White Paper

How To Implement WiMAX in a mobile network

Contents

Scope

Siemens and Cisco Systems® are leaders in wireless solutions and IP networking for fixed and mobile networks. The established strategic cooperation enables the broadest radio and networking portfolio.

This White Paper addresses the need to introduce WiMAX access technology to Siemens and Cisco representatives world wide to make them aware of the end to end solution that is available to them with WiMAX technology. The primary market is the application of WiMAX technology into existing operator networks.

Siemens and Cisco have joined together with Intel® and the WiMAX Forum™ industry organization to advance the IEEE 802.16 standard. As a result, interoperable WiMAX base-stations and customer premises equipments (CPEs) will be deployed before the end of 2005.

1 Introducing WiMAX

1.1 Global Standard

WiMAX is poised to become a globally available technology. It is based on the IEEE 802.16 standard, which is also recognized as the reference standard by ETSI in connection with the High Performance Radio Metropolitan Area Network (HIPERMAN). Several pending actions within regulatory bodies will make possible a worldwide WiMAX-friendly spectrum. The availability of this standard will allow mass production of chipsets that will reduce the CPE costs, ensure cross-vendor interoperability, and reduce investment risk for operators.

In parallel to the IEEE standardization efforts, the WiMAX Forum, backed by major players in the telecommunications industry (including system and component manufacturers and service providers), will encourage the widespread adoption of WiMAX access by establishing a brand for the technology and promoting interoperability through a certification program.

1.2 Filling the Available Gaps

WiMAX access technology is an integral part of the portfolio by complementing 2G/3G mobile access, DSL broadband fixed access, and Wi-Fi hotspot access:

- WiMAX broadband provides Portable high speed packet data services for IP applications that complement the full mobility, nationwide coverage, voice support at high speeds, and moderate data rates of 2G/3G mobile access.
- WiMAX complements broadband by helping delivery in new markets. After DSL operators have exploited their high-quality copper pairs in densely populated areas of advanced countries, WiMAX allows them to extend service rapidly and cost-effectively into areas of poor wire quality and lower population density.
- WiMAX, with its long range and quality-of-service (QoS) capabilities in licensed bands, complements current public WLAN hotspot offerings.

1.3 State-of-the-Art Radio Technology

WiMAX makes possible new advances in radio technology:

- High spectral efficiency, achieved through adaptive modulation and advanced coding schemes, allows optimized trade-off between throughput and coverage.
- Non-line-of-sight capability is achieved through a modulation scheme based on orthogonal frequency division multiplexing (OFDM). This provides multipath robustness, allowing 3-kilometer (km) coverage in dense urban areas and up to 30-km coverage in rural settings.
- QoS management supports both non-real-time and real-time applications, including corporate and Internet access along with valuable content distribution and interactive gaming applications.
- Advanced air link security is based on mutual authentication and robust air link encryption.

1.4 Broadband Access Anywhere

The goal of WiMAX is to make Portable IP broadband applications a reality. WiMAX chipsets integrated into laptops and other Portable IP devices will provide high-speed IP services to users on the move, extending today's public WLAN hotspot coverage and delivering broadband services everywhere outside the subscriber's home. The user will be "always best connected," accessing applications through the best available network.

Mobile IP broadband applications are another promising perspective for WiMAX. The ongoing enhancements in the IEEE 802.16e standard will add data distribution with session continuity while moving beyond stationary usage.

1.5 New Revenue Streams for Operators

WiMAX will provide widespread, reliable, cost-effective access to basic and advanced IP services. This means addressing market demands, now only partially addressed by current technologies, with useful paid services for residential and business users.

2 Services

In recent years many new services have been implemented on IP-based networks. As IP networks become faster (higher bandwidth) and more responsive (lower delay), the set of services has grown. This growth generates more revenue opportunities for service providers, and thus next-generation networks are all migrating toward IP technologies.

From an operator standpoint, services can be broken down into four billable classes:

- Basic Internet services
- Premium Internet services
- VPN services
- Operator premium services

2.1 Basic Internet Services

Basic Internet services are typically billed at a flat rate. They don't offer an operator the ability to increase average revenue per user (ARPU) for premium content or applications. Basic Internet service does not provide end-to-end QoS and therefore cannot guarantee good service for demanding QoS applications.

2.2 Premium Internet Services

Premium services are important not only to improve ARPU, but to add new services. Premium Internet services allow operators to have a business relationship with an application service provider (ASP) that feeds their QoS offerings. This is accomplished when both the operator and ASP use compatible QoS technologies.

Examples of billable premium content are TV stations, movies, on-demand content, and radio.

2.3 VPN Services

VPN is in its own class because the operator's network has no visibility into the application data. To meet the security needs of an enterprise the implementation of a VPN typically creates a tunnel between the user device and a VPN concentrator within the enterprise network. Because a VPN tunnel is encrypted, there is no mechanism for billing by application. However, an enterprise's VPN service can be billed by QoS level. Enterprises that outsource their data service might use a managed VPN which is slightly different because the operator owns at least one end of the tunnel.

2.4 Operator Premium Services

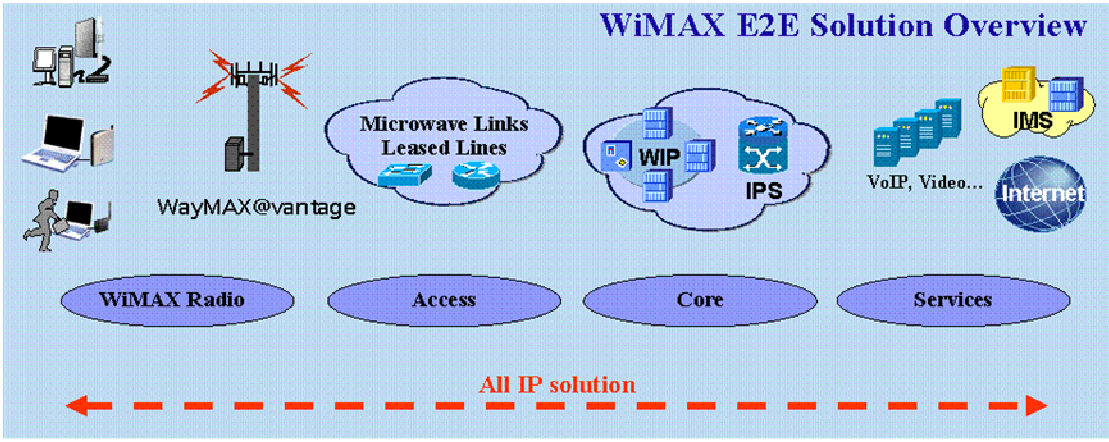
Operator premium services are applications provided on the operator's network. These services have the advantage of a controlled environment where QoS can be strictly enforced. For example, a voice-over-IP (VoIP) service on a QoS-enabled network can guarantee more consistent quality than a VoIP call over the best-effort Internet. In addition, broadcast services, based on IP multicast technologies, can be accommodated efficiently on an end-to-end IP-based transport network.

3 How To Implement WiMAX In A Mobile Network

3.1 Comprehensive Solution

Siemens and Cisco, with their established leadership in IP networking for fixed and mobile networks, are working together to build a comprehensive solution around the best wireless technology. The two firms' active participation in the WiMAX Forum and relevant groups in IEEE and IETF will help ensure fully interoperable solutions. The portfolio offered includes transport and core networks as well as IP application platforms. See the block diagram in Figure 1.

Figure 1. Elements of WiMAX Solution



The transport network includes Internet technologies along with microwave links. The core network includes a back-end infrastructure for centralized user authentication, authorization, and accounting (AAA) as well as charging and billing solutions that can be based on time, volume or content. The application platforms include VoIP components and content distribution servers.

3.2 Full IP Solution

WiMAX is part of an all-IP network combining wired and wireless IP packet transmission. The end-to-end architecture makes the greatest possible use of IETF and IEEE standards and protocols along with the adoption of commonly available standard equipment.

3.3 Unified Voice and Data Networks

The WiMAX solution reflects the general trend in the communications industry toward unified packet-based voice and data networks. Fundamental benefits of this transition are reduced operations cost, improved network optimization, and better management of change.

3.3.1 Flexible and Innovation-Friendly

The end-to-end architecture is flexible and innovation-friendly. It will accommodate growth in services as WiMAX evolves from fixed to Nomadic IP and Portable IP usage without service interruption.

3.4 Broadband Access Anywhere

The end-to-end network plays a key role in reaching the target of friendly ubiquitous broadband services for users. Siemens and Cisco provide advanced equipment including servers for centralized AAA, IP configuration servers, and user profile databases that support roaming agreements. The equipment can be configured to guarantee that users receive consistent SLA treatment independently from their point of attachment to the network.

3.5 Smooth Integration into Existing Networks

Standalone WiMAX networks are certainly feasible, but in most cases WiMAX access technology will be adopted by operators as an extension to their existing networks. This allows operators to make the most of their existing infrastructure: base station sites (in the case of mobile operators) and IP service infrastructure for service and related AAA and billing systems.

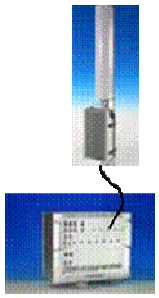
The end-to-end solutions may range from complete end-to-end designs to more limited deployments meant to work with other current equipment. As highlighted in later sections, the WayMAX@vantage Base Station, the Wireless Integration Platform (WIP), and the Intelligent Packet Solution (IPS) are the central elements for the most profitable integration of WiMAX access technology into existing networks.

4 Introducing WayMAX@vantage

4.1 WayMAX@vantage : The WiMAX Solution

Siemens WayMAX@vantage product aims to be a leading solution based on WiMAX with 802.16 technology for both the base station device and CPE. WayMAX@vantage provides cost-effective “last-mile” broadband wireless access for residential, small office-home office (SOHO), and small- and midsized-business (SMB) users. WayMAX@vantage is a high power solution that provides upgradeability of Base Stations for future enhancements as they are defined by the standard, together with the expected economies of scale on the CPE side will lead to a cost effective solution.

WayMAX@vantage employs non-line-of-sight OFDM technology compliant with the IEEE 802.16 standard and WiMAX Forum Profiles to deliver IP broadband applications with guaranteed QoS levels according to service-level agreements (SLAs) established between operators and service users. The WayMAX@vantage air interface is optimized for transporting IP traffic consisting of variable-sized packets with bursty patterns.



WayMAX@vantage

(Indoor Unit, Outdoor Unit and Antenna)

4.2 Forerunner with WiMAX Solutions

WayMAX@vantage participation to the first wave of Certification and Interoperability tests organized by the WiMAX Forum™ will allow it to be among the first interoperable products on the market.

4.3 Comprehensive Portfolio

The WayMAX@vantage offering includes a base station product line, a CPE portfolio for residential and business users, and the advantages of a comprehensive end-to-end network solution. The WayMAX@vantage CPE family minimizes installation time and operational costs, allowing operators to minimize the number of required base station sites.

4.4 Largest Coverage

The WayMAX@vantage Base Station's high-power solution, advanced modulation schemes, and smart redundancy concepts provide a high-performing, cost-effective, and reliable solution for carrier-class broadband wireless services. This solution provides the largest coverage because of the combined adoption of high output power dynamic usage of OFDM subchannelization, and cost-effective antenna diversity techniques at the base station receiver.

4.5 Secure Services

WayMAX@vantage performs authentication and encryption of packets according to the 802.16 standard. Device authentication is based on X.509 digital certificates. Key exchanges and air link encryption are based on 802.16 Personal Key Management (PKMv1). The RSA public-key encryption algorithm establishes secret keys. Additional user authentication may be provided in several ways including methods similar to Wi-Fi, such as Universal Access Method (UAM) and subscriber identity module (SIM).

4.6 Multiservice Support with Guaranteed Quality of Service

Advanced management of radio resources in WayMAX@vantage technology supports SLAs, definition of user classes, and QoS differentiation on a per-user and per-connection basis along with differentiation between uplink and downlink directions.

QoS is managed by the scheduling service centralized at the WayMAX@vantage Base Station. The air resources are assigned on a time domain basis (contention-free) to individual CPEs according to the four scheduling classes as defined in the 802.16 standard.

Incoming frames and packets are classified based on several IP and Ethernet criteria such as 802.1p priority field, 802.1Q VLAN ID, source and destination MAC address, IP masked source and destination address, differentiated services code point (DSCP)/IP type of service (ToS) field, and transport protocol source and destination port. WayMAX@vantage is therefore able to differentiate services like Web browsing, VoIP, and video streaming with the ability to map each of them into a different connection over the air interface.

4.7 Smooth Integration into All-IP Networks

WayMAX@vantage is conceived to be an integral part of an all-IP network. It supports VLANs, Ethernet, and IP over Ethernet traffic on Standard 100/1000BASE-T and Gigabit Ethernet WAN interfaces. It optimizes IP addressing with the possibility to support Dynamic Host Configuration Protocol (DHCP) server functionality on the CPE or to implement the DHCP server relay agent on the WayMAX@vantage Base Station. For QoS management the WayMAX@vantage behaves like a DiffServ node performing Ethernet or IP classification and implementing QoS mapping between Ethernet/IP classes and 802.16 classes

4.8 Innovation-Friendly Investment

WayMAX@vantage is a platform ready for 802.16e scalable OFDM access (SOFDMA) technology. Operators offering broadband fixed or nomadic services based on today's IEEE 802.16-2004 standard will be able to take advantage of new features (such as data session continuity for moving devices) introduced by advances in the 802.16 standard, while keeping the same deployed hardware.

More information on the WayMAX@vantage product line is available on the Siemens Website:
http://www.siemens.com/index.jsp?sdc_p=ft3mls2u1436o1270212i1269911pMNENcz3&sdc_bcpath=1302056.s_2,1269911.s_2,&sdc_sid=28932725850&

5 Transport Network

The WiMAX architecture is based on an end-to-end IP-based transport network. The classes of services defined within 802.16 are easily mapped onto Cisco QoS product configurations. A standards-based mechanism for mapping radio QoS to IP transport QoS is currently being defined in the WiMAX Forum. Regardless of the WiMAX Forum's signaling mechanism for mapping QoS, Cisco already supports a full set of technologies for end-to-end QoS connectivity across IP-based transport networks.

All QoS classes defined by the 3rd Generation Partnership Project (3GPP) are supported by the Cisco IP transport network. A simple non-standard-based (but very functional) QoS mapping can be applied immediately. Siemens and Cisco are leading the effort of the WiMAX Forum to standardize WiMAX to 3GPP/3GPP2 interconnectivity. Given the above described service classes and Cisco's comprehensive QoS implementation, any service class may be supported within the physical limitations of the deployed network.

The transport network is the binding element between the radio access and the operator core network. The architecture is based on IP technology. This may ensure easy and flexible deployment of new services at the cell site as well as a secure investment toward future architectures. Two main options are available for the access network:

- Layer 2-based access network, providing cost-effective traffic fast switching
- Layer 3-based access network, providing the benefit of managed IP services all the way to the WayMAX@vantage Base Station

The main components of this architecture are an aggregation switch or the IP router at the cell site and a highly scalable aggregation router at the operator point of presence (POP). These elements can be introduced into existing ATM, E1/T1, and microwave infrastructure while also providing support for next-generation broadband backhaul technologies.

5.1 Layer 2 Access Network

The Layer 2 access network provides a combination of traffic aggregation at Layer 2 and QoS management at Layer 2 and 3, resulting in a cost-effective solution for fast Layer 2 switching with QoS support. This solution comprises:

- Metro Ethernet connectivity
- Service Injection Point router

The Layer 2 access network is shown in Figure 2.

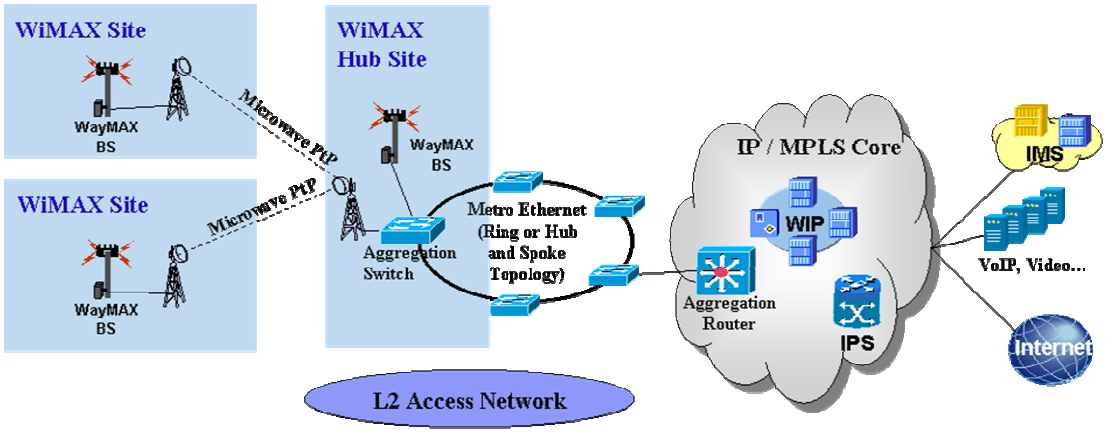
5.1.1 Metro Ethernet

This network provides bridged connectivity (unicast or multicast) between the subscriber's CPE and the operator's POP. The VLAN architecture model can be selected to provide a simple and optimal operation that also addresses the scalability issues that are behind the Ethernet broadcast medium. Physical topologies including hub-and-spoke and ring topologies are possible.

5.1.2 Service Injection Point

The Service Injection Point is the first IP/Multiprotocol Label Switching (MPLS) aggregation router. It is the point where either IP bridged subscribers or Point-to-Point Protocol over Ethernet (PPPoE) subscribers have access to the Layer 3 network.

Figure 2. Diagram of WiMAX Layer 2 Access Network



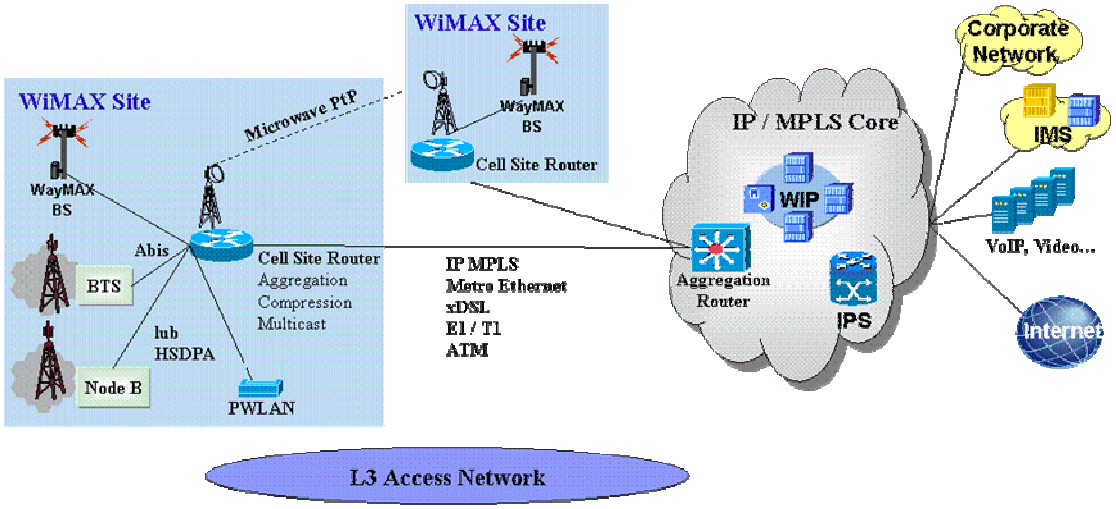
5.2 Layer 3 Access Network: Cell Site Router

The Layer 3 access network provides a cost-effective managed IP environment. The Layer 3 environment provides all the benefits of IP networks, including Layer 3 QoS management. This solution comprises three elements:

- Cell site router
- Transport network
- Aggregation router

Figure 3 shows the Layer 3 access network.

Figure 3. Diagram of WiMAX Layer 3 Access Network



5.2.1 Cell Site Router

The cell site router (CSR) connects different access technologies to the operator core network. This single network entry at the cell site allows an operator to consolidate the necessary transport networks, which yields direct savings in capital and operating expenses. Access technologies that can be connected to a cell site router include WiMAX, Global System for Mobile Communications (GSM), Code Division Multiple Access (CDMA), Universal Mobile Telecommunications Service (UMTS), PWLAN, 802.20, and more.

In addition to providing a simplified transport network, the CSR can take advantage of proven IP benefits enabling operators to build a highly available and cost-effective network. Example features include load balancing, high availability (reroute around failed links), full-featured QoS, multicasting, and VPN services.

5.2.2 Transport Network

Several different transport media maybe used between the WiMAX cell site and the aggregation site. The operator is given a broad selection to optimize its system. It is possible to reuse existing E1/T1 links as well as ATM networks. However due to the high data rate on WiMAX, transport media may also include IP MPLS, Metro Ethernet, microwave (such as PDH or SDH point-to-point links or PmP LMDS links), circuit based, and others.

5.2.3 Aggregation Router

The aggregation router concentrates traffic from multiple cell sites toward the operator core network. This high-availability, highly scalable network element helps ensure the delivery of next-generation service. Through the use of enhanced IP technologies such as multicast, QoS, and load balancing, the aggregation router enables services like video and radio broadcasting and provides an optimized, cost-effective backhaul link to the cell sites. Toward the core network, the aggregation router provides a full selection of high-speed interfaces (including Gigabit Ethernet and ATM) and efficient routing technologies such as MPLS.

6 Operator Core Network: WIP and IPS Platforms

6.1 Wireless Integration Platform

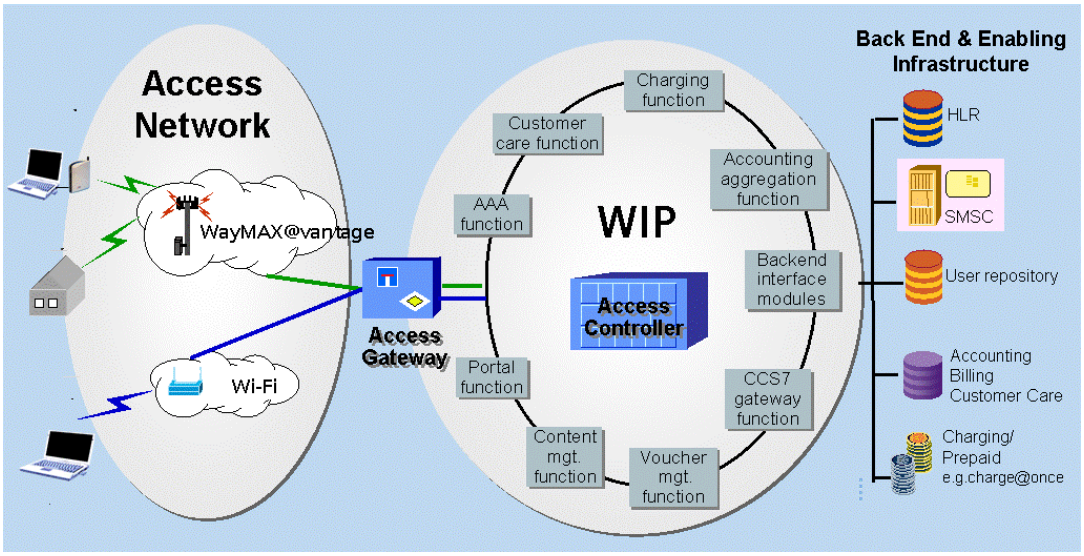
The Wireless Integration Platform (WIP) provides all the functions required for effective integration of WayMAX@vantage into any mobile or fixed operator or service provider environment through its IP-based open interfaces and standards compliancy. The same goal is also achieved with other IP-based access technologies such as Wi-Fi.

The WIP solution adopts highly capable products including an Access Gateway functionality. The access controller is operated at a central site where user traffic and signaling traffic are routed. (See Figure 4.)

6.1.1 High Modularity

The main components of the WIP are developed as separate modules. Only the required components need to be shipped, configured, and customized.

Figure 4. Diagram of WIP



6.1.2 High Availability in Load-Balancing Mode

WIP components may be deployed redundantly with hot-standby capabilities to provide high availability required for carrier-grade solutions. To increase the efficiency of the system, the redundant components operate in load-balancing mode. Under normal conditions the load is shared by both components. In case of a failure the operating part handles the entire load.

6.1.3 Easy Integration into Existing Networks

The WIP's modular architecture allows flexibility and reuse of existing infrastructure equipment, leading to savings in capital expenses.

6.1.4 Authentication and Billing

AAA operation can be based on user preregistration to the operator, paper vouchers (scratch cards), and electronic vouchers (SMS). In case of paper vouchers, the user receives a temporary user ID and password by scratching a paper voucher purchased at a hotel reception desk or airport drugstore. In the case of electronic vouchers, the user sends a cell phone number to the controller and receives temporary credentials through Short Message Service (SMS). In the case of preregistration, the user gets a permanent user ID and password supplied by the operator and receives a bill each month.

6.1.5 Broadband Access Anywhere

WIP supports services in fixed and nomadic environments and will accommodate the evolution of WayMAX@vantage toward Portable IP scenarios.

The WIP roaming solution is designed according to the WISP-r recommendation adopted within the Wi-Fi Alliance. The WIP would be adapted to support WiMAX access technology.

Mobile IP (MIP) based handover will be used for Portable IP scenarios; it allows data session continuity with best-effort performance during the network-managed handover procedure. MIP will also enable data session continuity between Wi-Fi, WiMAX, and 3GPP Universal Mobile Telecommunications Service/General Packet Radio Service (UMTS/GPRS) networks. In both cases, the handover latency will not guarantee real-time continuity of application sessions.

6.2 3GPP Interworking

WiMAX interworking with a 3GPP UMTS/GPRS mobile operator is a special case where the mobile operator has existing infrastructure that they want to reuse with a WiMAX access network. The WIP needs to be adapted to provide connectivity to the mobile operators existing services.

WiMAX–3GPP interworking solutions are based on the available results from WLAN and 3GPP UMTS/GPRS interworking specifications, which provide for loose-coupling and tight-coupling interworking scenarios.

Loose-coupling interworking is consistent with existing public WLAN interworking solutions and is a feasible solution for the near term. Loose coupling allows WiMAX to be an access network that complements current 2G/3G access networks, and does not require 3GPP protocols to be terminated at the WayMAX@vantage Base Station. This approach avoids changes to WiMAX standards and minimizes changes in existing 3GPP specifications, resulting in faster time to market for WiMAX solutions. This is currently in the focus of the WiMAX Forum.

IPS is a cost effective solution to the "Loose Coupling" approach[1] which is consistent with Public WLAN interworking solutions available on the market. The Figure 5 provides an example for Mobile Network Operator (MNO) scenario.

6.3 Intelligent Packet Solution

The Intelligent Packet Solution enriches conventional GSM/3GPP standard GGSN functionality with the ability of flow based charging for differentiated services by offering event, time, volume based charging for prepaid and postpaid customers on per service level (such as WAP, Web Browsing, Email, Streaming Video, etc.). The solution for IPS combines Cisco GGSN, SSG, CSG with Siemens servers for policy distribution and charging collection and management.

6.3.1 Advanced Billing Solutions

Up to now IPS has been implemented to integrate 2G/3G access technologies. The GGSN as part of the IPS terminates the GPRS Tunnel Protocol (GTP) tunnel, triggers subscriber authentication, unpacks the GTP information (IP packets) and forwards it to the Gi-node. The IP packets are then inspected by the Gi-Node of the IPS. Having the ability of deep packet inspection (L3-L7), the Gi-Node allows for differentiated charging models for event, time and volume based charging on protocol level.

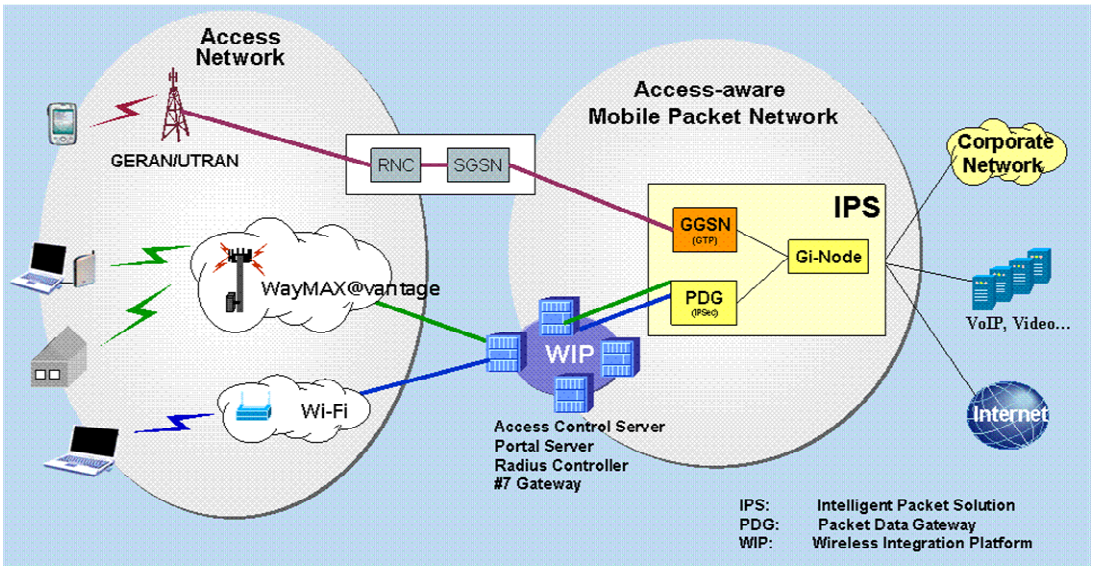
The capabilities of the Gi-Node may also be leveraged for WiMAX (as well as other alternative access technologies): similarly to 2G/3G access, a trigger function named PDG (Packet Data Gateway) interfaces the Gi-Node.

The Gi Node is reached after user access authentication which is provided by WIP (e.g. Portal authentication)

This allows the 3GPP Mobile Network operator to use the services provided by their current IPS solution to also support WiMAX and Wifi access networks.

Figure 5. Functional Diagram Showing 3GPP interworking and IPS.

[1] WiMAX interworking with 3GPP networks is being addressed within the WiMAX Forum following the same approach adopted in WLAN – 3GPP interworking specifications documents (e.g. 3GPP TR 23.934) providing both "Loose" and "Tight" Coupling interworking scenarios.



7 Conclusion

The power of WiMAX technology is attracting widespread industry attention. The latest developments from the 802.16 standardization are pushing broadband wireless access forward thanks to a standard with unique technical characteristics tuned for data (QoS, high capacity, and variable packet sizes on the air interface).

In parallel, the WiMAX Forum, backed by industry leaders, is pushing the widespread adoption of broadband wireless access by establishing a brand for the 802.16 technology and certification. Siemens and Cisco are principal members in the WiMAX Forum, driving the ongoing specification of a WiMAX-based end-to-end IP network which is a fundamental step toward interoperable IP-based solutions.

WiMAX access technology can be smoothly and cost-effectively integrated into existing fixed and mobile networks, reusing existing back-end infrastructure. Siemens and Cisco together offer a broad range of solutions based on their extensive radio and networking portfolio.

Siemens Mobile Communications S.p.A.
Sales Office
Viale P. e A. Pirelli, 10
20126 Milano - Italy
Phone + 39 02 243 1
B5.1 1766/500 • Siemens Mobile Communications S.p.A.

For further info:
Alessandro Casagni: alessandro.casagni@siemens.com
Michael Kaemper: mkaemper@cisco.com

Visit our website at **www.siemens.com**