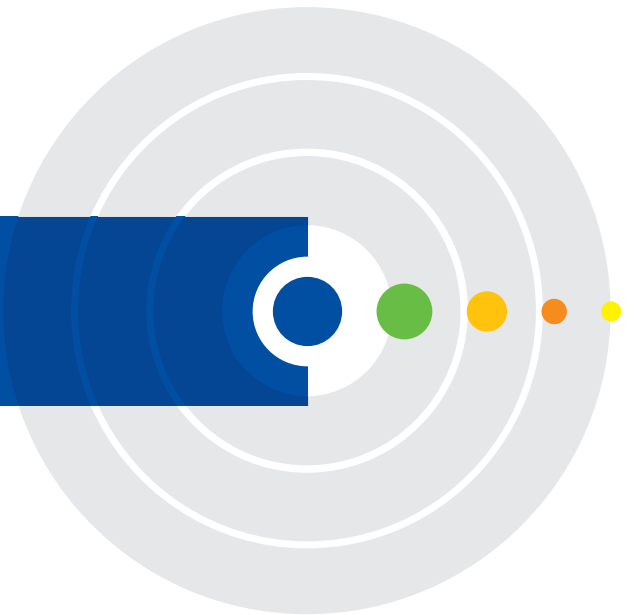




4Motion™

Solution Description

Solution Overview



Contents

Introducing 4Motion™	3
Solution Highlights	4
Main Components	4
Open Architecture and Interfaces	5
Distributed and Centralized Topology.....	5
Customer Premises Equipment.....	5
BreezeMAX Components	6
4Motion™ Networking Architecture	8
Network Reference Model	8
IP Architecture	12
Features and Applications	13
Radio and Air Interface Features	13
MS Network Entry Process.....	18
Quality of Service.....	19
Handover Control and Management.....	22
Security Features	23
Networking Features.....	24
Network and Element Management System.....	25

Introducing 4Motion™

Alvarion is a leading broadband wireless access vendor with over 30% global market share and more than 2 million deployed units in 130-plus countries. Alvarion provides solutions in a wide range of licensed and unlicensed frequency bands, and addresses every end-user market – whether large or small, residential or corporate.

The conditions now exist for mass-market adoption of broadband wireless access, and Alvarion believes WiMAX is the key to breaking through the last-mile barriers that have slowed such adoption worldwide.

After having engineered its leading BreezeACCESS™ wireless access system, Alvarion launched the WiMAX-certified BreezeMAX™ platform in June 2004. In so doing, the company demonstrated its pioneering and leadership position in the development of best-of-breed, carrier-class, standards-based WiMAX solutions. Alvarion also spearheaded the establishment of the WiMAX Forum, and holds executive positions as CFO and Marketing Working Group Chair of the prestigious organization.

Emanating from the broadband world and using all-IP architecture, mobile WiMAX is the leading technology for implementing personal broadband services. With huge market potential and affordable deployment costs, mobile WiMAX is on the verge of a major breakthrough. No other technology offers a full set of chargeable and differentiated voice, data, and premium video services in a variety of wireless fashions – fixed, portable and mobile – that increase revenue and reduce subscriber churn.

Leveraging leading technology and current favorable economics for broadband and mobile services, Alvarion's mobile WiMAX 4Motion solution represents the next evolution in communications.

With 4Motion, Alvarion offers a diversified range of products and services for all operators. Integrating the most advanced and adaptive radio management and control technologies, 4Motion optimizes usage of the operator's spectrum and network resources. At the same time, the solution supports the most stringent quality of service (QoS) requirements for next-generation applications such as gaming and video.

As a mobile solution, the 4Motion™ solution can be integrated with existing networks, including 3G, DSL, satellite, and cable, to provide multiple service applications.

Leveraging its leadership position in WiMAX and driven by BreezeMAX™ and now 4Motion™, Alvarion is taking the broadband market to its next level – the level of true mobile WiMAX.

Solution Highlights

Main Components

The Alvarion 4Motion product line has its foundations in the BreezeMAX platform. BreezeMAX is a mature, field-proven, carrier-class WiMAX 802.16e-2005 platform for fixed wireless access subscribers, which has been enhanced to support portable and mobile subscribers following mobile WiMAX/802.16e specifications. Fixed portable and mobile subscribers can connect to 4Motion through various end-user devices such as PC cards, compact flash devices, notebooks/PDAs, residential gateways and, once available, mobile WiMAX handsets.

Alvarion's solution enables operators and their customers to address the following consumer and enterprise market segments:

- Fixed (DSL equivalent) broadband access
- Portable broadband access
- "Personal broadband" (handheld) access
- Mobile broadband (including handover support)

4Motion™ supports the following services:

- IP-based services (e.g. VoIP, video streaming, gaming)
- QoS and application-based prioritization and de-prioritization

4Motion™ is designed as an end-to-end solution based on the following elements:

- The world most mature and deployed Radio Access Network (RAN) based on the BreezeMAX base station
- Access network with optional distributed or centralized access service network gateway (ASN-GW) provided by Alvarion and its leading WiMAX partners
- AAA servers provided by Alvarion and its leading WiMAX partners
- Home Agent
- Network and Element management system AlvariSTAR™ supporting NMS and OSS systems
- Customer premises equipment and handsets provided by Alvarion and its leading WiMAX partners

Figure 1 illustrates the entire service provider environment and 4Motion™ solution elements within the radio access network, core network and subscriber environment.

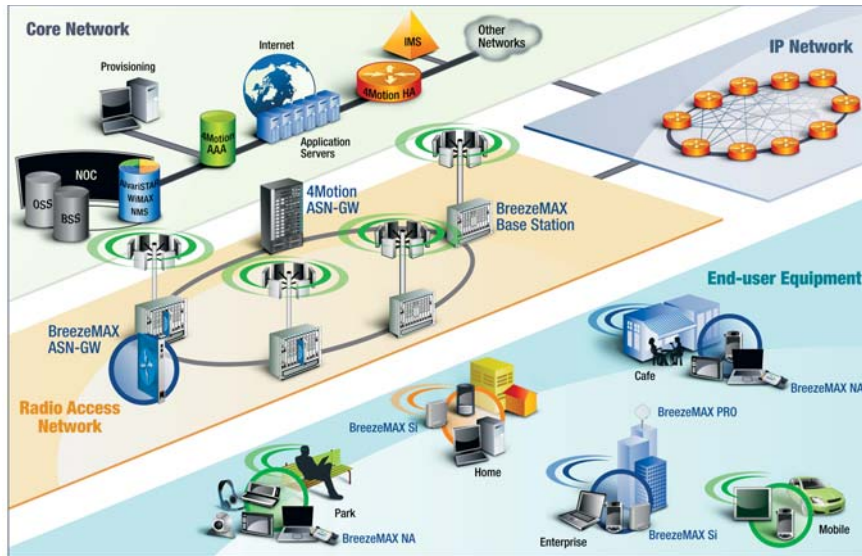


Figure 1: 4Motion™ in Operator Environment

Open Architecture and Interfaces

Alvarion believes that compliance with standard-driven open architecture protects the infrastructure investment, and opens the system to a variety of fully interoperable end-user devices. As such, 4Motion™ is designed with open architecture and interfaces according to the WiMAX Forum networking working group (NWG) profile C.

Distributed and Centralized Topology

Alvarion believes in providing operators with the flexibility to select the mobile WiMAX network topology that best suits their needs and existing network architecture. Therefore, 4Motion™ is designed to support both distributed and centralized topology approaches according to WiMAX Forum NWG profile C.

Customer Premises Equipment

Alvarion offers a variety of self-installable, portable, all-indoor CPE devices. Alvarion operates with leading user device vendors in order to ensure interoperability between 4Motion and a variety of use devices. This includes WiMAX/802.16e PC cards, compact flash cards, notebooks and PDAs. With a variety of interoperable user devices, Alvarion provides greater flexibility for operators and users.

BreezeMAX Components

Alvarion's 4Motion™ solution features a multi-carrier, high-power base station - BreezeMAX. Designed for high availability and redundancy, BreezeMAX utilizes a central networking and management architecture, and a range of diversity schemes. A BreezeMAX platform is comprised of a 19" rack-mounted indoor shelf and outdoor units (ODUs).

Figure 2 shows the shelf architecture.

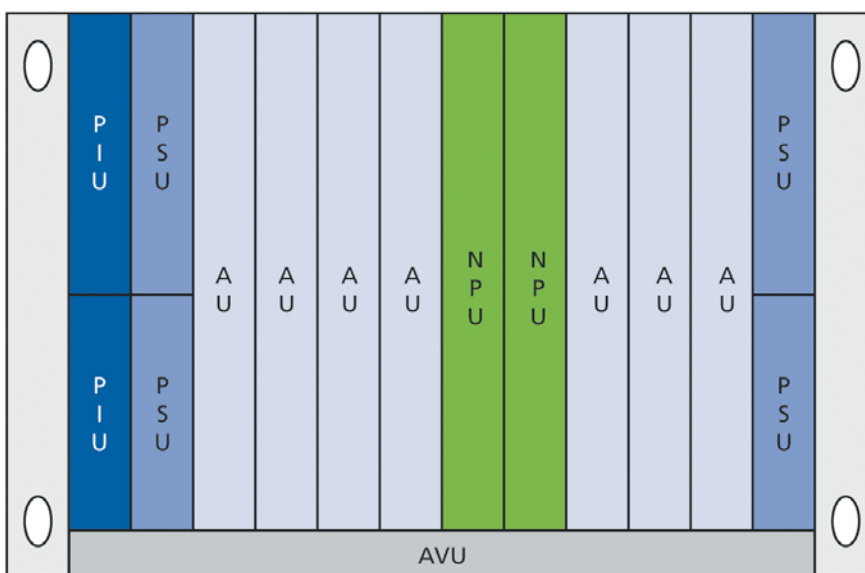


Figure 2: Shelf Architecture

Shelf Card Types

BreezeMAX is comprised of the following shelf card types:

Air Ventilation Unit (AVU): The 2U-high AVU includes a 1U-high integral chamber for inlet airflow and a 1U-high fan tray that includes 10 brushless fans and an internal alarm module.

Power Supply Unit (PSU): The PSU module is a -48 VDC power supply unit that generates low-voltage DC output to comply with PIMG 2.x standard requirements. Each BreezeMAX can contain up to four PSU modules supporting a 3+1 redundancy configuration scheme.

Power Interface Unit (PIU): The PIU is a 3U unit that interfaces between the external 48 VDC power source and both the PSU modules and external ODU outdoor radio transceivers. The ODUs receive power through the AU cards and power feeders, depending on the BreezeMAX configuration.

The PIU filters and stabilizes the BreezeMAX input power, and protects the system from power problems such as over-voltage, surge pulses, reverse polarity connection, and short circuits. It filters high-frequency interference (radiated emissions) and low-frequency interference (conducted emissions) at the external power source.

Access Unit (AU): The AU is a 6U unit that implements the WiMAX/IEEE 802.16e base station function according to the NWG Profile C definitions via digital signal processors (DSPs) and field-programmable gate array (FPGA) technology. Alvarion's AU card is designed to support high-traffic throughput and to enable diversity, MIMO and AAS, thereby extending capacity and range.

Network Processing Unit (NPU): The NPU is a 6U unit that can operate in either transparent or ASN-GW mode.

When operating in transparent mode, the NPU implements aggregate backbone Ethernet connectivity for the BreezeMAX users' data, control and management traffic, shelf interface configuration and control, internal and external traffic VLAN encapsulation, shelf card management (e.g. card startup and shutdown, card firmware), an SNMP and CLI agent for shelf cards, CPU rate limiting, access lists, and QoS marking.

When operating in ASN-GW mode, the NPU implements ASN-GW decision point (DP) and enforcement point (EP) functionality according to the WiMAX Forum networking working group (NWG) specifications in addition to the transparent mode functionalities.

Outdoor Unit (ODU): The ODU is a high power radio transceiver unit that amplifies and frequency-converts signals from the AUs to the antennas and vice-versa. BreezeMAX ODUs support the 2.3 GHz, 2.5 GHz and 3.5 GHz bands, in 1x1, 2x1 and 4x2 diversity configurations.

4Motion™ Networking Architecture

Network Reference Model

Figure 3 and Figure 4 show the basic mobile WiMAX network architecture, with and without multiple ASN-GWs, as defined by the WiMAX Forum NWG.

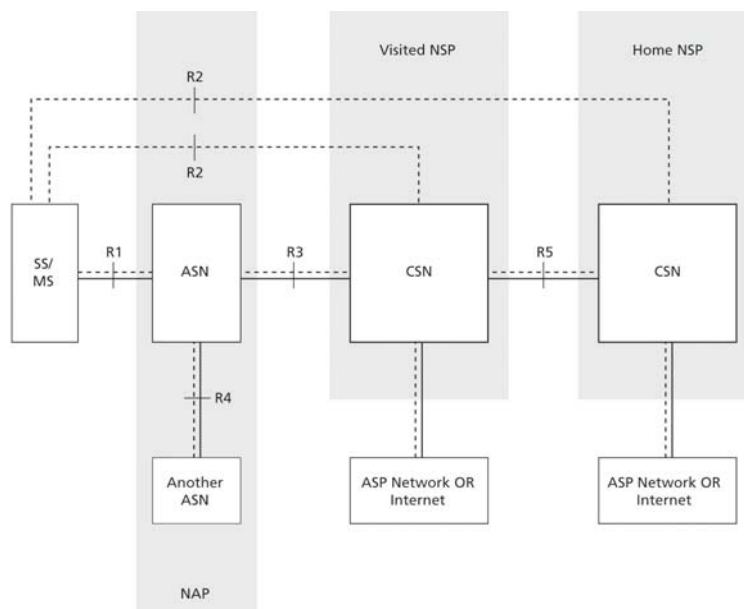


Figure 3: Mobile WiMAX Network Reference Model

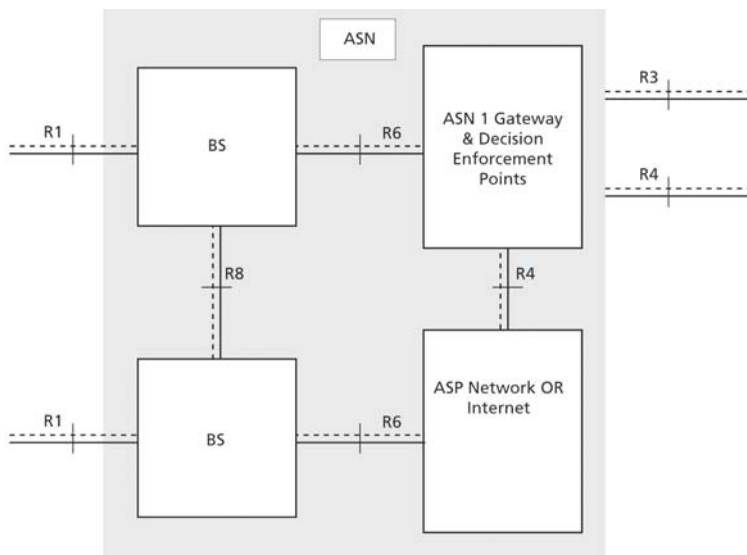


Figure 4: ASN Reference Model containing Multiple ASN-GWs

The various components and entities involved in the networking architecture are described below:

Access Service Network (ASN): An ASN is defined as a complete set of network functions needed to provide radio access to a WiMAX subscriber. An ASN is comprised of network elements such as one or more base stations and one or more ASN gateways.

Connectivity Service Network (CSN): A CSN is defined as a set of network functions that provides IP connectivity services to WiMAX subscribers. A CSN is comprised of network elements such as routers, proxy/servers, user databases, and inter-working gateway devices.

Network Access Provider (NAP): An NAP is a business entity that provides WiMAX radio access infrastructure to one or more WiMAX network service providers (NSPs). An NAP implements this infrastructure using one or more ASNs.

Network Service Provider (NSP): An NSP is a business entity that provides IP connectivity and WiMAX services to WiMAX subscribers compliant with the established service level agreement (SLA). The NSP concept is an extension of the Internet service provider (ISP) concept, providing network services beyond Internet access. To provide these services, an NSP establishes contractual agreements with one or more NAPs. An NSP may also establish roaming agreements with other NSPs and contractual agreements with third-party application providers (e.g. ASP, ISP) for the delivery of WiMAX services to subscribers.

Base Station (BS): The WiMAX BS is a logical entity that implements the WiMAX MAC and PHY in compliance with the IEEE 802.16e standard. A BS operates on one frequency assignment, and incorporates scheduler functions for uplink and downlink resources.

ASN Gateway (ASN-GW): The ASN-GW is a network entity that acts as a gateway between the ASN and CSN. The ASN functions hosted in an ASN-GW may be viewed as consisting of two groups – the decision point (DP) and enforcement point (EP). The EP includes bearer plane functions, and the DP includes non-bearer plane functions.

The WIMAX Forum NWG has adopted two different approaches for ASN architecture – centralized and distributed.

The following explains the 4Motion implementation of the two types of architectural deployment.

The 4Motion Centralized Approach

In a centralized approach there is at least one central ASN-GW provided by an Alvarion WiMAX partner, and the BreezeMAX NPU which operates in transparent mode, as shown in Figure 5.

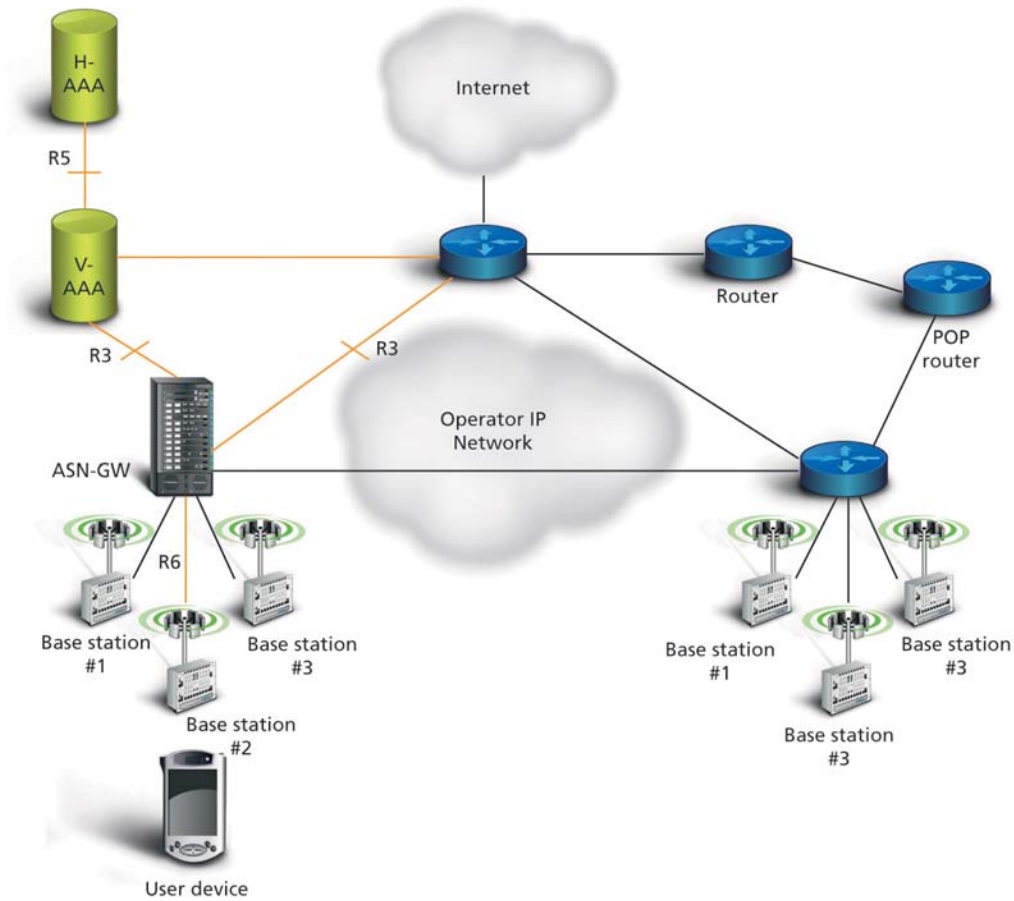


Figure 5: Centralized Network Reference Model

The 4Motion Distributed Approach

In the distributed approach, the BreezeMAX NPU operates in ASN-GW mode, as shown in Figure 6.

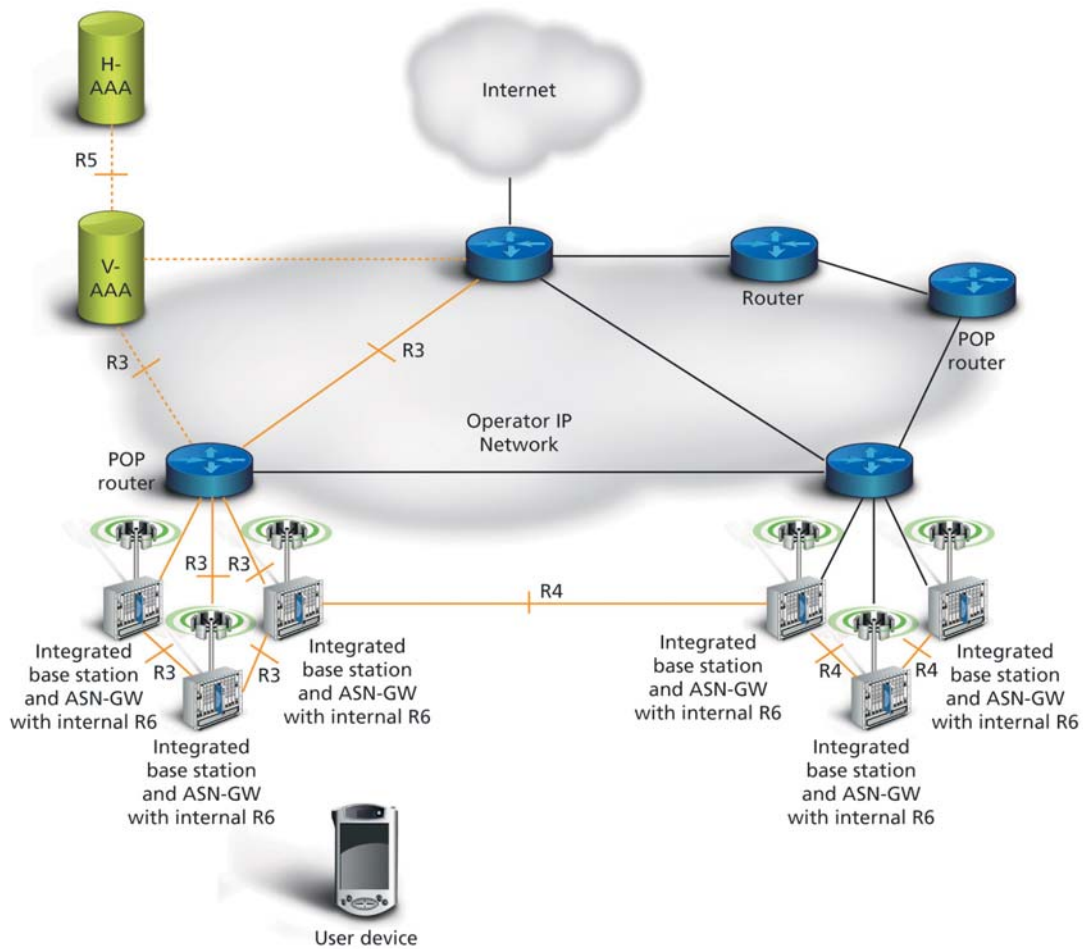


Figure 6: Distributed Network Reference Model

By supporting the two NPU modes Alvarion's 4Motion solution supports both centralized and distributed approaches.

IP Architecture

4Motion™ implements the IEEE 802.16e IP convergence sub-layer (IP-CS). Consequently, all user traffic exchanged between network entities in the reference model is Layer-3 IPv4 traffic.

Internal communication between ASN/CSN entities uses the IPv4 protocol. For this purpose, every entity in the ASN/CSN has its own IP address or addresses.

A guiding principle of the IP architecture is the isolation of different address domains as follows:

- User Address Domain – IP addresses assigned to MSs for user traffic (e.g. between the MS and a WWW server in the Internet)
- ASN/CSN Address Domain – IP addresses assigned to the ASN and CSN entities for control and encapsulated user traffic
- Network Management Domain – IP addresses assigned to ASN and CSN entities for network management traffic (e.g. SNMP messages between the NMS server and NPU)
- Internal Management Domain – IP addresses assigned to BTS entities for internal management traffic (e.g. BS auto-configuration by NPU)

Address domain isolation simplifies network-planning tasks by precluding the need for coordination when allocating IP addresses. It also improves network security by isolating the user, control and management networks.

IP Address Management

IP addresses for ASN entities (e.g. ASN-GWs, BSs) are manually allocated by the operator.

The MS IP address (from the user address domain) and required network parameters (e.g. subnet mask, default gateway, DNS servers) are obtained by the MS via DHCP. The IP address can be assigned either by the ASN-GW, an external DHCP server or the NSP AAA server.

Features and Applications

4Motion™ maintains a host of features and applications that help make it a comprehensive and compelling offering for operators. From radio and air interface and security features to QoS and handover control and management, the solution delivers a broad set of functionality that meets the growing needs of operators worldwide.

Radio and Air Interface Features

Each BreezeMAX AU card implements a single WiMAX BS entity that transmits and receives to/from the registered MSs over a 5/10 MHz frequency channel (with higher frequencies to become available), selectable by the operator, through one or more ODUs.

The transmitted signal is modulated using the orthogonal frequency division multiplex (OFDM) technique, by which the data stream is divided into several parallel sub-streams of a lower data rate, thereby increasing symbol duration. Each sub-stream is modulated and transmitted on a separate orthogonal sub-carrier. The increased symbol duration, together with the inclusion of a cyclic prefix (CP) between symbols, drastically improves system performance in non-line-of-sight (NLOS) scenarios.

In addition, the orthogonal frequency division multiplex access (OFDMA) technique allows the BS to simultaneously transmit and receive to/from different MSs in different sub channels, thereby improving system efficiency by reducing bandwidth allocation granularity.

A sub-channel is a group of sub-carriers that forms the base for bandwidth allocation. BreezeMAX employs partial usage of sub channels (PUSC) via a sub-channel allocation method in both downlink and uplink directions. This method provides the frequency diversity required for operating in high-mobility NLOS scenarios, while allowing different reuse patterns and flexible resource allocation.

OFDMA Sub-carriers

There are three types of OFDMA sub-carriers:

- Data sub-carriers for data transmission
- Pilot sub-carriers for channel estimation and synchronization
- Null sub-carriers for guard bands and DC sub-carrier

Before modulation, data is processed with a highly efficient error-correcting code called convolutional turbo coding (CTC). Data is coded and modulated in data sub-carriers using different modulation coding schemes (MCS).

The MCS used for each burst transmission is dynamically selected on a per MS, service type and burst basis.

Scalable OFDMA

To support different channel bandwidths (5 or 10 MHz) without compromising system efficiency and coverage, scalable OFDMA (SOFDMA) is used. SOFDMA maintains constant symbol duration by modifying the FFT size and related parameters in accordance with the selected channel bandwidth.

The sub-channel capacity, and as a result, bandwidth allocation granularity, also remains constant for the different channel bandwidths.

Air Frame Structure

The IEEE 802.16e media access control operates on a scheduled protocol where the BS allocates bandwidth for uplink and downlink transmissions on a per-air frame basis.

The 5 ms air frame is divided between downlink and uplink sub-frames, separated by transmit/receive (TTG) and receive/transmit transition gaps (RTG). To avoid BS-BS interference, the uplink/downlink duration ratio must be identical in all BSs in a geographical region. Air frames are synchronized among different BSs through a GPS-based system.

The different zones that constitute the air frame are illustrated in Figure 7 and described thereafter.

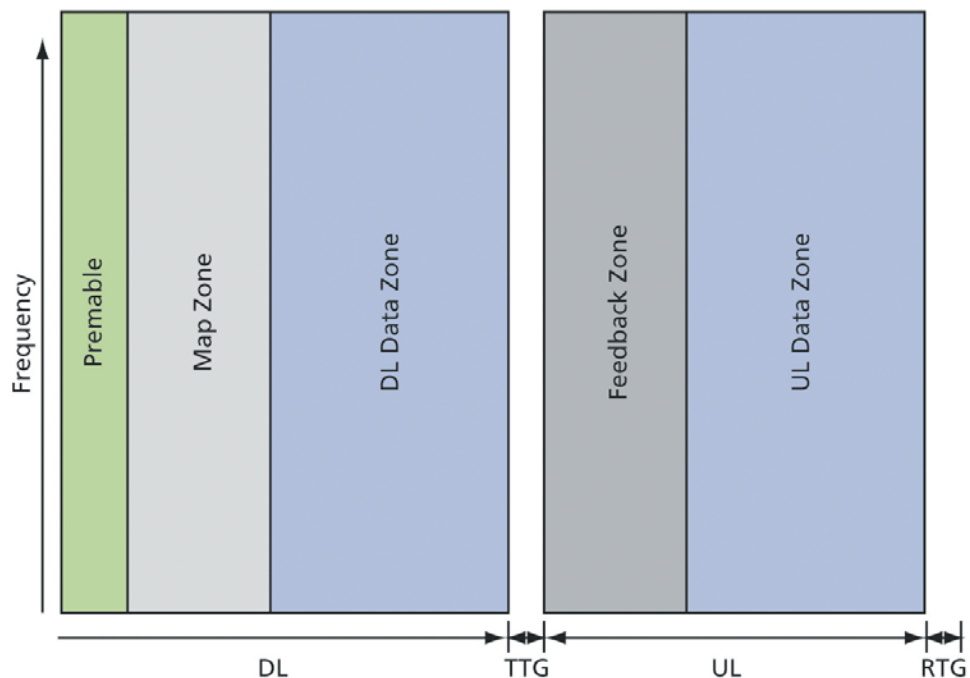


Figure 7: Air Frame High-Level Structure

Preamble: A short preamble used for synchronization is transmitted by the BS at the beginning of each frame.

Map Zone: This zone includes the frame control header (FCH) and downlink and uplink maps (DL-MAP, UL-MAP). The FCH is transmitted by the BS following the preamble, and contains information enabling the MS to decode subsequent maps.

The maps are transmitted following the FCH to inform the MSs about the bandwidth allocated by the BS for transmission over downlink connections in the current frame and uplink connections in the following frame.

Downlink allocations maximize the number of subchannels allocated to each MS in order to increase frequency diversity for downlink transmissions. Uplink allocations, on the other hand, minimize the number of subchannels allocated to each MS, thus improving the uplink link budget, and as a result, uplink capacity and coverage.

Downlink Data Zone: This zone is used by the BS to transmit user traffic and control messages (unicast and broadcast) to the MSs.

Feedback Zone: This zone is used by the MSs to transmit feedback information to the BS. The feedback zone is comprised of the ACK channel, CQI channel and CDMA ranging allocations.

Uplink Data Zone: This zone is used by the MSs to transmit user traffic and control messages to the BS.

Frequency Reuse

4Motion™ supports various frequency reuse schemes, enabling the operator to select the design that best suits its frequency allocation and requirements. The chosen scheme impacts network coverage, performance, spectral efficiency, and aggregate capacity.

There are two primary frequency reuse schemes – reuse 1 and reuse 3.

Reuse 1: In this scheme, all BSs in the network operate on the same frequency channel (5 or 10 MHz). Interference between BSs can be averaged by using different permutations when grouping frequency subcarriers into subchannels for each BS.

Reuse 1 maximizes the network spectral efficiency, and as a result, the aggregate capacity for a given frequency allocation. It can be utilized in all air-frame zones¹.

Reuse 3: In this scheme, the available spectrum is divided into three frequency groups assigned to different BSs in order to maximize coverage by reducing interference among them.

There are two ways to achieve a reuse factor of three in an OFDMA network – frequency channel reuse 3 – $N_L \times FA \times 1 \times 3 \times 3$ ($FA = N_L$) and frequency sub channel reuse 3 – $N_L \times FA \times 1 \times 3 \times 3$ ($FA=3N_L$).

In the frequency channel reuse 3 method, the frequency allocation is divided into three different frequency

¹ Using reuse 1 in the map zone leads to reduced BS coverage due to IEEE 802.16e protocol limitations (specifically the inability to use different permutations in the map zone).

channels (5 or 10 MHz) that are assigned to the different BSs. This method is applied to all air-frame zones.

In the frequency sub channel reuse 3 method, each frequency channel is divided into three sub channel groups² that are assigned to different BSs in order to maximize coverage by reducing interference among them. Reuse 3-SC is utilized only in the map and downlink data zones.

Diversity Techniques

BreezeMAX supports different mechanisms for exploiting the transmission channel diversity in order to improve network coverage.

Diversity techniques are available both in the downlink (transmit diversity) and uplink (receive diversity) direction, and can be independently configured and combined.

The following sections describe the available transmit and receive diversity mechanisms.

Transmit Diversity – MIMO/STC: In the multiple input multiple output (MIMO) Matrix A mechanism, also known as space time coding (STC) or Alamouti, the BS transmits the same information over two transmission paths, appropriately coded in space and time. This mechanism provides second-order diversity in the downlink direction.

Implementation of MIMO Matrix A requires MS support of this technique. MIMO Matrix A can be used only in the downlink data zone.

Transmit Diversity – Delay Diversity: In the delay diversity technique, the BS transmits the same information over several transmission paths with a specific delay applied to each transmitted signal. This mechanism achieves up to fourth-order diversity, depending on the number of transmitters employed.

The delay applied can be linear – whereby each transmitted data stream is simply delayed in time – or cyclical – whereby the symbols in each data stream are cyclically shifted by the specific delay before transmission. There are no specific requirements at the MS for implementing delay diversity techniques, which can be used in both the map zone and downlink data zone.

Receive Diversity – MRC: In the receive direction, the BS coherently combines signals received from different receive paths using the maximal ratio combining (MRC) technique. MRC provides up to fourth-order diversity, depending on the number of receivers employed.

There are no specific requirements at the MS for implementing the MRC technique, which can be used in both the feedback zone and uplink data zone.

Power Control

To increase network capacity in the uplink direction by reducing interference between neighboring BSs, the 4Motion™ BS adjusts MSs transmit power to receive their transmitted signals as close as possible to an optimal power level. The power control algorithms are optimized for an environment where link conditions continuously vary.

² Based on subcarrier major groups defined in IEEE 802.16e standard.

The BS can employ two different mechanisms to control transmit power for each MS: open-loop power control and closed-loop power control.

Open-Loop Power Control: When using this mechanism, the MS estimates its air link path loss and, based on uplink/downlink channel reciprocity, calculates the transmit power it should use to be received by the BS at the optimal power level. Additionally, the BS applies MS-specific power corrections when it detects that the received power from the MS deviates from the power target beyond a specified margin.

The open-loop power control mechanism allows the MS to calculate the required transmit power as often as on a per-frame basis. These fast tracking capabilities, coupled with the low protocol overhead, make it the preferred power control mechanism used by the BS.

Closed-Loop Power Control: When using this mechanism, the MS adjusts its transmit power only according to corrections it receives from the BS. The BS sends these corrections to each MS whenever the received power for the specific MS deviates from the power target beyond a specified margin.

In the closed-loop power control mechanism, there is a delay of several frames between the BS decision to send a power control correction until the MS implementation of the correction. In addition, there is a significant overhead of power control signaling overhead as every change in MS uplink power necessitates an explicit message from the BS.

For these reasons, closed-loop power control is only used in cases when the open loop mechanism is not effective.

Dynamic Power Control Mode Selection: The BS can dynamically select which of the two power control mechanisms, or modes, to use, on a per-MS basis.

Hybrid ARQ

Hybrid Automatic Repeat Request (HARQ) is a central feature of 4Motion™ that increases network coverage and capacity, especially in NLOS mobile environments where channel conditions can change rapidly and unpredictably. 4Motion™ HARQ implementation uses chase-combining HARQ.

Like the traditional ARQ mechanism, HARQ reduces and even eliminates errors in the channel by retransmitting errored bursts that cannot be corrected by the channel coding. In a mobile environment where MS channel conditions can significantly change after a few frames have elapsed, ARQ/HARQ mechanisms considerably enhance system performance.

Rate Adaptation

The goal of the BS rate adaptation mechanism is to select the MCS to be used in downlink and uplink transmissions so that throughput will be maximized while complying with service flow QoS requirements.

While the HARQ mechanism handles the BS response to short-term, rapid changes in channel conditions, the rate adaptation mechanism controls the BS response to longer-term changes in channel conditions.

The rate adaptation mechanism builds and maintains a set of rate selection tables that are used by the

scheduler to allocate BS and MS transmissions with the appropriate MCS based on the MS CINR. The rate selection tables are independently maintained for each MS and for the downlink and uplink directions.

For this purpose, the rate adaptation mechanism collects data relating to channel conditions and performance for all connected MSs from a number of sources.

The rate adaptation algorithm uses the collected data to dynamically adapt the rate selection tables to actual channel conditions.

MS Network Entry Process

Upon activation, the WiMAX mobile station (MS) initiates a process through which it connects to the WiMAX network. This process is known as network entry process. This section describes the major stages of the network entry process.

Network Advertisement and Selection

As part of the network entry process, an MS must select the network it will attempt to join, from among those network operators that cover the MS current location. For this to occur, the BS advertises the network operator “operator ID” in its downlink transmissions. The operator ID is a WiMAX Forum-assigned ID that uniquely identifies each network operator and is part of the “base station ID” that identifies every operator BS.

The MS will perform scanning and synchronization over all, or some, of the channels in the frequency band, and in the process will collect operator IDs of network operators in the coverage area.

Then, based on vendor-selected preference criteria (e.g. a provisioned prioritized list of operators), the MS will select which network it will attempt to join, and continue the network entry process with this operator network.

Authentication Process

One of the basic capabilities negotiated is the “authorization policy” to be used. 4Motion™ supports single-EAP mode. The purpose of the authentication process is to generate security material that will allow both the MS and BS to verify the authenticity of the air interface control messages they will subsequently exchange (e.g. to complete the registration process), using the CMAC authentication algorithm.

Different authentication methods, such as EAP-AKA, EAP-TLS or EAP-TTLS³, can be used on top of the EAP protocol, without changes to the ASN components (BS and ASN-GW). Depending on the selected method, different security credentials should be provisioned in the MS and AAA server, such as passwords, X.509 certificates, and SIM cards.

Authentication can be performed on the MS user credentials, MS device credentials, or both. The user and/or device credentials are authenticated against the AAA server in the CSN.

³ Specific EAP method support depends on AAA server and MS support

Establish IP Connectivity and Service Flows

Data Path Establishment: As part of the process of creating a new user, the operator will associate the user with a specific operator-defined service profile, which defines the service flows that will be established for this user.

At the end of a successful EAP initial authentication process, the AAA server will send the user provisioned authorization profile to the ASN-GW containing the user service profile name.

In the air interface, the BS will perform admission control for the requested service flows. If they are admitted, the BS will create an 802.16e connection for each one. In the ASN, a GRE tunnel will be established between the ASN-GW and BS for each provisioned service flow.

The ASN-GW is responsible for classifying downlink traffic per service flow into GRE tunnels, based on the classification rules in the user service profile. The BS will forward uplink packets into the relevant GRE tunnels and downlink packets into the relevant 802.16e connections.

MS IP Address Allocation: At this stage, the MS will obtain an IP address for user traffic. Subsequently, the allocated IP address will be included as "IP Destination Address" in the downlink classification rules for the service flows of this MS. As a result, incoming user traffic for this MS will be adequately classified and forwarded. Also at this point, the ASN-GW will update the MS service flows packet header suppression (PHS) rule for suppressing/inserting the MS IP address field in user traffic packets.

Quality of Service

4Motion™ allows operators to provide guaranteed end-to-end QoS for user traffic across the ASN. To achieve this, several network entities in the ASN need to be coordinated and involved in making QoS-related decisions, enforcing QoS policy and efficiently managing network resources to comply with QoS requirements.

The overall QoS approach is connection-oriented, whereby user traffic is classified into "service flows." A service flow is a unidirectional stream of packets, either in the downlink or uplink direction, associated with a certain set of QoS requirements (e.g. maximum latency, minimum rate). Service flows are transported over the R1 air interface in 802.16e transport connections, and over the R6 interface in GRE tunnels.. In addition, the ASN-GW can mark outgoing traffic in the R3 interface for further QoS processing within the CSN.

The QoS requirements for service flows are derived from "service profiles" defined by the operator. A service profile is a set of attributes shared by a set of service flows. For instance, an operator might define a service profile called "Internet Gold" that will include QoS and other definitions to be applied to service flows associated with users subscribed to the operator's "Internet Gold" service package.

End-to-End QoS

Several entities are involved in the QoS framework, helping 4Motion™ provide end-to-end quality of service across the ASN.

QoS Parameters and Service Types

Different QoS requirements lead to different QoS policies used by the entities involved. For instance, connections carrying delay-sensitive traffic (e.g. voice) will be handled differently from connections carrying delay-tolerant traffic (e.g. Web browsing). The IEEE 802.16e standard defines different data delivery service types, each of them with a certain set of QoS parameters as shown in Table 2-1.. Each transport connection (i.e. a connection carrying user data) in the R1 air interface is associated with one of these service types.

Table 1: Data Delivery Service Types

Scheduling Type	Application	QoS Parameters
UGS (unsolicited grant service)	Real-time applications generating fixed-rate data such as voice over IP without silence suppression	<ul style="list-style-type: none"> • Maximum latency • Tolerated jitter • Minimum reserved traffic rate • Service Data Unit (SDU) size • Unsolicited grant interval
ERT-VR (extended real-time variable rate service)	Real-time applications with variable bit rates that require guaranteed data rate, delay and low jitter such as voice	<ul style="list-style-type: none"> • Maximum latency • Tolerated jitter • Minimum reserved traffic rate • Maximum sustained traffic rate • Traffic priority • Unsolicited polling interval
RT-VR (real-time variable rate service)	Real-time applications with variable bit rates that require guaranteed data rate and delay such as streaming video	<ul style="list-style-type: none"> • Maximum latency • Minimum reserved traffic rate • Maximum sustained traffic rate • Traffic priority • Unsolicited polling interval
NRT-VR (non-real-time variable rate service)	Real-time applications with variable bit rates that require guaranteed data rate and are delay-tolerant such as file transfers	<ul style="list-style-type: none"> • Minimum reserved traffic rate • Maximum sustained traffic rate • Traffic priority
BE (best-effort service)	Applications with no strict rate or delay requirements	<ul style="list-style-type: none"> • Maximum sustained traffic rate • Traffic priority

QoS Management in the WiMAX Network

To enable the operator to provide end-to-end QoS across the ASN and even the CSN (e.g. when providing corporate VPN services), all ASN entities (BS and ASN-GW) can mark outgoing control, management and user traffic with DiffServ Code Points (DSCP) and/or 802.1p priority bits for appropriate QoS handling by the ASN and CSN networks.

QoS Management in the BS

Following WiMAX Forum NWG Profile C architecture, radio resource control and management (RRC and RRM) functions that deliver QoS take place locally within the BS.

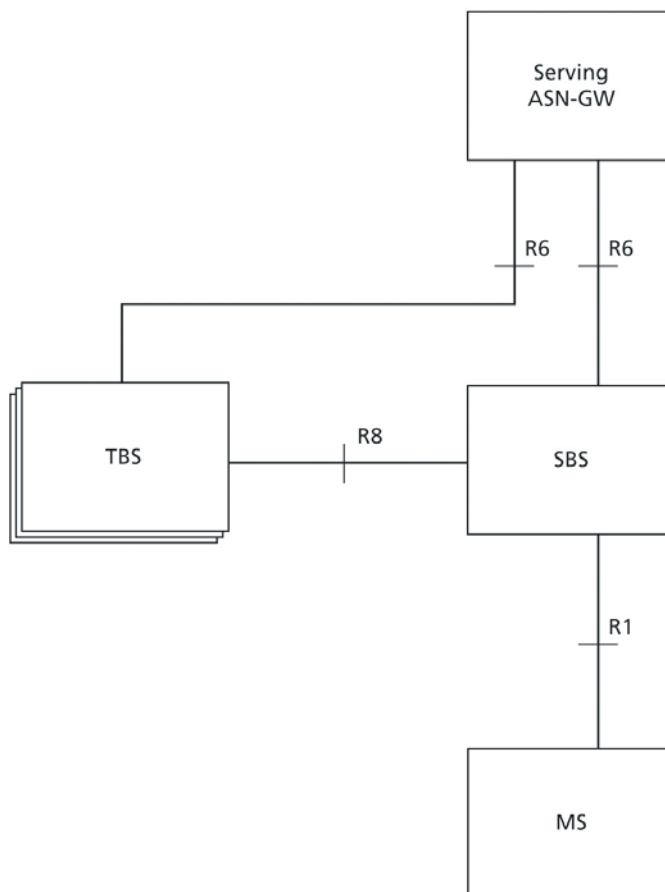
To enable the operator to guarantee minimum radio capacity for specific service types (e.g. voice, video), the available radio resources are allocated by the BS scheduler among the various service flows.

The BS scheduler decides how to divide the available radio resources between the active service flows on a per-air frame basis. The scheduler makes real-time decisions based on a range of inputs including available radio resources, MCS used by each MS from rate adaptation module and active service flow QoS requirements (e.g. traffic rate, latency).

Handover Control and Management

4Motion™ supports network-assisted, MS-controlled seamless handover between different BSs. The solution implements several mechanisms that optimize the handover process by assisting the MS in its choice of target BS, and by transferring MS-related information between the serving and target BS across the operator backbone. As a result, handover completion time is significantly reduced.

Figure 8 shows the entities participating in the handover process and their potential interconnections across reference points.



All of the entities involved in the handover process are described in Table 2.

Table 2: Handover Participating Entities

Name	Description
Anchor ASN-GW	ASN-GW that interconnects the MS data paths with the CSN through the R3 reference point, as the MS moves across different BSs
MS	Mobile station
SBS (serving base station)	Base station to which the MS is connected before the handover
TBS (target base station)	Base station to which an MS may potentially hand over. There might be more than one TBS during HO preparation stage.

The anchor ASN-GW will continue to serve the MS as it moves across different BSs. Upon BS handover, the anchor ASN-GW will establish new data paths with the target BS via the R6 interface.

Security Features

4Motion™ maintains a number of security features as described below.

Control Plane Authentication

4Motion™ supports the use of EAP methods to mutually authenticate the MS and/or the user against the operator AAA server. Subsequently it also verifies the authenticity of the air interface control messages the BS and MS will exchange, using the CMAC authentication algorithm.

User Plane Authentication and Encryption

At the end of a successful EAP authentication process, the BS and MS will negotiate the user data authentication and encryption policy (“ciphersuite”) to be used. The possible options are:

- No user data authentication and no user data encryption
- AES-CCM for both user data authentication and encryption

If AES-CCM is selected, the BS will generate and securely provide the MS with the TEKs (Traffic Encryption Keys) that will be used to both authenticate and encrypt user traffic with the AES-CCM data encryption algorithm. The TEKs will be periodically refreshed.

IP Spoofing Protection

The ASN-GW verifies that the source IP in uplink traffic from each MS matches the IP address provided by the ASN-GW during the MS IP address allocation process. This verification can prevent different types of IP-spoofing attacks, such as denial of service attacks.

Figure 8: Handover Logical Architecture

Networking Features

This section describes major 4Motion™ networking and security features.

User Traffic Classification

Downlink user traffic is classified by the ASN-GW into GRE tunnels, which, in turn, are mapped into 802.16e connections in the air interface. The operator can select the rules according to which user traffic will be classified, called “classification rules,” that are part of the service profile provisioned in the ASN-GW.

Packet Header Suppression

Packet header suppression (PHS) is a mechanism that conserves air-interface bandwidth by removing parts of the packet header that remain constant along the traffic session. PHS operates by allowing the MS and ASN-GW to associate PHS rules to each service flow. Each PHS rule basically specifies which header fields are candidates for suppression and the expected constant value for each field.

Accounting

4Motion™ enables the operator to bill its customers based on connection time and time of day. For this purpose, the ASN-GW sends RADIUS-based accounting messages to the operator AAA server, which, in turn, sends usage data records (UDRs) to the operator billing system.

Roaming

4Motion™ supports access to CSN resources (e.g. Internet access) while the MS is in a visited WiMAX network that has a roaming agreement with its home network operator.

De-registration

MS de-registration is a process that terminates the MS connection to the serving BS and ASN-GW. De-registration conserves network resources by releasing all MS-related information stored at the ASN-GW and BS (“MS context”), and tearing down the data paths previously established for the MS service flows.

MS de-registration can be initiated by the MS itself, serving BS, or ASN-GW.

Network and Element Management System

AlvariSTAR™

AlvariSTAR™ is a comprehensive, carrier-class network and element management system (EMS) for Alvarion networks. Designed for today's most advanced network operation centers, AlvariSTAR™ provides OA&M staff with all network surveillance, monitoring, configuration, and service provisioning capabilities required to effectively manage the network, while keeping resources and expenses at a minimum. At the same time, AlvariSTAR™ provides operators with a robust and scalable network management system.

AlvariSTAR™ offers network OA&M staff a unified, scalable and distributable network management system. Utilizing distributed client-server architecture, the system gives the service provider a robust, scalable and fully redundant network management system in which all single points of failure can be avoided.

AlvariCRAFT™

Alvarion's AlvariCRAFT™ is a Simple Network Management Protocol (SNMP) application designed for the online management of BreezeMAX components. This utility simplifies the installation and maintenance of small deployments by easily allowing single-BTS configuration changes or firmware upgrades.

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