, 3 party conference, Explicit call transfer, Call hold, Call waiting, PBX Line hunting etc

Some of intelligent services are:

- Prepaid Card service
- Freephone, Premium Rate.
- Televoting

Service providers in all over the world are looking to deliver new broadband services. IPTV is one of the broadband services that all operators tend to offer to customers.

For offering IPTV services the network should be prepared for supporting some specific protocols for signal stream processing. The main reason for using these protocols is that the bandwidth demands are increasing from day to day. Integrating WiMAX in NGN network is very good solution for offering IPTV services. Bandwidth limiting is critical in copper lines. So, it is needed to use some intelligent compressed techniques that are specified by some international standards for telecommunication. The

main techniques for video compression are MPEG [4] (moving pictures expert groups) techniques. Usually, for video compression is used MPEG-2 TS (for transport stream) and MPEG-4 (for aggregated streams). Also it is needed to use audio compression protocols such as MPEG-1 audio, DOULBY digital etc. The equipment in access network must support IGMP [5] snooping.

Operators must deliver broadband services (IPTV, VoIP, HIS-High speed Internet) to any user at any time in the most efficient and cost effective way. To achieve this, operators must use a variety of access technologies including [6]:

- WiMAX technology
- FTTx technology
- DSL technology
- Carrier ethernet

TV channels require the most bandwidth of all in a network. Thus, bandwidth requirements for offering one TV channel with MPEG-2 compression method are:

MPEG-2 SD 4 Mbps
MPEG-2 HD 18-24 Mbps

Whereas, bandwidth requirements for offering one TV channel with MPEG-4 compression methods are:

MPEG-4 SD 2 Mbps
MPEG-4 HD 8 Mbps

Those requirements for broadband dictate the needs for using broadband access technology. The best case is using FTTH (or FTTU-Fiber to the User). In rural areas this wireline technology is very expensive, so in these areas it is more appropriate to use wireless access broadband technology such as WiMAX.

4 QoS routing in NGN network

The main goal of QoS based routing is to select the most suitable path according to traffic requirements for multimedia applications. Selection of suitable transmission paths is done through routing mechanisms based on existing network resources and QoS requirements. Multimedia applications might suffer degradation in quality in traditional networks such as Internet [7]. This problem can be solved in networks that contain dynamic path creation features with bandwidth-guaranteed and constrained delays [8]. Real–time applications impose strict QoS requirements. These application requirements are expressed by parameters such as acceptable and end-to-end delays, necessary bandwidth and acceptable losses. For example, audio and video transmissions have strict requirements for delay and losses. Wide bandwidth must be guaranteed for high capacity transmission. Real time traffic, video in particular, quite often utilizes most important quantities of network resources**.** Efficient management of network resources will reduce network service cost and will allow more applications to be transmitted simultaneously. The task of finding suitable paths through networks is treated by routing protocols. Since common routing protocols are reaching their acceptable complexity limits, it is important that complexity proposed by QoS based routing [9] should not damage scalability of routing protocols. NGN network is a right solution for a lot of current problems faced by internet nowadays [10]. NGN network is based in IP/MPLS. By a wide support for QoS and traffic engineering, MPLS is establishing itself as a standard of the next generation's network.

NGN is a network that is designed for offering multimedia communications [11], which implies that it has broadband capacities, multichannel transport with high data rates, low latencies, low packet loss and QoS guarantees [12]. NGN represents new technology and services that all operators want to have at their disposal. Every operator worldwide tends to implement NGN, thus enabling converged IP/MPLS network services, focusing on opportunities for service differentiation and service-oriented technology. The convergent services are based on packet switching rather than circuit switching technology.

5 WiMAX Standards

IEEE 802.16 is a solution to broadband wireless access, commonly known as WiMAX. Today there are two main WiMAX standards 13 :

- **IEEE 802.16–2004** – for Fixed Broadband Wireless Access (sometimes referred as IEEE 802.16d) , and
- **IEEE 802.16e–2005**–for Mobile Broadband Wireless Access.

These two standards are evolved from the earlier versions of WiMAX standards. First standard IEEE 802.16 specified fixed broadband wireless systems operating in the frequency band 10 – 66GHz, and is only used for LOS transmissions. Another standard is IEEE 802.16a (published in April 2003, an improved version of 802.16) introduces NLOS transmission, adopts OFDM at the PHY layer, and can support lower frequency band 2-11GHz. This standard also introduces mesh topology in addition to Point-to-Point and Point-to-Multipoint, and adaptive modulation which enable BS to

dynamically assign modulation schemes to the subscribers [14].

IEEE 802.16-2004 (published in October 2004) is designed for fixed BWA systems, includes frequency bands 10-66 GHz and 2-11 GHz, and can support multiple broadband services. So far, the most likely spectrum is available at 2.3 GHz, 2.4 GHz, 2.5 GHz, 3.5 GHz, and 5.8 GHz. The goal of this standard is to enable global deployment, and to support interoperability of multivendor BWA products.

IEEE 802.16e (published in February 2006) standard add portability and mobility to wireless devices, and also enhance network performance by using OFDMA technique. Compared with IEEE 802.16-2004, this standard can support lower data rate (up to 15Mbps). In addition to mobile and nomadic service, IEEE 802.16e can also be used to provide fixed service. According to the WiMAX Forum, frequency bands for the IEEE 802.16e profiles are 2.3-2.4 GHz, 2.496-2.690 GHz, and 3.4-3.6 GHz. The WiMAX Forum has begun certification for mobile products in the beginning of 2008. Some of the features of WiMAX are:

- **Physical layer**: The physical layer (PHY) is based on OFDM technique that allow WiMAX to operate in NLOS conditions,
- **The very high peak data rate**: WiMAX support very high peak data rates (up to 75Mbps for fixed profile). Users can expect data rates up to 5Mbps. Data rate it depends on a number of different factors, including which frequency is being used, distance of the user from BS, type of transmission (LOS or NLOS), the number of users in the network, etc.
- **Adaptive modulation and coding (AMC):** 802.16-2004 support different modulation schemes in the downlink and uplink communication, i.e., BPSK, QPSK, 16QAM, 64QAM, and 256QAM, and forward error correction coding (FEC) schemes.
- **TDD and FDD duplexing techniques**: IEEE 802.16d and IEEE 802.16e supports both Time division duplexing and frequency division duplexing techniques. WiMAX also supports half frequency division duplexing (HFDD) techniques. According to the WiMAX forum certification profiles, mobile WiMAX supports only TDD, and Fixed WiMAX support both FDD and TDD.
- **Quality of Service (QoS):** due to MAC layer has a connection oriented architecture and can support different applications
- **Security:** the key aspects supporting wimax security are: key management protocol PKMv2 (manages MAC security using PKM-REQ/RSP messages), device user authentication using EAP protocol, traffic encryption, and control message protection.
- **IP network architecture:** WiMAX is based in all IP Network architecture.

The two standards mentioned above (IEEE 802.16e-2004 and IEEE 802.16-2005) are limited to the control and data plane aspects of the air-interface. Some aspects of network management are defined in IEEE 802.16g. For a complete end-to-end system, particularly in the context of mobility, several additional end-to-end service management aspects need to be specified. This task is being performed by the WiMAX Forums Network Working Group (NWG).

WiMAX certification is constantly evolving. Change is necessary to ensure that WiMAX retains its flexibility and technological edge. New system profiles can be created to support additional capabilities defined in IEEE 802.16 standard. In the table 1 are shown WiMAX system profiles and currently approved system profiles according to the WiMAX Forum [15].

Table 1. WiMAX standards

SYSTEM PROFILES	CERTIFICATION PROFILES		
	Spectrum	**Duplexing**	**Channel Width**
Fixed WiMAX (IEEE 802.16-2004, OFDM)	3.4 - 3.6 GHz	TDD	3.5 MHz
	3.4 - 3.6 GHz	TDD	7 MHz
	3.4 - 3.6 GHz	FDD	3.5 MHz
	3.4 - 3.6 GHz	FDD	7 MHz
	5.725 - 5.850 GHz	TDD	10 MHz
Evolutionary (IEEE 802.16e-2005, OFDMA)	4.935 - 4.990 GHz	TDD	5MHz
Mobile WiMAX (IEEE 802.16e-2005, OFDMA)	2.3 - 2.4 GHz	TDD	5, 10 MHz (dual)
	2.3 - 2.4 GHz	TDD	8.75 MHz
	2.496 - 2.690GHz	TDD	5, 10 MHz (dual)
	3.4 - 3.6 GHz	TDD	5 MHz
	3.4 - 3.6 GHz	TDD	7 MHz

Currently there are two main spectrum bands covered by Fixed WiMAX. The 3.5GHz licensed band has certification profiles for both TDD and FDD. The 5.8GHz band is the second spectrum band which is typically license exempt, and is based only in TDD. Also Mobile WiMAX can be deployed in several bands, but only in two bands currently certified equipment are available.
There are two main mobile system profiles: Release 1.0 and Release 2.0. the release 1.0 Mobile system profile has two waves associated with it, the initial wave 1 providing the majority of basic functionality, which is then enhanced with MIMO (Multi input multi output) in wave 2. Releases beyond 1.0 are not been defined yet for any system profiles.

6 MAC Layer and Physical Layer

MAC (medium Access Control) is at the centre of WiMAX operation. The WiMAX MAC Layer supports both PMP and mesh operation, and consist of three sublayers (see Figure 3):

- **Service specific convergence sublayer (CS)**- Some of the main features of service specific CS are: packet classification, payload header suppression, and support of upper layer protocol.
- **MAC common part sublayer (CPS**)– allocation of bandwidth, connection establishment and maintenance.
- **Security sublayer**–provides functionalities like authentication, secure key exchange, and encryption.

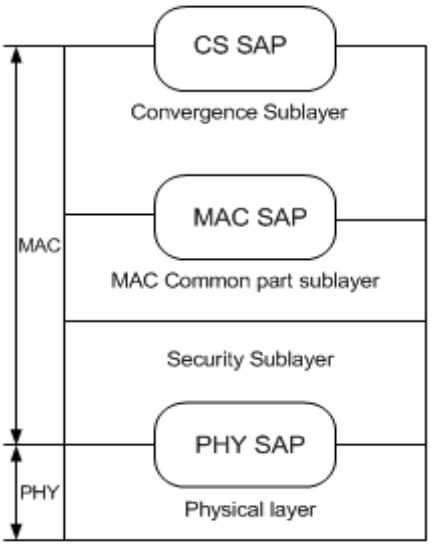

Figure 3 – IEEE 802.16 reference model

The physical layer (PHY) can be implemented in one of four main ways:

- **Wireless MAN-SC**: is designed to operate in the frequency band 10 GHz- 66 GHz using either FDD or TDD mechanism. This configuration use a single carrier within the SHF and EHF bands, and need LOS between transmit and recieve points.
- **Wireless MAN-Sca**: this configuration also uses a single carrier but at significantly lower frequencies – less then 11GHz. Therfore, this enable to operate in NLOS enviroments dealing with the effects of multipath propagation.
- **Wireles MAN-OFDM**: is based on multi carrier aproachin which 256 subcarriers can be used. This configurations has many advantages comparing with single carrier variants. Wireles MAN-OFDM also operates within frequency bands lower than 11GHz, and supports PTP, PTM, and mesh architectures.
- **Wireles MAN-OFDMA**: it utilizes multiple carriers, but unlike WirelesMAN-OFDM method, can support up to 2048 sub-carriers. In addition, a number of more sophisticated management techniques are supported including HARQ (Hybrid Automatic Repeat Request).

7 WiMAX Architecture

The IEEE 802.16e-2005 standard provides the air interface for WiMAX but does not define the full end-to-end WiMAX network. The WiMAX Forum's Network Working Group (NWG), is responsible for developing the end-to-end network requirements, architecture, and protocols for WiMAX, using IEEE 802.16e-2005 as the air interface.

In the figure 4 is shown WiMAX network architecture, developed by NWG to serve as reference model for WiMAX deployments and to ensure interoperability between various equipments and operators. The network reference model describes network architecture for supporting fixed, nomadic, and mobile deployments and is based on an IP service model.
This network may be logically divided into three parts:

1. Mobile Stations (MS) used by the end user to access the network.

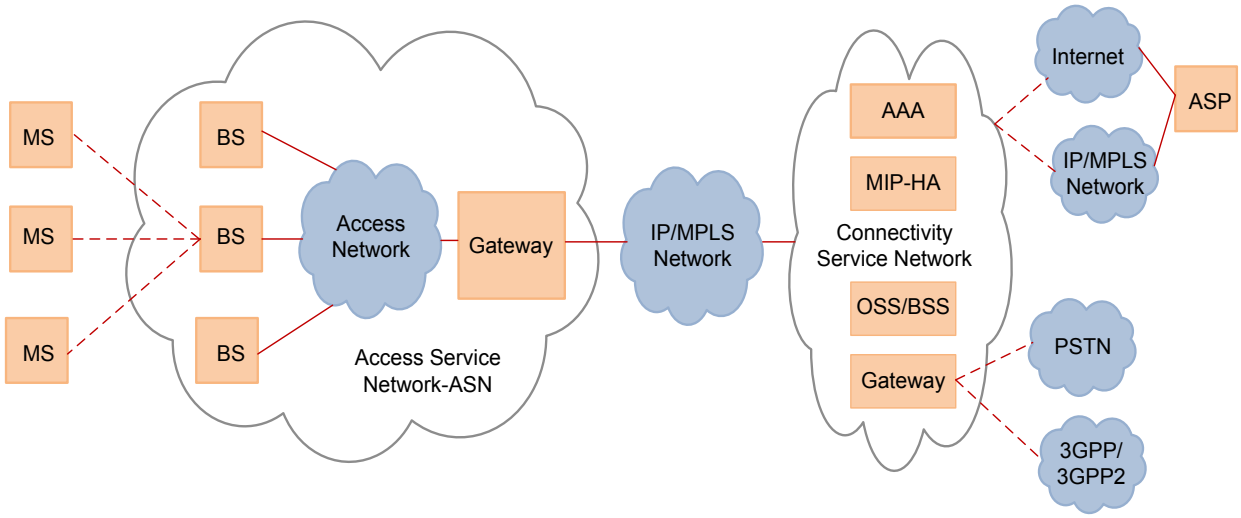

Figure 4: IP-Based WiMAX network architecture

2. The access service network (ASN), which comprises one or more base stations and one or more ASN gateways that form the radio access network at the edge.
3. Connectivity service network (CSN), which provides IP connectivity and all the IP core network functions.

The network reference model developed by the WiMAX Forum NWG defines a number of functional entities and interfaces between those entities. Figure 4 below shows some of the more important functional entities.

Base station (BS): The BS is responsible for providing the air interface to the MS. Additional functions that may be part of the BS are micro mobility management functions, such as handover triggering and tunnel establishment, radio resource management, QoS policy enforcement, traffic classification, DHCP (Dynamic Host Control Protocol) proxy, key management, session management, and multicast group management.

Access service network gateway (ASN-GW): The ASN gateway typically acts as a layer 2 traffic aggregation points within an ASN. Additional functions that may be part of the ASN gateway include intra-ASN location management and paging, radio resource management and admission control, caching of subscriber profiles and encryption keys, AAA client functionality, establishment and management of mobility tunnel with base stations, QoS and policy enforcement, foreign agent functionality for mobile IP, and routing to the selected CSN.

Connectivity service network (CSN): The CSN provides connectivity to the Internet, ASP, other public networks, and corporate networks. The CSN is owned by the NSP and includes AAA servers that support authentication for the devices, users, and specific services. The CSN also provides per user policy management of QoS and security. The CSN is also responsible for IP address management, support for roaming between different NSPs, location management between ASNs, and mobility and roaming between ASNs.

The WiMAX architecture framework allows for the flexible decomposition and/or combination of functional entities when building the physical entities. For example, the ASN may be decomposed into base station transceivers (BST), base station controllers (BSC), and an ASNGW analogous to the GSM model of BTS, BSC, and Serving GPRS Support Node (SGSN).

8 Routing metrics in WiMAX technology

Routing metrics have a significant role, not just in complexity of route calculation but also in WiMAX QoS. The use of multiple metrics is able to model the network in a more precise way, but the problem for finding appropriate path can become very complex [12] [13]. There are 3 types of metrics: additive, multiplicative and concave. They are defined as below: If m(n_1, n_2) are metrics for link (n_1, n_2). For one path P= (n_1, n_2, ..., n_i, n_j), metric m is (n_1, n_2, ,...,n_i, n_j):

Let $d(i, j)$ be a metric for link (i, j).

- For any path $p = (i, j, k, ...l, m)$, we say that d is additive if:

$$d(p) = d(i, j) + d(j, k) + ... + d(l, m) \quad (1)$$

- We say that metric *d* is multiplicative if:

$$d(p) = d(i, j)xd(j, k)x...xd(l, m) \quad (2)$$

- We say that metric *d* is concave if:

$$d(p) = \min[d(i, j), d(j, k)..d(l, m)] \quad (3)$$

Integrating WiMAX in NGN is able to offer real time services. Thus, it is important to take into consideration some metrics that play a key role in offering those services.

9 Quality of Service (QoS) in WiMAX

WiMAX support different applications, such as voice, data, video, and multimedia services. Each of these applications has different QoS requirements. Packet switched technologies are designed only to support non real time traffic such as data, and when they are used to support real time applications (voice and multimedia) delay and jitter may become excessive if the flows of traffic are not controlled. In WiMAX QoS controlled by using connection oriented MAC architecture [16].

In order to support different applications WiMAX defines five scheduling services [17]:

- **Unsolicited grant services (UGS):** is designed to support constant bit rate services, such as T1/E1 and VoIP.
- **Real-time polling services (rtPS):** Ii is used to support real-time variable bit rate services, such as MPEG video and VoIP.
- **Non-real-time polling services (nrtPS):** It is used to support nonreal-time variable bite rate services, such as FTP.
- **best-effort service:** This enable to forward packets on a first-in-first basis using the capacity, which is not used by other services.
- **Extended real-time variable rate (ERT-VR) service**: is defined only in IEEE 802.16e, and is designed to support real time applications, that have variable data rates but require guaranteed data rate and delay.

10 Security in WiMAX

Network security plays a critical part in the operation of WiMAX network as it does in most other communication systems. The key aspects supporting WiMAX security are [18]

- **Key management protocol:** privacy key management protocol version 2 (PKMv2) is the basis of WiMAX security. This protocol manages MAC security using PKM-REQ/RSP messages. PKM EAP (Extensible Authentication protocol), TEC (Traffic Encryption Control), HKE (Handover Key Exchange) and Multicast/Broadcast security messages are based on this protocol.
- **Device/user authentication**: WiMAX supports device and user authentication using internet engineering task force (IETF) EAP protocol, by providing support for credentials that are SIM-based, USIM-based, or digital certificates or user name/password based.
- **Traffic encryption**: AES-CCM (Advanced Encryption Standard – Counter with Chiper block chaining Message authentication code) is the cipher used for protecting all the user data over the WiMAX MAC interface.
- **Control message protection:** control data is protected using AES based CMAC (Chiper Message Authentication Code), or MD5 (Message Digest 5) based HMAC (Hashed Message Authentication Code) schemes.
- **Fast handover support:** a three way handshake scheme is supported to optimize the re-authentication mechanisms for supporting fast handovers.

11 WiMAX integration in NGN network

WiMAX is based on IP network. As a result, today many operators around the world are interested to integrate WiMAX in existing networks to facilitate the move to an all IP. In figure 5 is shown PMP WiMAX scenario supporting different applications such are broadband for residential, small office/home office (SOHO), and small- to medium-enterprise (SME) markets; E1 or fractional E1-like services to businesses, and; wireless backhaul for Wi-Fi hotspots [14].

For an incumbent fixed operator trying to extend their existing network with BWA; most, if not all, of the edge, core and central office equipment would already be in place. The exception would be the possible need to add capacity to support the additional anticipated customers that would be covered by the WiMAX portion of the access network.

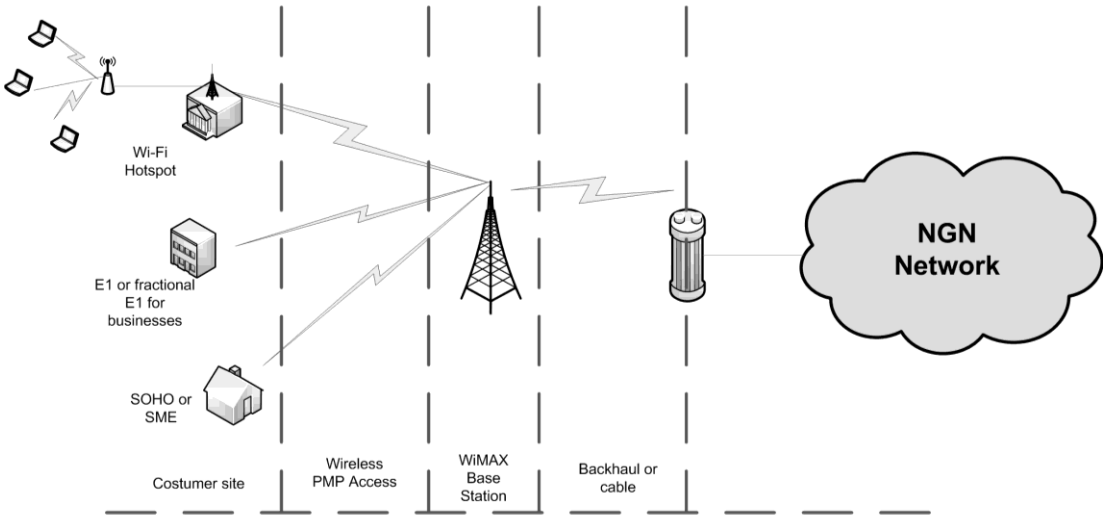

Figure 5 – WiMAX integration in NGN network

The wireless portion of the network begins at a fibre node with a WiMAX base station or a wireless point-to-point link to a remotely located WiMAX base station. This wireless backhaul connection must have sufficient capacity to match the WiMAX base station capacity. The backhaul link can be a WiMAX-compliant, point-to-point solution or another commercial off-the-shelf point-to-point radio in any frequency band licensed for fixed microwave applications.

To integrate WiMAX into NGN core network we need new hardware and software solution in order to provide QoS control for subscriber services, especially VoIP telephony. Point of Integration to NGN's Edge/Core Network will be Ethernet Service Switch. Service switches should provide 10/100/1000Base-T Ethernet ports, Layer 2 VPN, VLL, VPLS and service-aware Ethernet aggregation as well as IP and MPLS tunnelling. They should also handle routing with IS-IS, OSPF, RIP, GRE and IGMP. For MPLS, static and dynamic LSPs are used and LDP and RSVP-TE as signalling protocols.

These switches should also provides DoS (Denial of Service) attack prevention, access control lists, MD5 (message digest algorithm 5) password encryption and authentication for routing protocols, classification and prioritization of control traffic and prevention of unauthorized communication between subscribers. Each WiMAX base station should have a dedicated backhaul transmission with capacity up to 155 Mbps.

12 Conclusion

Actually, fixed incumbent operators are competing with so called alternative operators in all aspects. While, their starting advantage is existing customer base, the big disadvantage is legacy network, which can't meet growing demands for bandwidth and other new services.

For voice and data integration operators should implement NGN network based on IP/MPLS. This is the first step of voice and data integration into one common network. Next step on finalizing of its technological strategy is implementation of BWA. It will provide the coverage in the areas that are difficult to cover with wireline. This approach is forced by real business needs as well as license obligation for network coverage and QoS.

In this paper we have explained NGN network and integration of WiMAX technology in NGN network for offering convergent services. This is a good solution for operators in their way on completing of their technological and business strategies and is an interesting example of how fixed operators can successfully compete in a dynamic market.

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