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WiMAX Core Network

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1. Introduction

1.1 WiMAX core network system architecture

In the last few years, worldwide interoperability for microwave access (WiMAX) has been proposed as a promising wireless communication technology due to the fact that it can provide high data rate communications in metropolitan area networks (MANs). Until now, a number of specifications for WiMAX were standardized by the IEEE 802.16 working group. In this chapter, the architecture of WiMAX core network, all-IP mobile network, and optical integrative switching are introduced. It also tells the accounting of WiMAX in detail.

1.2 Mobile network core network architecture

WiMAX network structure mainly includes WiMAX Access Service Network and WiMAX Connectivity Service Network. CSN is the core network of WiMAX. It provides the IP-connection service for the users. Its connection modules are shown in the figure below:

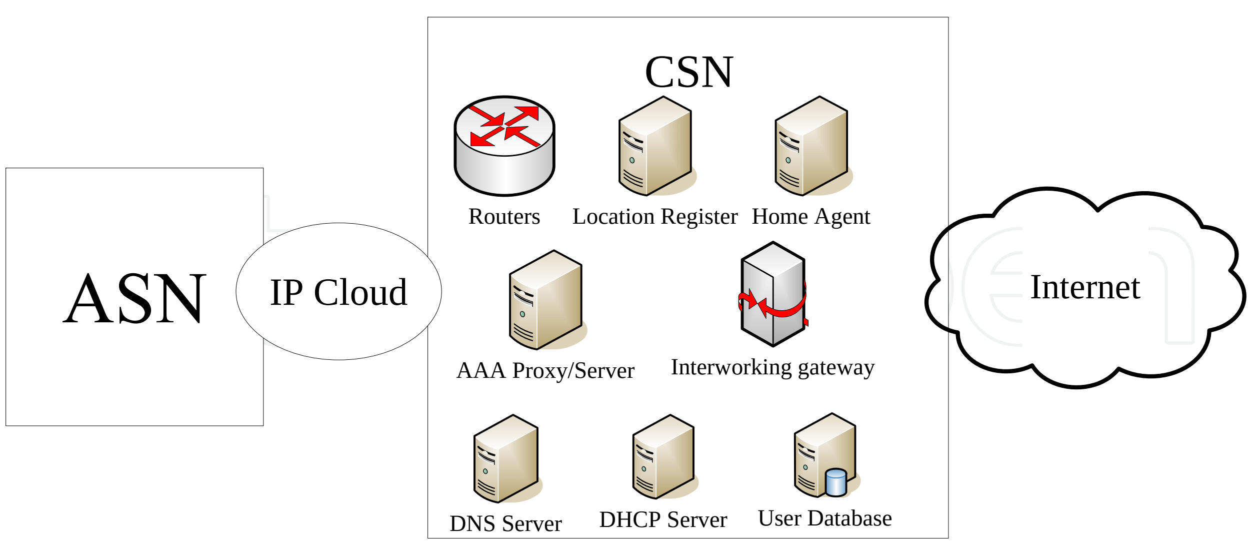


Fig. 1. CSN connection modules

As you can see in CSN, it includes the router, location register, home agent and AAA-server. Router connects CSN with the other modules. Location register record the user's login and location information. In order to support the mobility, CSN provides mobile IP function.

Home agent is responsible for maintaining MS position information and sending the packets to the network of MS.AAA proxy/server provide authentication, authorization and accounting services. As to connect Internet or any other IP network, CSN may also include user database and interworking gateway devices, DHCP server and DNS server.

CSN is defined as the combination of network function. It includes these performances:

a. MS IP address and endpoint parameter allocation for user sessions
b. Internet access
c. AAA services
d. Policy and Admission Control based on user subscription profiles
e. ASN-CSN tunneling support
f. WiMAX subscriber billing and inter-operator settlement
g. Inter-CSN tunneling for roaming
h. Inter-ASN mobility
i. Connectivity to WiMAX services such as IP multimedia services (IMS), location based services, peer-to-peer services and provisioning.

ASN and CSN are not belong to the same operator. CSN can use several ASNs and it is the same to ASN. Several CSNs can share the services that just one ASN provides. In this case, it will change information between ASN and MS to let ASN know that which CSN is connected with MS.

If WiMAX is arranged alone, CSN can be used as independent network construction. If it constructed with the other network, they can share some function entity.

1.2.1 All-IP mobile network

The mobile broadband wireless industry is in the midst of a significant transition in terms of capabilities and means of delivering multimedia IP services anytime, anywhere. So the all-IP mobile network specification is being defined by the Network Working Group (NWG) in the WiMAX Forum. The ip-based WiMAX architecture is shown in the figure below:

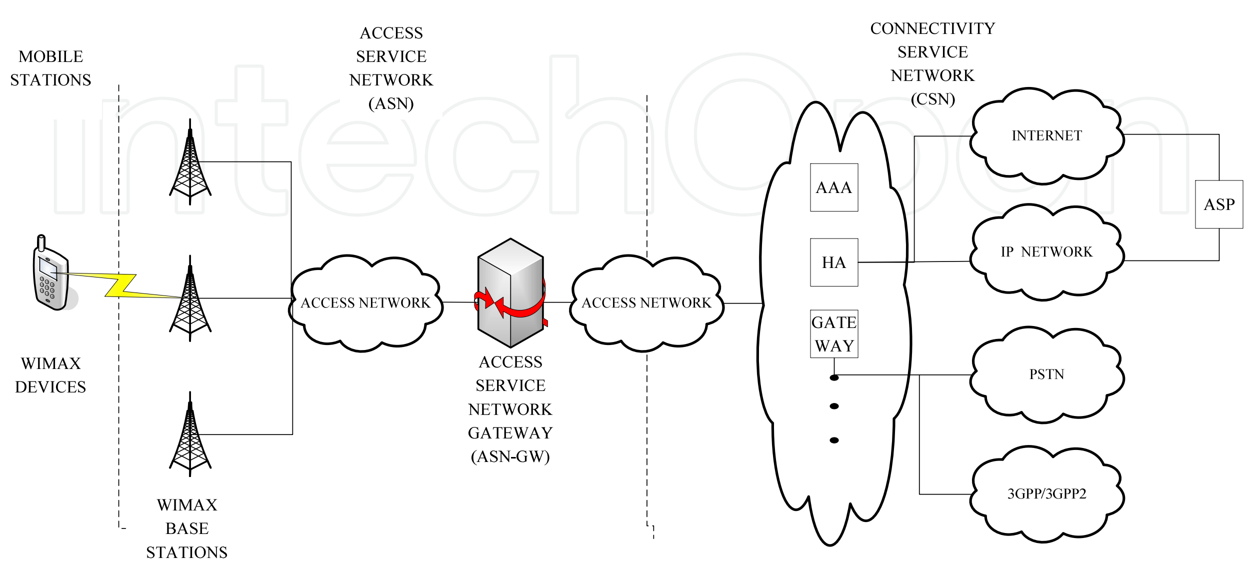
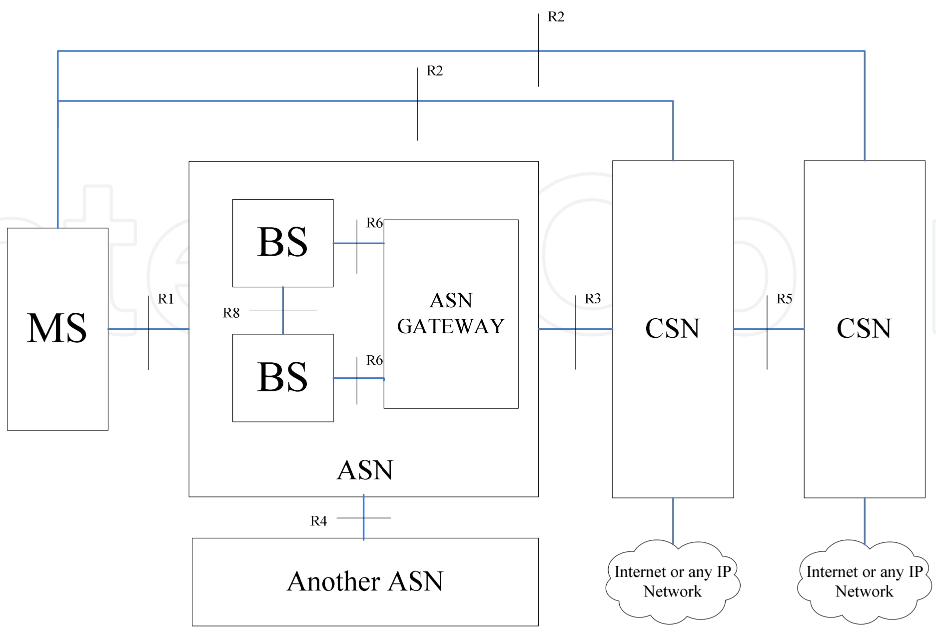


Fig. 2. IP-based WiMAX architecture

And its reference model is shown in the figure below:



It gives the reference network model interfaces:
R1 Interface between the MS and the ASN. Functionality: air interface.
R2 Interface between the MS and the CSN. Functionality: AAP, IP host configuration, mobility management.
R3 Interface between the ASN and the CSN. Functionality: AAP, policy enforcement, mobility management.
R4 Interface between ASNs. Functionality: mobility management.
R5 Interface between CSNs. Functionality: internetworking, roaming.
R6 Interface between BS and ASN gateway. Functionality: IP tunnel management to establish and release MS connection.
R8 Interface between BSs. Functionality: handoffs.
R7 is the interface in ASN gateway. It is not shown in figure 3.

Fig. 3. IP-based WiMAX network model

A prominent feature of the NWG specification is the extensive use of IP and IETF-standard protocols. The focus is on enabling IP access for mobile devices. Networking functionality requirements for client devices consist of just standard IP protocols like DHCP, Mobile IP, EAP protocols. IP connectivity is assumed between all interacting entities in the network. Mobile IP used as the mechanism for redirection of the data as a mobile device moves from one ASN to another ASN, crossing IP subnet/prefix boundaries. Mobility support for mobiles that are not Mobile-IP capable is provided by the use of Proxy Mobile IP. On the network side, IP address pool management provided through IETF standard mechanisms like DHCP or AAA. Decomposition of protocols across reference points enables interoperability while accommodating flexible implementation choices for vendors and operators.

WiMAX network architecture utilizes a combination of the IETF-standard Mobile IP protocol and special protocols defined by WiMAX NWG to handle mobility. The use of standard Mobile IP makes it possible to leverage off-theshelf components such as Home Agent in addition to simplifying the interface to the rest of the IP world.Alongside IETF Mobile IP, WiMAX specific protocols are used to allow for optimizations and to provide flexibility in handling mobility. For a given MS, the Mobile IP Home Agent (HA) resides in a CSN and one or more Foreign Agents (FA) resides in each ASN. Data for this MS is transported through the Mobile IP tunnel, which is terminated at an FA in an ASN. Once Mobile IP tunnel is terminated at the FA, WiMAX specific protocols (i.e. Data Path Functions) take over and transport the data from the FA to the serving base station, to which the MS is attached.This design offers multiple levels of anchoring for the user data plane path during handovers. Mobile IP is used to provide a "top" level of anchoring of the data flow for a mobile. WiMAX specific Data Path Function (DPF) to provide further levels of anchoring "below" Mobile IP.

Note that many mobile clients today such as PDAs and laptops are not Mobile-IP capable; instead they work with simple IP. WiMAX network architecture assures that those clients, together with Mobile-IP capable clients, are fully able to use services offered by the network. This is achieved by employing Proxy Mobile IP Client (PMIP Client), which acts as a proxy for the mobile client, in the network and handles the Mobile IP procedures in lieu of the mobile client in a transparent fashion.

1.2.2 Optical integrative switching

With the increasing of data traffic and the growing diversity of services, several optical network paradigms for future internet backbone have been under intensive research. Wavelength division multiplexing (WDM) appears to be the solution of choice for providing a faster networking infrastructure that can meet the explosive growth of the Internet. Since this growth is mainly fueled by IP data traffic, wavelength-routed optical networks employing circuit switching which is also called optical circuit switching (OCS) may not be the most appropriate for the emerging optical Internet. OCS is lack of flexibility to cope with the fluctuating traffic and the changing link status. Optical packet switching (OPS) is an alternative technology that appears to be the optimum choice. The OPS requires the technologies such as optical buffer and optical logic which is not mature enough to provide a viable solution.

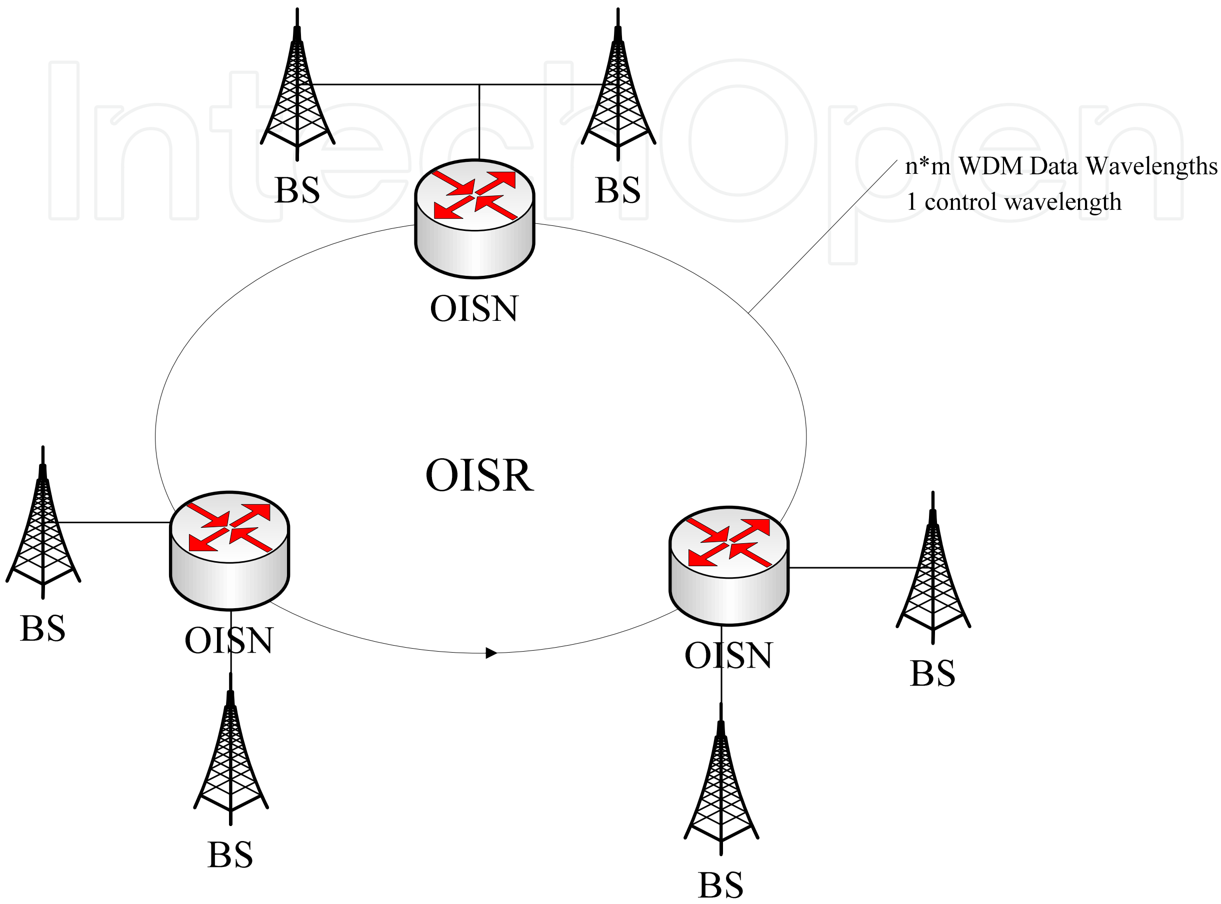
Optical burst switching (OBS) represents a balance between optical circuit switching and optical packet switching that combines the best features of both. A comparison of optical burst switching approaches shows that OBS delivers a high-bandwidth utilization, cost efficiencies and good adaptivity to congestion while avoiding OPS's implementation difficulties such as high processing and synchronization overhead and the need for too immature optical buffer memory. OBS delivers a high-bandwidth utilization and it is much agile than the OCS. While OBS is not good at transmitting circuit switching services.

Optical Integrative Switching (OIS) networks technology can agilely support the multi-services[1 IEEE Std 802.16e] in WIMAX. In OIS ring networks technology supporting WiMAX, four different classes of service traffic are considered. The 0 class of traffic (Class 0) can support Unsolicited Grant Service (type 0) in WiMAX; The class 1 traffic can support Real-Time Variable Rate Service (type 1) and Extended Real-Time Variable Rate Service (type 4) in WiMAX; The class 2 traffic can support Non-Real-Time Variable Rate service (type 2) in WiMAX; The class 3 traffic can support Best Efforts Service (type 3) in WiMAX. For service flows, the class parameter should be used when determining precedence in request service and the lower numbers indicate higher priority.

1.2.2.1 System architecture

Ring and node architecture

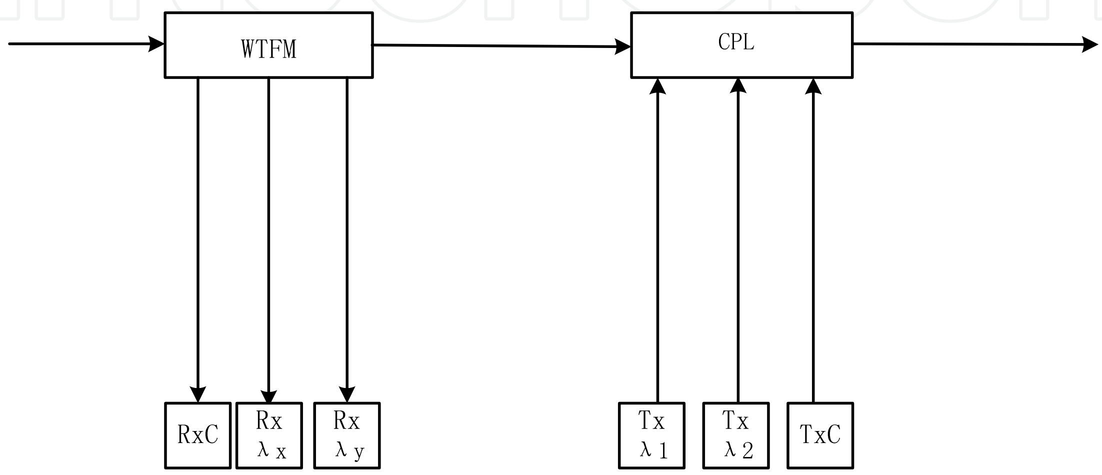
OIS can be mesh network or ring network. The OIS ring network is shown in figure below.



OISN: Optical integrative switching ring node
OISR: Optical integrative switching ring network
BS: WiMAX Base Station
The system has n OIS nodes in an unidirectional OIS ring. The OIS ring can be a backbone of wireless metropolitan area network (MAN) that interconnects a number of WiMAX base stations.

Fig. 4. Architecture of OIS ring network

The optical integrative switching ring network has n×m+1 wavelengths. The total data transmitters number in the OIS ring network is n×m corresponding n×m WDM wavelengths. Each node has m wavelengths which are referred as the home wavelengths of the node. The (n×m+1)th wavelength is the control channel for the wavelengths in the set and it carries control frames. The control frames implement the signaling necessary for OIS. Each OIS node in the ring has m data transmitters each fixed-tuned to one of the m home wavelengths, and m tunable receivers. These m pairs of transceivers are used for transmitting and receiving bursts. A node can only transmit bursts on its home wavelengths. A free receiver can tune to receive a burst arriving on any wavelength in the ring. A WTFM (wavelength tunable filter module) was installed at the destination node to drop any m data wavelengths and the control wavelength. The network scheme has the feature of transmitting wavelengths collision free, traffic collision free when switching at the midst nodes, traffic collision free from the source node. The core WDM network utilizes the W-token (token supporting WiMAX) signaling scheme to resolve receiver collisions at the receivers. In the W-token access protocol, the token can be captured according to the service class. The OIS node is equipped with a control module which performs its functions based on the information each control frame carries around the ring. Each node has its own slot into which it can write information during transmission. The control frames on the m control wavelengths travel around the ring in a synchronous manner.



CPL: coupler
WTFM: wavelength tunable filter module
RxC: the receiver of control channel
TxC: the transmitter of control channel
Rx: the receiver of traffic channel
Tx: the transmitter of traffic channel

Fig. 5. The Node Architecture of OIS ring network when m=2

Each OIS node serves a number of WiMAX base stations. In the direction from the WiMAX base stations to the ring, the OIS node collects and buffers electronically data packets, transmitted by users over the WiMAX base stations. Buffered packets are subsequently grouped in different burst according to their classes and destination. A burst can be of any size between a minimum and maximum value. Bursts travel as optical signals along the ring, without undergoing any electro-optic conversion at intermediate nodes. In the other direction from the ring to the WiMAX base stations, an OIS node terminates optical bursts destined to itself, electronically processes the data packets contained therein, and delivers them to users in its attached WiMAX base stations.

A WTFM was installed at each destination node before m data receivers and the control channel receiver to drop any m data wavelengths and the control channel wavelength. The architecture of the node when m=2 is shown as Fig.2. When the node receives the wavelengths from the ring, the two data wavelengths and the control channel wavelength was dropped by the WTFM. The other wavelengths were coupled with the two home data wavelengths (λ1 and λ2) which transmit the burst of the node as well as the control channel wavelength and transmit to the OIS ring network.

In OIS ring networks technology supporting WiMAX, there are four different classes of service traffic. The 0 class of traffic (Class 0) can support Unsolicited Grant Service (type 0) in WiMAX; The class 1 traffic can support Real-Time Variable Rate Service (type 1) and Extended Real-Time Variable Rate Service (type 4) in WiMAX; The class 2 traffic can support Non-Real-Time Variable Rate service (type 2) in WiMAX; The class 3 traffic can support Best Efforts Service (type 3) in WiMAX. For service flows, the class parameter should be used when determining precedence in request service and the lower numbers indicate preemptive priority. Bursts with different classes are served by using W-token access protocol. In the W-token access protocol, token can be released and captured according to the service class. In the OIS network, token0 and token1 are distributed for every receiving port to indicate the receiving port is unoccupied. Token0 can support class0 service and token1 can support other service in OIS network.

Control wavelength operation

The control channel wavelength is used for the transmission of control signal. In a ring with n nodes, n×4×m control slots, 4×m slots corresponding to m transmitters of each node, are grouped together in a control frame which continuously circulates around the ring. Four control slots includes token0, token1, answer frame (ACK) and a control frame (CF) corresponding to each transmitter of each node.

Each node is the owner of 4×m control slots in each control frame. Each control slot contains several fields. Each token0 control slot includes fields for the destination address, the token serial number, class of traffic is 0, the offset, the transmitter wavelength of exist class0 service, the time slot of exist class0 service, the time slot of reserving class0 service and so on. Each token1 control slot includes fields for the destination address, the token serial number, class of traffic, the offset, the transmitter wavelength, the time slot of exist class0 service, the time slot of reserving class0 service and so on. Each answer frame (ACK) includes fields for the destination address and the source address, the token0 serial number, class of traffic, the offset, flag, the transmitter wavelength and the size of data, the time slot of exist class0 service, the time slot of reserving class0 service and so on. Each CF control slot includes fields for the destination address, the token1 serial number, class of traffic, the offset, flags, the transmitter wavelength, the burst size the time slot of exist class0 service, the time slot of reserving class0 service and so on.

The value of traffic class is as follows: 0 is corresponding to class 0 traffic, 1 is corresponding to class 1 traffic 2 is corresponding to class 2 traffic, 3 is corresponding to class 3 traffic, and 9 is corresponding to no traffic. The offset 1 value is the processing times at intermediate nodes and the offset 2 value is the time of WTFM to switch to receive different wavelength. The offset value is the sum of the offset 1 and the offset 2. The offset time doesn't include the transmitting time from source to destination.

1.2.2.2 The W-token access protocol in OIS network

The protocol uses tokens to resolve receiver collisions at the receivers. Tokens are used for all classes. Every node has m token0 and m token1 corresponding to m receivers of this node circulating around the ring. If a source wants to transmit a burst to a particular destination, it has to catch the token for that destination according to classes of service. To accommodate the extant PCM network (including SDH), 125μs is adopted as data period for receiving port. A token may be either available or in use. When the sending node catches token0, the time slot of receiving port will be reserved. If the time slot of receiving port reserved successful, the connection of class0 will be established. Then the class0 occupy the same time slot in every period of 125μs. This message of occupying time slot will be write in token. The else service will keep away from this time slot when they catch token.

Since only the node that has possession of the token can transmit a burst to the appropriate destination in its time slot, the receiver of the destination can only receive a single burst at a time, and therefore the W-token protocol is a receiver collision-free protocol.

The maximum bandwidth of each class can be defined by the network. The service bandwidth which has a lower priority can be taken up by the higher priority; however, the defined maximum bandwidth can not be exceeded. Processes of each class service sending as below:

The processes of sending class 0 service

At the sending node, the node checks each received control frame. If the node detects an available token0, it deletes token0 from control frame, and puts token0 into its own FIFO token queue. If there is no class 0 service, the node will release token0 to the next node, otherwise, it will examine the receiving port time slot pool, and detect whether there are available time slots of the receiving port which is limited by the network (The time slot which is not occupied by class 0 can be regard as an available time slot. When the time slot is occupied by lower priority service, it can be grabbed by higher ones. However, the class 0 bandwidth can not be wider than the maximum class 0 bandwidth which is defined by network. According to the network resources, network can define the maximum class 0 service bandwidth of the whole network. The maximum connections bandwidth between each pair of nodes can be defined. Idle available time slot means it is longer than data required). If there is none, the node will release token0 to the next node, else, it will examine local sending time slots, and see whether there are idle available sending time slots (If the total bandwidth including the bandwidth which is required by the sending data is not larger than the class 0 service maximum bandwidth, then it has idle sending time slots, or else it has no idle sending time slots. Idle available sending time slot means the idle time slot is larger than required time slot of data sending),if there is no idle available time slots, the node will release token0 to the next node, otherwise it will reserve sending time slots, and write reserving message into token0, then release token0 to the next node.

When the receiving node reveives token0, it will send the controlling order to WTFM to receive the wavelength which carrying data during the time slot and to receive class 0 service data according to the reserved time slots. Class 0 service coming from different source nodes is received according to the time slots in the frame with the period of 125μs. The frame period 125μs is defined for receiving ports, and different sending nodes occupy different time slots of receiving port. Because the wavelengths of different nodes are different, the WTFM may be used at the receiving ports. Only one OIS class 0 service data packet from one sending node is sent in each frame with the period of 125μs (Multiple E1 frames may be included in the period of 125μs.). Class 0 service supports WiMAX type0 service. When the receiving port was reserved to receive class0 service, the receiving node will send an ACK message to the source node and the receiving node writes arrangement message to token0 and releases it to the next node. When receiving token1 and CF, it writes into the time slots information, and releases it to the next node. After the source node receives ACK which indicates that reserving time slots is successful, it starts to send class 0 service. When finished sending data and receiving token0, the source node write the releasing message into token0 and releases it to the next node. When received the token0 including the releasing message, the receiving node sends controlling order to the WTFM and releases the connection. It writes this time slot releasing message to token0 and ACK and release to the next node. When receiving token1 and CF, the time slot releasing information is updated and token1 and CF released to the next node.

The processes of sending class 1 service

At the sending node, it checks each received controlling frame. When it detects an available token1, then it deletes token1 from the controlling frame, and puts token1 into its own FIFO token queue. If there is no class1 service, the node will check whether there is class2 or class3 service. If there is class1 service, it will check whether there are idle available time slots at the receiving port (Idle time slots of the receiving port here is the time slots not occupied by class 0 or class 1. When the time slot is occupied by lower priority service, it can be grabbed by higher ones. However, the maximum class 1 bandwidth defined by network should not be exceeded. According to the network resources, the network could define the maximum class 1 service bandwidth of the whole network, and also it could define the maximum connection bandwidth between each pair of nodes. Idle available time slot means it is longer than burst packets required), if there is none, the node will check whether there is class2 or class3 service. If there are idle available time slots, then it checks whether there are local idle available sending time slots limited by the network (If the sum of the bandwidth of the existed class 1 service and the required bandwidth of sending time slots is not larger than the maximum bandwidth of class 1 service defined by the network, then the node will consider that there are idle sending time slots, otherwise, there are none. Idle available sending time slot means that it is larger than the burst packet sending time slot, and the time slot doesn't conflict with the idle time slot of the receiving port),if there are none, the node will go on to check whether there is class2 or class3 service. If there are idle available sending time slots, the message of occupying time slots will be written into token1, and then to check whether there is class 3 service. At the same time, the sending node writes the message about the occupied time slots into the control message CF and sends it to control frame. And then sends class1 data after the offset time. Every time the node captures token1, it could send multiple OIS class1 service burst packets in different frames whose period is 125μs (each class 1 service burst packet can contain multiple MPEG frames etc). Only one OIS class1 service burst packet is sent in each frame with the period of 125μs. The total bandwidth should not larger than the maximum bandwidth defined by the network. Receiving CF, the receiving node will send control order to the WTFM and receive class1 service data according to the reserved timeslot.

The processes of sending class2 service

Check whether there is class2 service, and if there is none, it will check whether there is class3 service. If there is class2 service, it will check whether there are idle available time slots in the receiving port (The idle available time slot here means the time slots which are not occupied by class0, class1 and class2. The service can grab the time slots of service with lower priority. The total bandwidth of class2 can not be larger than the maximum class2 service bandwidth defined by the network. According to the network resources, the network can define the maximum class2 service bandwidth of the whole network. It can also define the maximum connection bandwidth between each pair of nodes. Idle available time slot means it is longer than the burst packets required), if there is none, the node will go on to check whether there is class3 service. If there are idle available time slots, it will check whether there are local idle available sending time slots limited by the network (If the sum of the bandwidth of existing class2 service and the bandwidth of sending time slots required is not larger than the class2 service maximum bandwidth defined by the network, then the node will consider that there are idle sending time slots, otherwise it considers there are none. Idle available sending time slot means it is longer than that required by the burst packet, and the time slot does not conflict with the idle time slot in the receiving port), if there is none, it will go to check whether there is class3 service. If there are idle available sending time slots, it will write the message about time slot occupying into token1, then go to check if there is classs3 service. At the same time, the occupied time slot message is written into the control message CF and then CF was sent. The class2 data was sent after the offset time. When the node captures token1, it can send multiple OIS class2 service burst packets in different frames with the period of 125μs. When receiving CF, the receiving node sends control order to WTFM and then receives class2 service data according to the reserved time slots.

The processes of sending class3 service

The node checks whether there are idle available time slots at the receiving port (Idle available time slot at the receiving port is the time slot which is not occupied by class0, 1, 2 and 3. However, the class 3 bandwidth can not be wider than the maximum class 3 bandwidth which is defined by the network. According to the resources, the network can define the maximum class3 bandwidth of the whole network. The maximum connections bandwidth between each pair of nodes can be defined. Idle available time slot means it is longer than burst packets required), if there is none, token1 will be released to the next node. Otherwise, it will check whether there are local idle available time slots limited by the network. (If the sum of the bandwidth of existing class3 service and the required bandwidth of sending time slots is not larger than the maximum bandwidth of class 3 service defined by the network, then the node will consider that there are idle sending time slots, otherwise it considers there are none. Idle available sending time slot means it is longer than that required by the burst packet, and the time slot does not conflict with the idle time slot in the receiving port), if there is none, the node will release token1 to the next node. If there are idle available sending time slots, it will write the message about time slot occupied into token1, then release token1 to the next node. At the same time, the occupied time slot message is written into the control message CF and then CF was sent. The class3 data was sent after the offset time. When the node captures token1, it can send multiple OIS class3 service burst packets in different frames with the period of 125μs. When receiving CF, the receiving node sends control order to WTFM and then receives class3 service data according to the reserved time slots. After the receiving node receives token1, it will write the message about the time slots occupied by class 0 service into token1.

2. WiMAX core network main function

Considering the main function of the WiMAX core network, it includes the exchanging with the existing network and accounting. So these points below should be thought about:

1. WiMAX network architecture should be considered working together with existing wireless or wired networks such as GSM, WCDMA, Wi-Fi, DSL and so on. Meanwhile, they should be based on IP/IETF protocol standards.
2. WiMAX network architecture will also support global roaming, billing and settlement systems in public.
3. WiMAX network architecture will support a wide variety of user authentication, authentication methods, such as based on user name / password, digital certificate, SIM, USIM.

2.1 Interoperability with 3GPP networks

WiMAX network has the features with high spectrum efficiency, large data throughput, and effective cost. While 3GPP network has the mature services of voice, roaming, handover, improved authentication and accounting.Achieving the interoperability of these different networks will meet the future needs of the growing market.

There are many programs to achieve the interoperability of these two networks but operators must determine the details according to the actual situation. Generally, the interoperability between 3GPP and WiMAX has the following six application modes:

1. Unified billing and customer relationship mode: users sign with two network operations, and it is able to access to both networks, but use one list of all settlement costs
2. Based on WCDMA accessing control and billing: certification, authentication and billing are provided by WCDMA.
3. WCDMA PS services: users who access via WiMAX network can directly use WCDMA PS services, such as LCS, MMS, instant messaging, etc.
4. WCDMA & WiMAX continuous service: Users can conduct sevices switching in both of two networks, it may cause the pause and packet loss.
5. WCDMA & WiMAX seamless service: Users can conduct sevices switching in both of two networks, it can not cause the pause and packet loss.
6. WCDMA CS services: users who access via WiMAX network can directly use WCDMA CS services, and provide seamless handover.

In these modes, WiMAX can be added to or be side by side with WCDMA.

Considering current network deployment, existing 3GPP network and commercial development progress of WiMAX, it is recommended the following two interconnections:

- WiMAX is attached to the WCDMA; two networks belong to the same operator.
- WiMAX's authentication, authorization and accounting are conducted by AAA, HLR and other network elements of WCDMA.
- WiMAX transport the data through its own AC (AGW), directly connect to the external PDN. Users' accounting information is collected at AC and then report to the accounting system of WCDMA.

- WiMAX works as an additional network and cause less impact on WCDMA.

This program is suitable for the case that WCDMA construction is completed. It can enhance the data rate by deploying WiMAX.

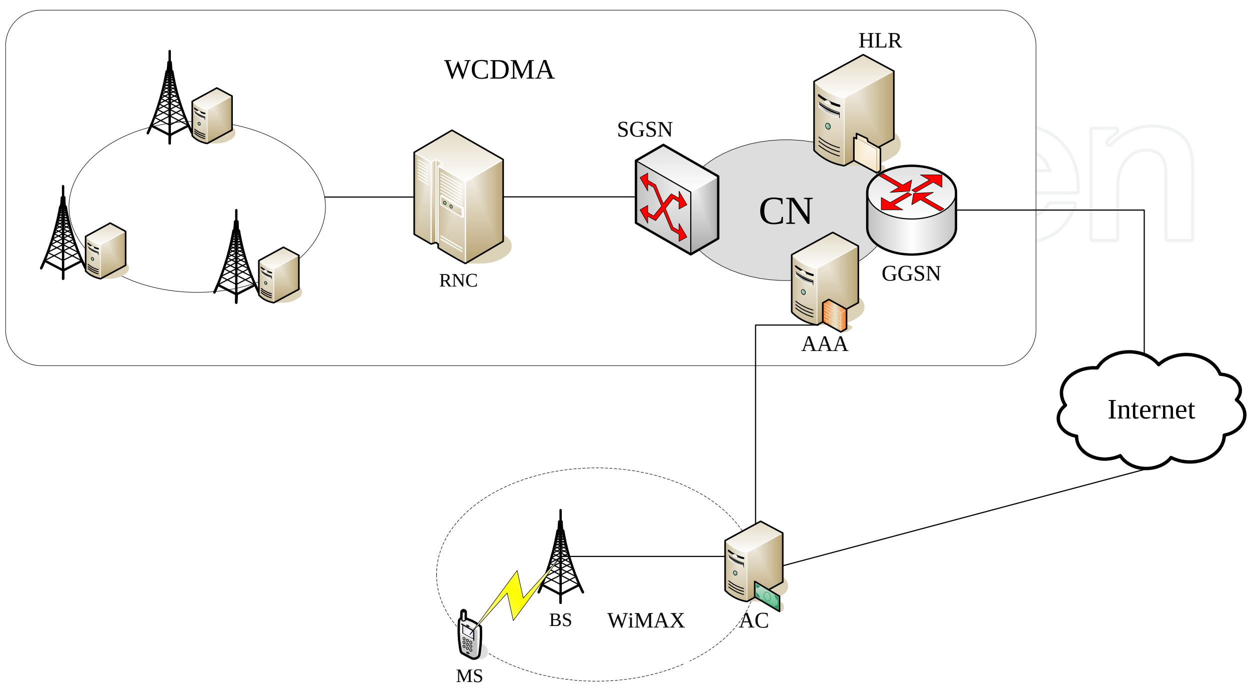


Fig. 6. First Plan for Interoperability with 3GPP networks

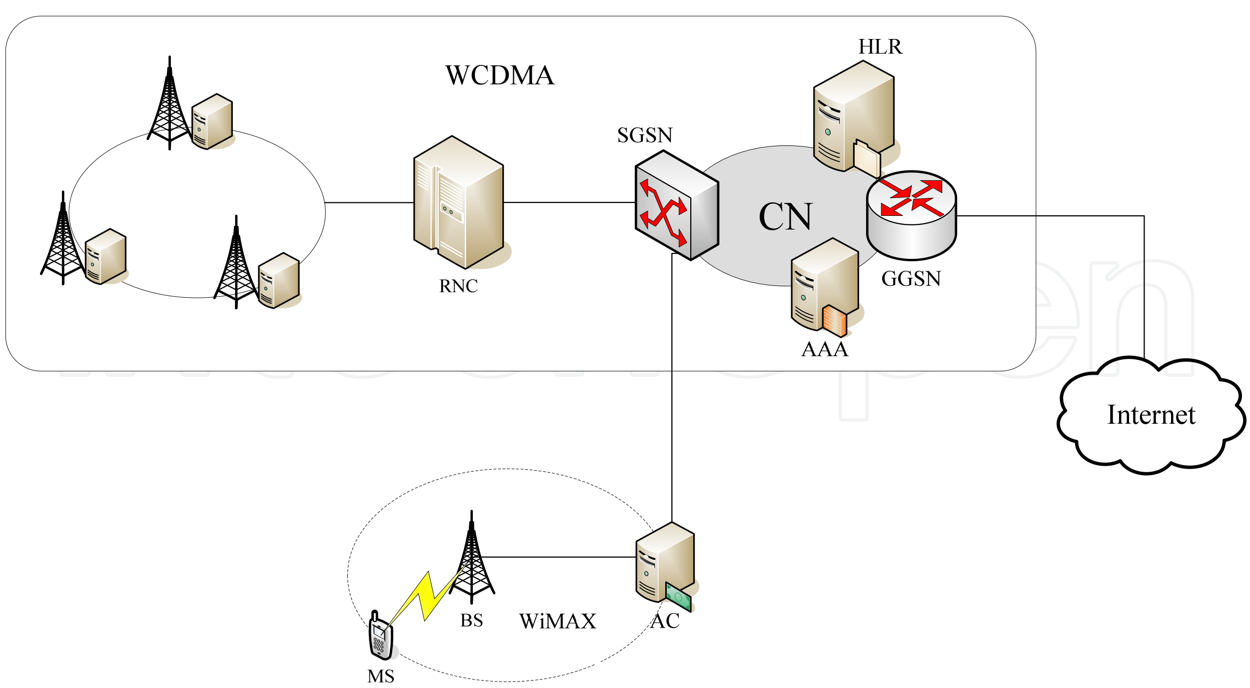


Fig. 7. Second Plan for Interoperability with 3GPP networks

- WiMAX is attached to the WCDMA . The authentication and authorization of WiMAX users are completed by WCDMA HLR.
- SGSN packages WiMAX data and sends it to GGSN. GGSN is responsible for routing it to the external PDN.
- According to the actual deployment of the integration,WiMAX users can access to PS services of WCDMA to achieve more closer integration.
- This plan involves all of WCDMA core network elements. There is a greater impact on the system and it has a higher risk.

The first plan is for initial solution of interconnection between two networks. With the development of this service, you can choose the second plan. Data services will be open to the users of WiMAX gradually.

2.2 Accounting

2.2.1 The network structure of accounting

The accounting structure of WiMAX access layer is shown in the figure below:

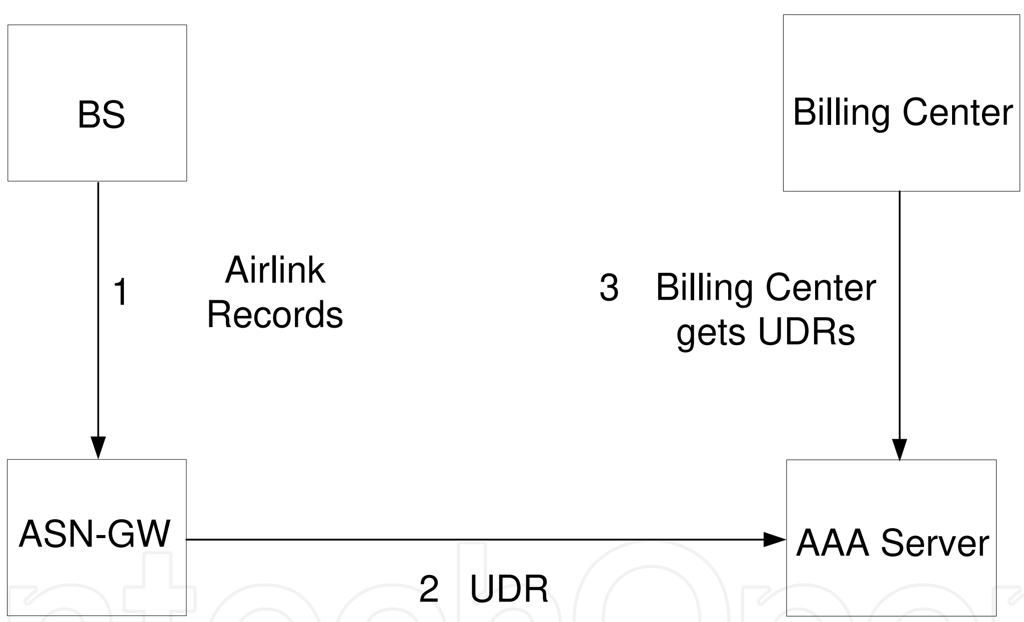


Fig. 8. Accounting Structure of WiMAX access layer

WiMAX accounting consists of two parts: BS collects the accounting parameters of the wireless side and ASN-GW collects the accounting parameters of the network side. BS sends the wireless side accounting parameters to ASN-GW through the interface between them. ASN-GW integrates the wireless side and network side accounting parameters into UDR and then sends it to AAA-server through RADIUS interface. AAA-server provides the interface to the accounting center and it can collect the initial voice information from AAA-server.

The interface between ASN-GW and AAA-server supports RADIUS protocol and the evolution to DIAMETER protocol. Considering the special bits of WiMAX accounting, it will use RADIUS or DIAMETER according to the producers.

2.2.2 Accounting modes

Fixed accounting

According to the user's contract situation, fixed accounting makes user do not need to consider the service usage when he access to WiMAX to use all sorts of services. When the user's contract expires, the system will stop user from accessing the network. Fixed accounting includes the following four modes:

- Accounting according to the conversation.
- Accounting according to the conversation and limit the maximum duration in each session. E.g. a longest session is 24 hours.
- Accounting according to the conversation and limit the period in one day to access the network. E.g. from noon to night.
- Accounting according to the time and do not consider how many services the user uses. E.g. account monthly.

Accounting based on services usage

This mode is according to the services usage of user. There are three methods:

- Duration of the conversation.The actual use of time in a continuous session.
- Data traffic. The user and air interface transport and receive data bytes
- Sessions number. The number of sessions which are successfully established.

Accounting based on services

This mode is according to all kinds of the value-added services supported by operators. There are three possible methods:

- User information contains the particular IP applications (e.g. VOIP), QoS/SLA agreement and some kind of roaming agreement in the contract.
- Temporary and dynamic authorized content by the network (such as the conversation accessed to VPN).
- Using third party to provide the services in the conversation.

2.2.3 Accounting solutions

Post-paid billing

This mode is that user uses services first and then the operator charges according to the usage of the services.

When the user's session is set up, the system generates the accounting start list of this session. During the session, the system generates the accounting interim list at an interval of some time. When the session ends, the system generates the accounting stop list. Here is the figure of its procedure:

Its procedure is mainly about these points:

a. User establishes the session through the authorization of AAA.
b. ASN-GW send the message to AAA to start accounting.
c. After some time of this session, the system billing timer is overtime.

d. ASN-GW sends accounting message to AAA in the middle of the session.
e. The user ends up the session.
f. ASN-GW send stop accounting request to AAA.
g. Billing center uses the interface provided by AAA to collect the accounting records.

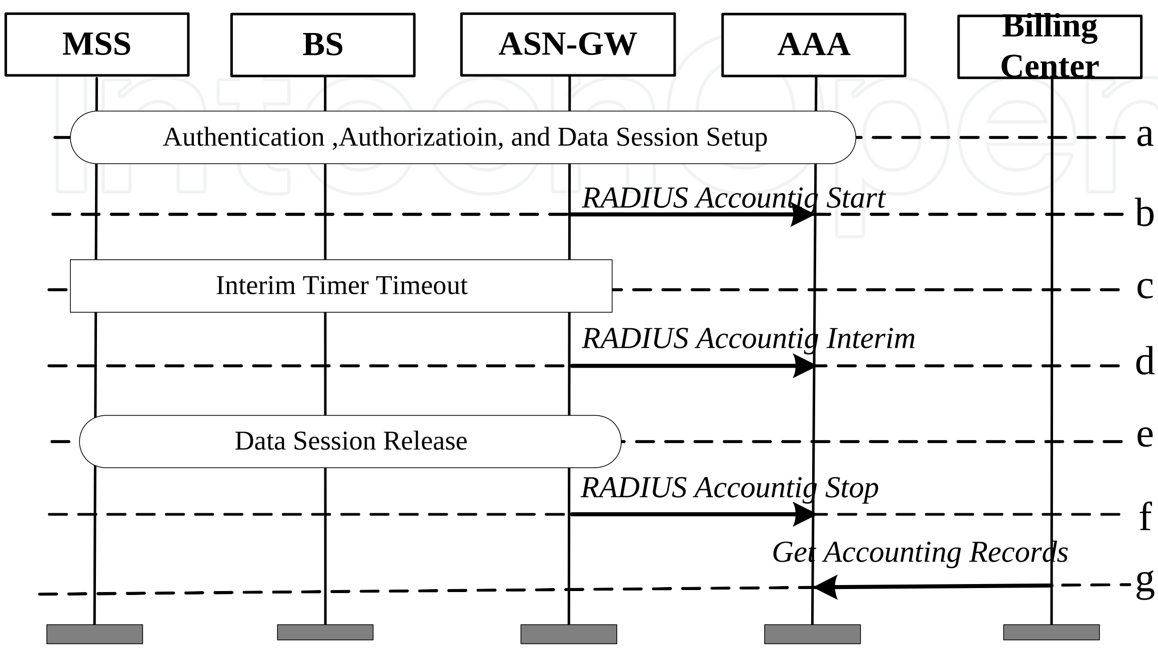


Fig. 9. Post-paid Billing Accounting Procedure

Pre-paid billing

This mode is that the user pays first and the operator check user account information. The user uses the services according to the balance in his account. Pre-paid billing can get the cost of settlement at real-time. According to the balance of the user's account, the operator can control the user's usage of services to ensure the interest of itself.

The difference between pre-paid billing and post-paid billing is that pre-paid billing must pay first and then use the services. The user's accounting information is saved in the system previously. ASN-GW get the information of the balance and during the services ASN-GW diminish this balance.When the balance runs out, ASN-GW request the system to redistribute the account balance, and so on in turn. When all of the user's accounting balance runs out, the system will terminate user's services initiatively.

At present WiMAX can not support pre-paid billing. You can see the following exsiting reference structure of pre-paid billing:

Pre-paid billing entity includes:

AAA-server: Provide authentication, authorization and accounting services.

PPS: Pre-paid server. Control the services of pre-paid billing user.

PPC: Pre-paid client. Provide services according to the PPS pre-paid control strategy.

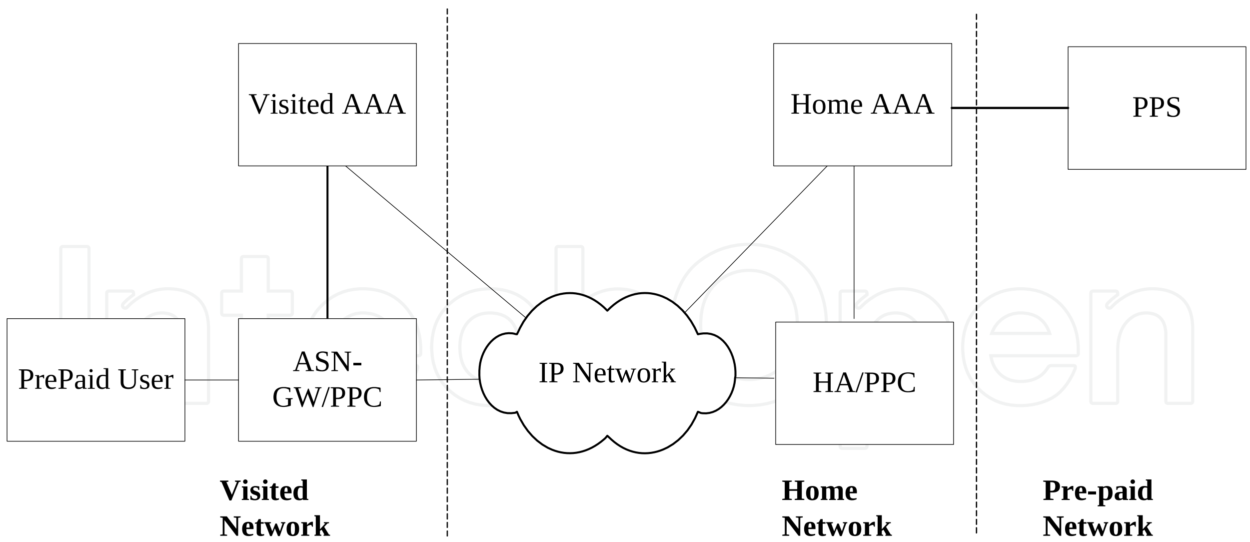


Fig. 10. Pre-paid Billing Reference Structure

Roaming billing

In the actual roaming environment, it may include many scenarios and network configuration. In order to manage this complexity, it defines an universal roaming model and it is shown in the following figure. There is only one accounting mode that the operator send the bill to users.

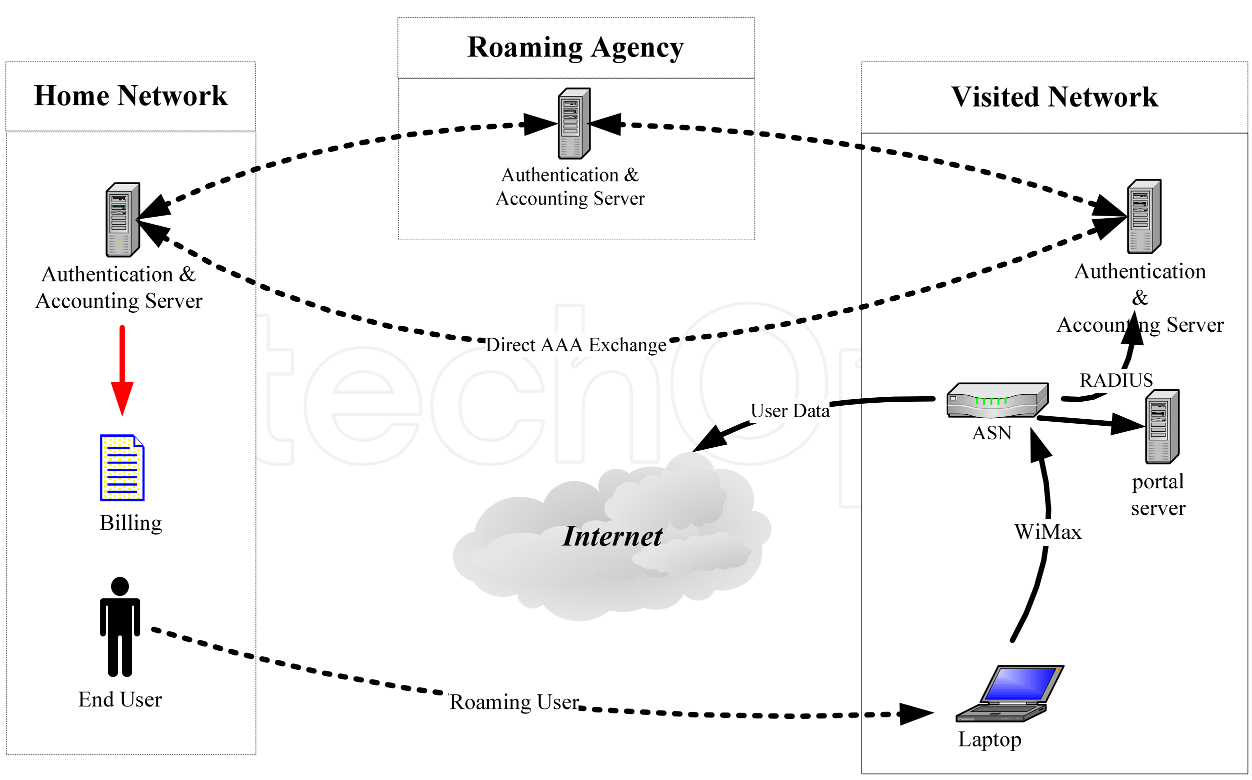


Fig. 11. Universal Roaming Model

In the above roaming model, WiMAX is divided into three parts: Visited Network, Roaming Agency and Home Network. By exchanging the information between these parts, it can provide authentication, authorization and accounting services to ensure the user to access to WiMAX.

In WiMAX, roaming agency is an optional part. It will use roaming agency or not according to the actual need. Roaming agency takes on an intermediary role in multiple roaming. In the actual roaming environment, an operator must communicate with several operators to realize the roaming of WiMAX. If they communicate with each other directly, it will be very difficult and its cost will be very large. However, if a operator access to the roaming agency, it can communicate with the other operators which are attached to the roaming agency. This is similar to the structure of Internet. Currently iPass and GRIC are most influential in roaming agency.

Roaming agency can be divided into two parts:

a. Route based on the authentication information. It sends the authentication information from visited network to home network to realize the user's authentication by proxy function of radius protocol. In this process, the authentication information may experience several proxies, which depends on the network environment.
b. Accounting. Some roaming agencies undertake the function of billing center to deal with accounting in roaming.

3. Concluding remarks

In summary, it can be observed that the future network will have the following characteristics: IP-based, broadband, lower cost, more convenient to manage, and multiple technologies could integrate through a unified core network, achieving the the seamless switching between various services.

The core network of WiMAX adopts mobile IP framework, which provides the ability of seamless integration with all-IP network. It has following advantages:

1. WiMAX core network meets the QoS requirements of various service and applications, effectively utilizing end-to-end network resources.
2. The extendibility, flexibility, and robustness of WiMAX core network help to reach the demand for telecommunication level network deployment.
3. WiMAX core network is equipped with advanced mobility management, including paging, location management, cutover between various technologies, and cutover between different operator networks.
4. WiMAX core network could provide the security and QoS indemnification in all mobile patterns.

In the next stage, WiMAX core network will gradually evolve towards IMS, adapting to the requirements of interconnecting with other network.

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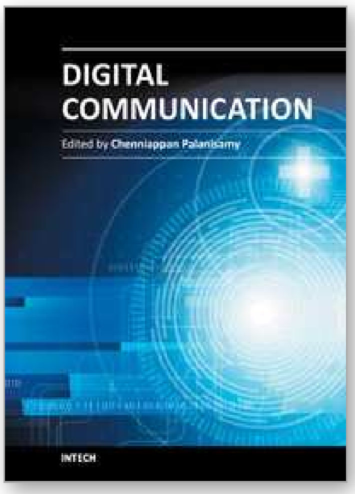

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All marketing is digital and everyone should have a digital strategy. Everything is going mobile. "The world has never been more social" is the recent talk in the community. Digital Communication is the key enabler of that. Digital information tends to be far more resistant to transmit and interpret errors than information symbolized in an analog medium. This accounts for the clarity of digitally-encoded telephone connections, compact audio disks, and much of the enthusiasm in the engineering community for digital communications technology. A contemporary and comprehensive coverage of the field of digital communication, this book explores modern digital communication techniques. The purpose of this book is to extend and update the knowledge of the reader in the dynamically changing field of digital communication.

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