Challenges of Deploying WiMAX Networks and Signaling Test Solutions

IP Network Convergence Operation

Agilent Technologies
Agenda

- WiMAX Technology Overview
- WiMAX Test Challenges and Requirements
- Signaling Analyzer WiMAX Test Solution
Mobile Technology Evolution Path

• WiMAX – 3 x releases (R1, R1.1, R1.5)
  • Each release has 3 stages
  • All three stages of R1.1 are completed
  • R1.5 definition work is in progress

• 3.5G – HSPA / HSPA+
• 4G / Super 3G a.k.a. LTE - Long-Term (Radio) Evolution - 3GPP Release 8
  • OFDM / MIMO
  • 200 Mbps (DL) & 100 Mbps (UL)
• 3G / 4G – Mobile WiMAX – IEEE 802.16e-2005
  • OFDMA / MIMO
  • 70 Mbps (DL) & 70 Mbps (UL)
WiMAX™ - Definitions and Terminology

- WiMAX enables the delivery of *last mile wireless broadband* access as an *alternative to cable and DSL*.
- *Theoretically provides 4 - 10Mbps up to 10 miles at 75mph*. Up to 5x HPSA today.
- The *WiMAX Forum®* is an industry-led, not-for-profit organization formed to certify and promote the *compatibility* and *interoperability* of IEEE 802.16/ETSI HiperMAN based broadband wireless products
- *WiMAX™ is not a technology*, but rather a certification mark, or *“stamp of approval”* given to equipment that meets certain conformity and interoperability tests.
- For more info [www.wimaxforum.org](http://www.wimaxforum.org)

### WiMAX Standards

<table>
<thead>
<tr>
<th>Fixed WiMAX</th>
<th>Mobile WiMAX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Access type</strong></td>
<td>Fixed and nomadic</td>
</tr>
<tr>
<td><strong>Devices</strong></td>
<td>Outdoor and indoor subscriber units, Laptop and PDA cards, and modules</td>
</tr>
<tr>
<td><strong>Standard</strong></td>
<td>IEEE 802.16-2004 (802.16d) ETSI HiperMAN 1.2.1</td>
</tr>
<tr>
<td><strong>Multiplexing</strong></td>
<td>OFDM, OFDMA</td>
</tr>
<tr>
<td><strong>Duplexing mode</strong></td>
<td>TDD, FDD</td>
</tr>
<tr>
<td><strong>Channel size range</strong></td>
<td>3.5-10 MHz (approved profiles)</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>Fixed: 20Mhz/52 subcarriers</td>
</tr>
<tr>
<td><strong>Frequency bands</strong></td>
<td>3.4-3.6 GHz 5.7-5.8 GHz</td>
</tr>
<tr>
<td><strong>Theoretical. Likely speeds achievable at short range 10 Mbps at 10 km. (6Mi)</strong></td>
<td>DL 70 Mbps UP 70 Mbps</td>
</tr>
<tr>
<td><strong>Coming next…</strong></td>
<td>802.16m – mesh networks</td>
</tr>
</tbody>
</table>
WiMAX Advantages and Challenges

**Advantages**

- All IP-based (allows for converged services on one core network)
- Improved spectrum efficiency (in terms of bps/Hz and use of TDD approach)
- Potentially fewer base stations required
- OFDMA approach improves QoS (Resistance to Fading, reduced ISI)

**Challenges**

- New technology, not yet fully proven
- Requires new capex (for existing operators)
- Mobility limited to 120 KPH (but this is pretty fast!)
- Spectrum is not consistent WW (2.3 GHz, 2.5 GHz, 3.4-3.8 GHz)

WiMAX Network Reference Architecture

- **BS** – Base Station
- **MS** – Mobile Station
- **GW** – GateWay
- **ASN** – Access Service Network
- **CSN** – Connectivity Service Network
- **NAP** – Network Access Provider
- **NSP** – Network Service Provider

![Diagram of WiMAX Network Reference Architecture](image)
Key WiMAX Monitoring Point --- R1 interface

- R1 is the interface between the MS and the ASN as per the air interface (PHY and MAC) specifications (IEEE P802.16d/e)
- R1 consists of the protocols and procedures between MS and ASN as per the air interface (PHY and MAC), it also includes additional protocols related to the management plane
- The related specifications including IEEE P802.16e-2005, IEEE P802.16-2004 and IEEE 802.16g
- The key protocols for R1 signaling monitoring purpose include:
  - PHY, MAC, PKMv2, EAP, TCP/IP applications, etc.

The key R1 signaling procedures:
- Network Entry
- Service Flow Procedure
- Network Exit
- Hard Handover
- Soft-HO/FBSS
Key WiMAX Monitoring Point --- R3 interface

- R3 is the interface between the ASN and the CSN to support AAA, policy enforcement and mobility management capabilities.

- Typical R3 interface is based on 100/1000M Ethernet.

- It also encompasses the bearer plane methods (e.g., tunneling) to transfer IP data between the ASN and the CSN.

- The key protocols for R3 signaling monitoring purpose include:
  - RADIUS, EAP, DHCP, MIP, GRE (or IP-in-IP), TCP/IP applications, etc.

The key R3 signaling procedures:
- Network Entry
- User Plane Activation
- Network Exit
- Network Re-Registration
Key WiMAX Monitoring Point --- R6 interface

- R6 consists of the set of control and Bearer Plane protocols for communication between the BS and the ASN-GW.
  - The Bearer Plane consists of intra-ASN datapath between the BS and ASN gateway.
  - The Control Plane includes protocols for datapath establishment, modification, and release control in accordance with the MS mobility events.
- The typical R6 interface is based on 100/1000M Ethernet.
- Most of NEM (Network Equipment Manufacturer) has their own R6 proprietary protocol.
- The key protocols for R6 signaling monitoring purpose include:
  - WiMAX Forum R4/R6/R8 Protocols, EAP, DHCP, MIP, GRE, TCP/IP applications, etc.

The key R6 signaling procedures:
- Network Entry
- User Plane Data
- Network Exit
- Radio Resource Management
- Location Update
- Paging Procedure
- Idle Mode Entry/Exit
- Re-Authentication
- Handover
WiMAX Network Protocol Stacks (Control plane)

Legend:
- Defined by IETF
- Vendor specific or non-existed
- Defined by WiMAX forum
- Defined by IEEE
WiMAX Network Protocol Stacks (User plane)

Legend:
- Defined by IETF
- Vendor specific or non-existed
- Defined by WiMAX forum
- Defined by IEEE
WiMAX Key Features

- AAA with CSN for homers and roamers
  - IEEE 802.16 security framework extended to cover mobility scenarios
  - RADIUS for AAA, evolving to DIAMETER
- QoS management
  - Based on subscription
  - Policy enforcement
- Mobility management
  - Mobility management is tiered
    - Intra-ASN
    - Inter-ASN
    - Inter-CSN when V-CSN supports the HA for mobile IP
- WiMAX/3G Interworking
- Protocol
  - Support for both IPv4 and IPv6
- RF Technologies
  - OFDM/OFDMA, MIMO, AMC/HARQ, AAS
Agenda

• WiMAX Technology Overview

• **WiMAX Test Challenges and Requirements**

• Signaling Analyzer WiMAX Test Solution
WiMAX Network and Systems Lifecycle

- Agilent Protocol Solutions
- Agilent Instrument Solutions
- Agilent OSS Solutions

R&D → Manufacturing → Installation & Deployment → Tactical Maintenance → Proactive Maintenance

Network Equipment Manufacturer → System Support by NEM → Operations by Network Operator
The WiMAX Signalling Test Challenges and Requirements

• Shortened time-plan for development and deployment
  – Development in parallel with standards refinements

• Some important interfaces (such as R3, R6) are vendor proprietary and its traffic is IPSec encrypted while decrypted key can’t be retrieved from open interface
  – Support for vendor proprietary protocol decode and IPSec decryption

• High traffic loading on WiMAX backhaul interfaces
  – Protocol Analyzer must guarantee 100% packet capture for both control and user plane data
  – Protocol Analyzer needs to support real-time call trace and KPI statistics
  – Application layer performance and QoS/QoE analysis on the user plane

• Correlate the WiMAX R1 data with backhaul signalling messages for end-to-end troubleshooting
  – Drive Test and Signalling Monitoring integration test with R1-R6-R3 combined call trace
NEM WiMAX R&D Test Requirements

- **ASN (BS & ASN-GW) Functional Testing**
  - R3 and R6 simulation and emulation
  - In depth decoding of protocols, including R1, R3, R6 interface protocols
  - RF (R1 interface) testing (via GIGE span port of BS in the Alcatel-Lucent case)
  - Multi-interface call trace to group both control plane and user plane traffic
  - Real-time L1-L7 KPI correlation analysis (eg. throughput and retransmission)
  - R1 frame efficiency analysis

- **Mobility Management Functional and IOT Testing**
  - Intra-ASN, Inter-ASN, Inter-CSN when V-CSN supports HA for mobile IP
  - WiMAX device IOT (Interoperability Test)
  - WiMAX/HSPA/LTE/IMS Interworking Test

- **Base Station BER (Bit Error Rate) testing on user plane**
  - This test application is also required by WiMAX BS production line

- **BS and ASN GW Load Testing**

- **Regression Testing and Conformance Testing**
WiMAX I&M Test Requirements

- End to end WiMAX network troubleshooting
  - In depth decoding of protocols, including R1, R3, R6 interface protocols
  - IP-Sec Decryption on R3, R6 interface
  - RF (R1 interface) testing (via GIGE span port of BS or Drive Test)
  - R1-R6-R3 multi-interface call trace to group both control plane and user plane traffic

- KPI Statistics on R1,R3 and R6 interface

- Mobility Management Optimization
  - Handover KPI (such as Handover time, Handover successful ratio, etc.)
  - Performance optimization, Charging verification, Roaming analysis

- WiMAX Drive Test & Signaling Monitoring integration

- User plane (per user based) KPI analysis
  - IP, UDP, TCP and application layer (such as HTTP, FTP) throughput analysis
  - TCP retransmission analysis
  - RTP/RTCP QoS measurements, such as packet Loss, delay, jitter, etc.
  - Voice and Video playback and MOS testing
Agenda

• WiMAX Technology Overview
• WiMAX Test Challenges and Requirements
• **Signaling Analyzer WiMAX Test Solution**
Agilent’s Involvement in WiMAX Forum

- Agilent is a **Principal Member** of the WiMAX Forum since March 2007 and has been a Regular member, and first T&M participant since September 2004
- Agilent actively participates in working groups:
  - **TWG** (Technical Working Group)
    - **Radio Conformance Test (RCT) Group**
  - **NWG** (Network Working Group)
    - **Network Interoperability Testing (NWIOT) Task Group**
      - NWIOT Plugfest
  - **Certification Working Group (certification policies and processes)**
    - **STEG: Specialized Test Equipment Group**
      - Deliverable: Statement of the Art (SOA) Document
Software Solutions – Fixed and Wave 2 Mobile WiMAX
89601A VSA Software
E7613/15B Signal Studio
ADS WiMAX Design Libraries

VSA, PSA, ESG, Scope, Logic

MXA/MXG R&D and Production
Mobile WiMAX Test Set & PCT E6651A

Digital VSA
Network Analyzers, Power supplies, and More!

VSA, PSA, ESG, Scope, Logic

Battery Drain

RCT system (AT4 wireless)

Digital VSA
Network Analyzers, Power supplies, and More!

Conformance

MXZ-1000

Mobile WiMAX Test Set & PCT E6651A

R&D

Conformance

Mfg

I&M

More Coming Soon!

HH SA N9340

HH CAT N9330 A

Drive Test E6474

J7910A WiMAX Signaling Analyzer

FrameScope N9320A

N8300A Mobil WiMAX Mfg

Conformance Mfg I&M

Digital VSA
Network Analyzers, Power supplies, and More!

R&D

Conformance

Mfg

I&M

Slide 20

Agilent WiMAX Test and Optimization Seminar
2008/07/02
SART WiMAX™ Test Solution Overview

Signaling Analyzer supports:
- Real-time data capture and protocol decode in R1, R3 and R6 interface
- Integration with Drive Test (DT) tools for end to end performance analysis
- Single interface and Multi interface call trace (combined R1-R6-R3)
- Many different types of KPI statistics and optimizers

Note: R6 can be NDA based proprietary support
SART WiMAX™ Test Solution Applied Scenarios

- **Functional and IOT Testing**
  - In depth decoding of protocols, including R1, R3, R6 interface protocols
  - Real-time graphical call trace across multiple interfaces (R1, R3 and R6)
  - WiMAX devices IOT (Interoperability Test) for Inter-ASNs, Inter-CSNs and ASN-CSN

- **System Integration Testing**
  - End-to-end WiMAX troubleshooting and performance analysis/optimization
  - Seamlessly drill up and down between messages, calls & measurements

- **QoS/QoE Monitoring for User Plane**
  - QoS/QoE monitoring for VoIP, Video and data services

- **Load Test and KPI Monitoring**
  - Real time KPI monitoring
  - Historical CDR query for quick root cause troubleshooting
## Supported WiMAX related protocols

<table>
<thead>
<tr>
<th>Issuing Authority</th>
<th>Protocol Name</th>
<th>Specification</th>
<th>Version</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel</td>
<td>OFDMA PHY SAP</td>
<td>OFDMA PHY SAP Interface Specification for 802.16 Broadband Wireless Access Base Stations</td>
<td>2.31</td>
<td>R1</td>
</tr>
<tr>
<td>IEEE</td>
<td>WiMAX R1 MAC</td>
<td>IEEE Std 802.16, IEEE Std 802.16e</td>
<td>Cor 1-2005 / Cor2D4</td>
<td>R1</td>
</tr>
<tr>
<td>IETF</td>
<td>DHCP</td>
<td>RFC 2131</td>
<td>(1997-03)</td>
<td>R1/R3/R6</td>
</tr>
<tr>
<td>WiMAX Forum</td>
<td>R4/R6/R8</td>
<td>NWG_R1.1.0-Stage-2 and NWG_R1.1.0-Stage-3</td>
<td>V1.1</td>
<td>R4/R6/R8</td>
</tr>
</tbody>
</table>
SART WiMAX™ Test Solution - Features (1)

- High performance multi user and flexible licensing platform enabling highly efficient use of test tool for multi users’ testing in real time
- Comprehensive WiMAX R1, R2, R3, R4, R5, R6, R8 Decode & Filtering capabilities
- Robust Call Trace Engine
  - Single and Multiple Interfaces (Combined R1, R3, R6)
  - Call Details, per Call Statistics and per Call KPI Measurements
- Log file import/export with Wireshark/Ethereal
- Full Automated Testing utilizing XML API for remote configuration & control
- Integration with Agilent Ni-XT Drive Test tool for end-to-end WiMAX troubleshooting and optimization
  - Merging R1 Data from DT with R6/R3 Data for R1 & R6 & R3 combined call trace
  - Extracting R1 data from DT, e.g. R1 physical parameters for some customizing WiMAX R1 optimizers.
SART WiMAX™ Test Solution - Features(2)

- WiMAX optimizers
  - Latency across multi interfaces, e.g. R1-R6, R6-R3, R1-R3
  - Correlated analysis with HARQ/ARQ/TCP retransmission
  - Throughput from L2 to L7 across multi interfaces
  - OFDMA efficiency analysis

- KPI Statistics, Monitoring and Reporting
  - Tabular and Graphical KPI
  - Real time KPI

- Integration with TPA for analyzing the QoS/QoE
- Drill Down and Drill Up Troubleshooting and Optimization, Seamlessly move between messages, calls & measurements
- Powerful embedded IP transport network troubleshooting capability
- Single integrated platform supports all technologies, e.g. 2G, 3G, IMS
Mobile Solutions Portfolio Overview

- **Distributed Performance Manager**
  - Quality of Service Analysis
  - Flexible Service Profile Definitions
  - Dynamic Threshold & Alarming

- **Call Manager**
  - Historical xDR analysis and long-term trending for millions of calls
  - Drill-down analysis to decodes for any call
  - Shares Call Trace and Analysis GUI from Signaling Analyzer

- **Signaling Analyzer Client Software**
  - Operates in stand alone, multi-user and offline client modes.
  - Fully integrated analysis solution for all signaling technologies
  - Robust Decode, Call Trace, Statistics & Optimization applications that work and link together
  - Disk buffering enables better performance in high-load environments

- **Multi-User Server**
  - Allows multiple simultaneous independent client sessions sharing the same probe data.
  - Test coexistence, clients operate without interfering with each other or the data capture process.
  - Centralizes complex configurations; each client connects and begins analysis within a minute
  - Software version management, pushed upgrades to clients automatically.

- **DNA Probes**
  - High performance common probe platform, independent Line Interface Modules support wide variety of different physical interfaces.
  - Utilized by all Network, Signaling & Triple Analysis solutions for Fixed, Mobile, Voice, Video & Data analysis.
  - 400Mbps high performance streaming: line rate captures and filtering, real-time ATM SAR on 4096 channels, demux and channelization

- **Line Interface Modules (LIM’s)**
  - Hot-swappable enables reuse of DNA; save on hw costs.
  - High port density LIM’s for STM-4/OC-12, STM-1/OC-3, DS-1, E1/T1, 10/100/1000 Ethernet (Optical, Electric)
  - Single LIM supports all possible configurations (e.g. Channelized, ATM, HDLC)
  - Multiple Time Synchronization methods supported for co-located and distributed probing deployments.
Signaling Analyzer Usage Models

Multi User Architecture
Interleaving, Filtering, Correlation, Data and Measurement Distribution

R1 + R6 + R8

R3 + MIP + AAA
Signaling Analyzer Multi-User Architecture

- True client server architecture
  - Enables distributed probing.
  - Highly Scalable
  - Enables correlated analysis for local and remote data.

- High performance analysis for all connected clients.

- Supports all clients concurrently
  - Network Analyzer
  - Signaling Analyzer
  - Call Manager
  - Distributed Performance Monitor

- Probe once, test many
  - Reduces CAPEX
  - Client independent filters
    - By probe, port, link, ...
  - Each user can focus on their specific test domain simultaneously.

- Centralized client management
  - Reduces OPEX
  - Configuration management
  - Performance management
  - Health management
  - SW upgrade management
SART WiMAX™ Data Measurement Platform

- Extensive LAN/WAN/ATM test functions, alarm detection, L1/L2 statistics
- Available Line Interface Modules used for WiMAX R1, R3, R6 interface monitoring
  - J6830A 10/100 BaseTX Ethernet
  - J6831A 10/100 BaseFX Ethernet
  - J6832A 1000 BaseX Ethernet
  - J6850A 8 Port 10/100/1000 Ethernet
  - J6851A 16 Port 10/100/1000 Ethernet
- Hardware capture filters, including Control Plane / User Plane auto-detection and filtering
- Dedicated Gigabit Ethernet interface for high speed Run Time Store to Media (RTSM)
  - Capable of line rate capture and storage for extended periods for post-processing analysis
    - 200 Mbps when not using Jumbo frames on Switches and PC / Server NICs
    - 400 Mbps when using Jumbo frames on Switches and PC / Server NIC
- Time synchronization between DNAs
  - GPS interface hardware and connectors
  - NTP via embedded NTP client
  - Control/Sync cable
- Probe Features
  - Supports the hot-swapping of line interface modules (LIMs)
  - Provides AC and DC power connections
  - Rack mountable
  - Application independent
  - Non-intrusive
Network Protocol Monitor Example – R1 Decode

Decode and Traffic Overview

- Indicate all or call related messages time based
- Decode all protocol layers
- Flexible Column settings (Any field can be added in the TO column)
- Comprehensive view filter
- Export log to CSV/CAP/PCAP file format
- WiMAX R1 MAC reassemble
Network Protocol Monitor Example - Call Trace

- Multiple Interface & Technology Profiles
- Indicate each call and related KPI in a single line
- Phase Graphics identify key signaling events during call session
- Flexible Column settings
- Drill Down & Filter Direct from Call Trace
- Export to CSV file
The Call Trace Sequence Diagram is a graphical ladder diagram showing the messages of a call over one or multiple interfaces.

The user can click on any of the messages in the diagram and drill down to the corresponding message in traffic overview and view the decode of the message.

The Call Trace Sequence Diagram also provides options for printing the view or saving the diagram in a graphical format.

The user can also add message numbers to the diagram to enable anyone to easily find a particular message in a call.
Network Protocol Monitor Example - KPI Statistics

Graphical statistics:
➤ The overall events/messages statistics over R1/R6/R3 interface

Tabular statistics:
➤ BS based KPI e.g. Handover, PHY/IP/MAC/TCP/UDP throughput
Network Protocol Monitor Example - Real-time KPI

Real Time KPI

- Per call based KPI
- Over 30 R1 KPIs included
- Multi KPIs and calls can be shown simultaneously
- Very helpful for radio performance analysis in real time
- Support offline playback
- KPI result can be exported to txt file for post process
End to end WiMAX network testing(1)

Import of BS side Test Data for end-to-end R1&R3R6 Call Trace

Note: In this example, Intel PHY-SAP is the used protocol at BS side
By DT integration with SART:

- Faster and more comprehensive troubleshooting
  - Detailed end-to-end picture of the true network issues/performance
  - Optimize both the uplink and downlink
  - Isolate BS with RF problems

- Optimize WiMAX performance
  - Detect messages lost over the R1 interface
  - Determine the overall RF performance
End to End WiMAX Network Testing - WiMAX Optimizer

- **Optimizers**
  - Either per call based or per BS based analysis
  - Kinds of optimizers:
    - Latency across multi interfaces, e.g. R1-R6, R6-R3, R1-R3
    - Correlated analysis by HARQ/ARQ/TCP retransmission
    - Throughput from L2 to L7 across multi interfaces
    - OFDMA efficiency analysis
  - Very useful to achieve end to end performance from plenty correlated data
  - Powerful for indentifying and troubleshooting the network performance issues
  - Optimizer analysis result can be exported to txt file for post process
Frame Efficient Analysis:

- Per call based or per BS based analysis
- Help to analyze the **radio resource usage efficiency**, then evaluate the radio algorithm performance.
WiMAX R3/R6 IPSec Decryption

- Troubleshooting and analysis of encrypted traffic on WiMAX R3 and R6 interface
- Protocol decode for IPSEC AH/ESP/IKEv2
- Phase I: Manual Decryption
  - The user needs to enter the necessary information for IPSec decryption, such as
    - Cryptographic algorithm, like 3DES-CBC etc..
    - Session Key(s)
    - SPI (Security Parameters Index) and Src/Dest IP addresses
- Phase 2: Automatic Decryption
  - The NEM customer needs to provide the API to allow SART to retrieve the IPSEC KEYs in real-time.
Triple Play Analysis in WiMAX Environment

Delivering mobile protocol and triple play solutions, enabling customers to achieve faster time-to-profit and higher quality voice, video and data networks.

Multiple Applications:
- IP Transport
- 3G, WiMAX Mobile
- Triple Play
Network Analyzer Multi-User Client
Troubleshooting 100/1000 Ethernet Transport Network Problem

Network Analyzer – Expert Analysis

- Network Analyzer MU Client
  - Operate concurrently with SART Client on same PC
  - Utilizes same MU Server used by SART Client

IP Connection Statistics
Summary of SART WiMAX™ Test Solution

Features
- Powerful platform with high performance DNA hardware and flexible real-time multi user client server architecture
- Flexible E2E troubleshooting and optimization applications
- Extensive correlated KPI statistics from L1 to L7 across multi interfaces for both control plane and user plane
- Proven solution which can be applied for comprehensive WiMAX test scenarios

Benefits
- Help to increase the test efficiency significantly and reduce CAPEX and OPEX especially in lab test environment
- E2E troubleshooting and indentify root cause of problems quickly
- Easy way to understand the network performance and indentify the issues among the multiple layers, interfaces or network elements
- Leverage time-to-marketing capability