

PLUGTESTS
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TO THE

3rd PLUGFEST
MARCH 2006 · SOPHIA ANTIPOLIS · FRANCE

WiMAX
FORUM

12-19 MARCH 2006
SOPHIA ANTIPOLIS - FRANCE

Hosted by
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White Paper

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Introduction

The idea of group tests or more formally known as a Plugfest is one of several venues used by numerous technology consortiums. The venue is a means for providing vendors the opportunity to address potential ambiguities and to improve the testing scenarios and capabilities in a technology standard.

In the WiMAX Forum, a Plugfest is a one week long event carried out at a WiMAX Forum-contracted testing site to primarily validate and verify the interoperability of a vendor's equipment with other vendor's equipment. A vendor is considered to be interoperable once they have demonstrated that their hardware is able to send and receive packets of data with two other vendors involving base stations and subscriber stations for a selected certification profile. Before the Plugfest venue takes place, participating vendors must agree on a set of RF/PHY characteristics within a given certification profile. In all instances, a minimum of 3 vendors must be available to conduct interoperability testing in a certification profile. Ideally, the WiMAX Forum requires a minimum of 5 to 6 vendors to execute the planning of a Plugfest.

The key objectives of a Plugfest are to:

- Identify where there may be differing standards interpretations that must be resolved
- Identify interoperability problems which may be firmware or software related
- Encourage open and unambiguous technical discussions of the test scenarios and the standard with a means to correct them
- Prepare a vendor to submit their products for formal certification testing
- Continuously improve the quality of interoperability testing to ensure a viable WiMAX Certification process
- Make improvements for implementing future group testing venues

The WiMAX Forum Certification Working Group has determined that Plugfest events will be planned about every six months. In some instances we may see additional Plugfests planned to prepare vendors for future certification releases. Typically, these events are posted on the WiMAX Forum Site for the members of the Certification Working Group or the Technical Working Group. The current Plugfest is extraordinary in that we have the European Telecommunication Standards Institute (ETSI) in collaboration with Centro de Tecnología de las Comunicaciones, S.A. (Cetecom Labs), and the Forum jointly hosting the venue. This is the third Plugfest that we have conducted where service flow with Quality of Service (QoS) traffic and Encryption, SS (Subscriber Station) authentication and data packets classification were achieved as we are in the midst of WiMAX Forum Certification Testing for Wave 1 of the 2 certification profiles.

This event was organized in the context of the cooperation agreement between ETSI and the WiMAX Forum signed in April 2005 and amended in February 2006 to cover new areas of interest. Beyond the organization of Plugtests events the agreement incorporates the harmonization of relevant parts of IEEE 802.16 and ETSI HiperMAN standards and joint development of protocol conformance test specifications that are one of the essential elements of the WiMAX Certification program. The Technical Committee BRAN (Broadband Radio Access Networks) is the home to these activities at ETSI where HiperAccess and HiperMAN standards and WiMAX/HiperMAN test specifications are developed, with extensive support of ETSI's Protocol and Testing Competence Centre (PTCC).

This event will greatly contribute to bring Equipment Vendors closer to achieve certification.

WiMAX Forum overview

The WiMAX Forum™ is an industry-led, non-profit corporation formed to promote and certify the compatibility and interoperability of Broadband Wireless Access (BWA) products using the IEEE 802.16 and ETSI HiperMAN wireless MAN specifications. The Forum's goal is to accelerate the introduction of these systems into the marketplace. WiMAX Forum Certified™ products will be fully interoperable and are expected to support both Broadband Fixed and Portable Applications. Through WiMAX Forum-led efforts, the economies of scale made possible by standards-based, interoperable products will drive price and performance levels unachievable by proprietary approaches. As a result, service providers worldwide will be able to deliver economical broadband data, voice and video services to both residential and business customers.

Designed for carrier-class deployments, as well as low-cost, license-exempt deployments, WiMAX Forum Certified systems will provide fixed, nomadic, portable and, eventually, mobile wireless broadband connectivity without the need for direct line-of-sight with a base station. In a typical cell radius deployment of three to ten kilometres, WiMAX Forum Certified™ systems can be expected to deliver capacity of up to 40 Mbps per channel, for fixed and portable access applications. This is enough bandwidth to simultaneously support hundreds of businesses with T-1 speed connectivity and thousands of residences with DSL speed connectivity.

WiMAX Technology framework

WiMAX is a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL. WiMAX will provide fixed, nomadic, portable and, eventually, mobile wireless broadband connectivity without the need for direct line-of-sight with a base station. In a typical cell radius deployment of three to 10 kilometers, WiMAX Forum Certified™ systems can be expected to deliver capacity of up to 40 Mbps per channel, for fixed and portable access applications. This is enough bandwidth to simultaneously support hundreds of businesses with T-1 speed connectivity and thousands of residences with DSL speed connectivity. Mobile network deployments are expected to provide up to 15 Mbps of capacity within a typical cell radius deployment of up to three kilometers. It is expected that WiMAX technology will be incorporated in notebook computers and PDAs in 2006, allowing for urban areas and cities to become "MetroZones" for portable outdoor broadband wireless access.

Key elements of WiMAX Technology

One of the main elements of WiMAX technology is the interoperability of WiMAX equipment, certified by the WiMAX Forum, resulting in mass volume and confidence for service providers to buy equipment from more than one company and that everything works together. The WiMAX Forum for the first time brought together leaders in the communications and computing industries to drive a common platform for the global deployment of IP-based broadband wireless services.

The IEEE 802.16 Air Interface Specification contains options for a number of physical layers for different frequency bands and region-by-region frequency regulatory rules. In order to achieve interoperability, WiMAX has undertaken the development of the System Profiles specifying which options to utilize, Testing Specifications to verify these specific profiles and the development of Certification Labs to permit vendors to prove that their equipment meets these profiles and interoperates.

Other key elements are cost, coverage, capacity and standard for both fixed and mobile wireless access.

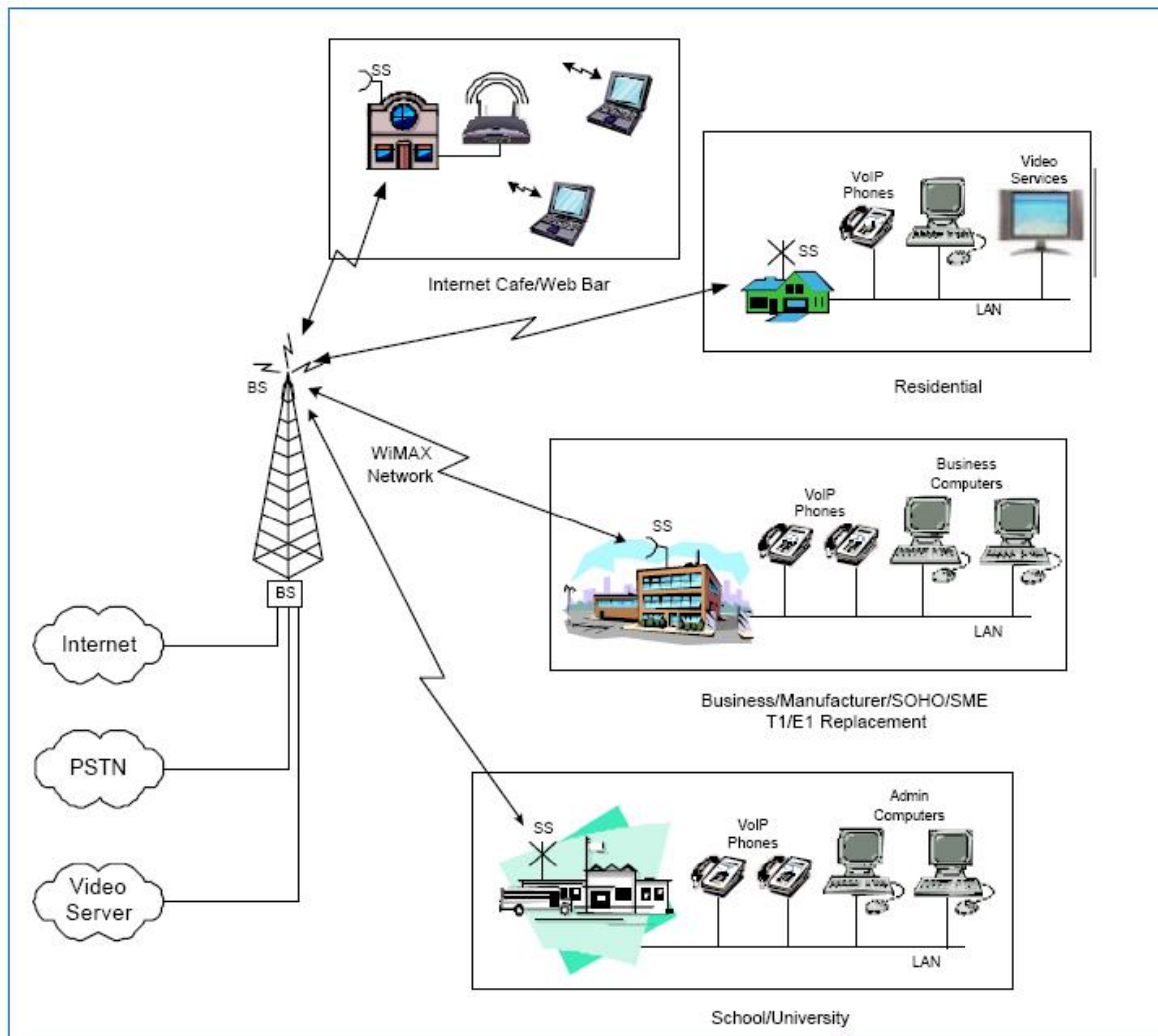


Figure 1: WiMAX Network

WiMAX Plugfest Testing

Test architecture

Four system test configurations are defined and used in the WiMAX Plugfest. A System Under Test (SUT) is defined as a network consisting of one Base Station (BS) and 1 to 3 Subscriber Stations (SSs) and, when necessary, monitoring devices as a WiMAX Protocol Analyzer and/or a Vector Signal Analyzer (VSA). The following specific configurations are used in the Plugfest:

- SUT1: 1 BS (+monitoring device).
- SUT2: 1 BS + 1 SS (+monitoring device).
- SUT3: 1 BS + 2 SS (from different vendors and at least one of them from a different vendor to that of the BS) (+monitoring device).
- SUT4: 1 BS + 3 SS (from different vendors and at least two of them from different vendors to that of the BS) (+monitoring device).

Devices in each SUT shall be interconnected by wired means.

QoS testing will only be done in terms of interoperability (i.e. transmission of data according to the QoS parameters defined and checking that the QoS of a service flow is not affected by other Best Effort (BE)-type data transmissions). Since performance testing is not in the scope of Plugfest events organized by the WiMAX Forum, no performance-related parameters (e.g. latency, jitter, throughput, etc.) are measured and therefore, performance test tools are not employed. Instead, visual checking that the quality of the traffic flow is not affected at all by BE traffic is used.

System-Under-Test (SUT) Configuration # 1

Figure 2 below shows the SUT test configuration # 1. In this SUT test configuration #1, the BS is transmitting broadcast messages while the monitoring device is capturing all the necessary MAC messages and PHY/RF parameters. It is assumed that the BS is connected to a test controller (not shown in the figures) via a local area network. Furthermore, it is assumed that BS can be configured either manually or remotely such that each test case can be executed.

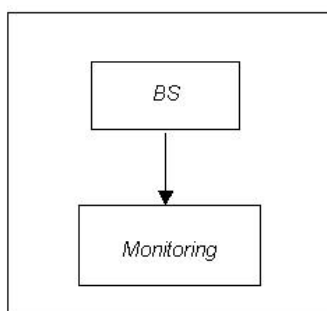


Figure 2: SUT configuration # 1

System-Under-Test (SUT) Configuration # 2

Figure 3 below shows the SUT test configuration #2. In this SUT test configuration #2, the BS is transmitting and receiving data packet from a single subscriber station (SS1) while a monitoring device is capturing all the necessary MAC messages and PHY/RF parameters.

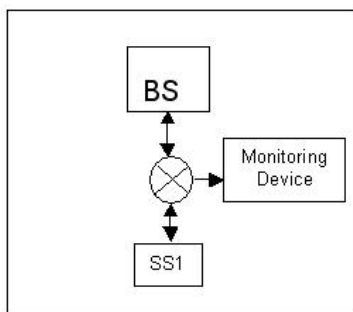


Figure 3: SUT configuration #2

System-Under-Test (SUT) Configuration # 3

Figure 4 shows the SUT test configuration #3. In this SUT test configuration #3, the BS is transmitting and receiving data packet from two subscriber stations (SS1 and SS2) from different vendors while a monitoring device is capturing all the necessary MAC messages and PHY/RF parameters. SS1 and BS vendors are different. SS2 may be from the same vendor of the BS.

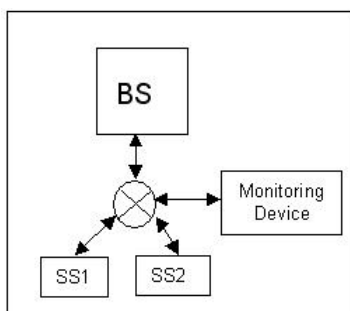


Figure 4: SUT configuration #3

System-Under-Test (SUT) Configuration # 4

Figure 5 shows the SUT test configuration #4. In this SUT test configuration #4, the BS is transmitting and receiving data packet from three subscriber stations from three different equipment vendors (SS1, SS2, and SS3) while a monitoring device is capturing all the necessary MAC messages and PHY/RF parameters. SS1, SS3 and BS vendors are different. SS2 may be from the same vendor of the BS.

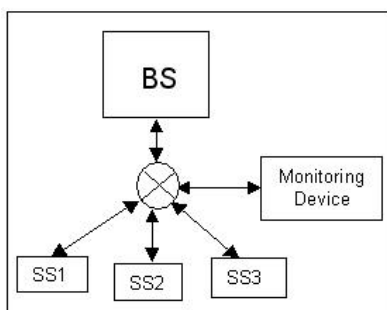


Fig. 5: SUT configuration #4

Certification Profiles tested in this Plugfest consisted of:

- 3.5 GHz, 3.5 MHz, TDD
- 3.5 GHz, 3.5 MHz, FDD

Test Plan

Test cases for the WiMAX Plugfest are organized in six different groups in the expected flow described below to achieve exchange of data packet between Vendors hardware:

- Radio Link Control.
- Initialization.
- Privacy and Key Management.
- Dynamic Services.
- Bandwidth Allocation and Polling.
- Classification.

Quality of Service (QoS), Privacy and Key Management (PKM), Classification, IP Connectivity and data encryption mechanisms (Data Encryption Standard (DES) and Advanced Encryption Standard (AES)) are the main new functionalities included in the test plan.

Figure 6 below shows the test suite structure for the WiMAX Plugfest.

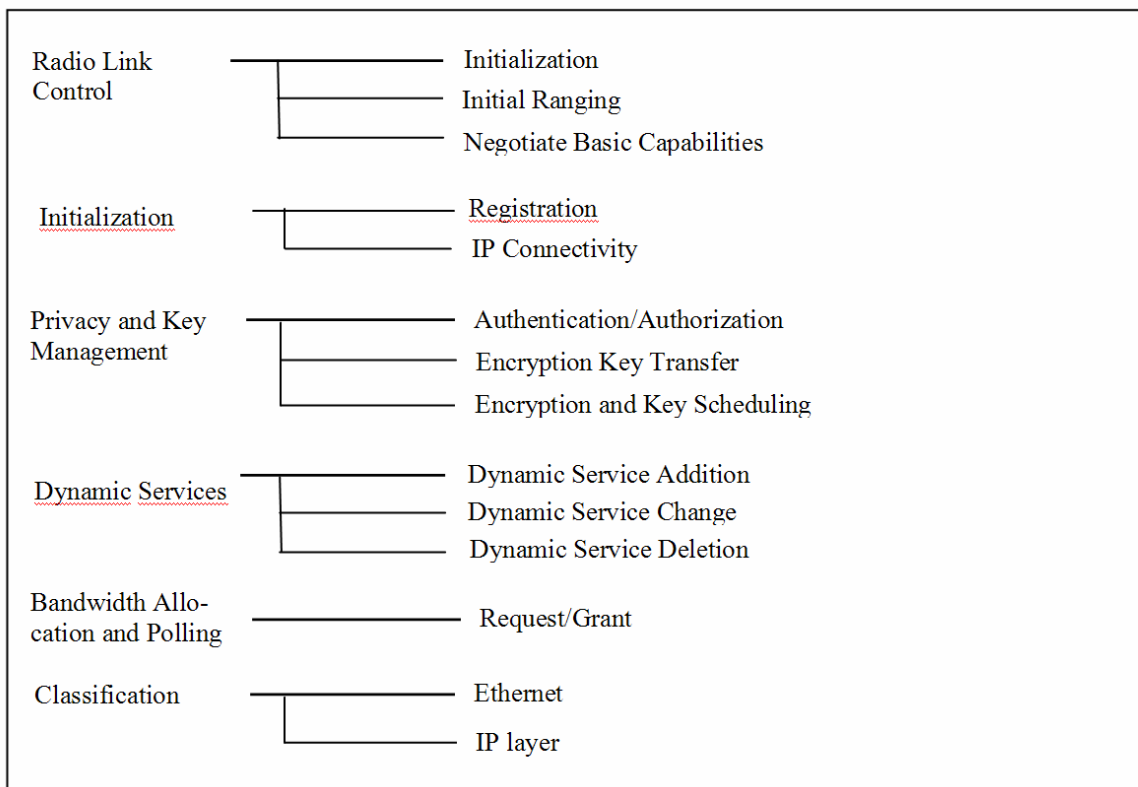


Figure 6: Test suite structure for WiMAX Plugfest

Test cases were developed in order to test each functionality.

As an example, below are several test purposes for three test cases developed to test the encryption key transfer, from the Privacy and Key Management group.

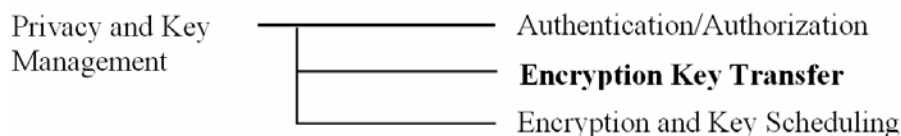


Figure 7: Encryption and key transfer is one of the functionalities included in the Privacy and Key Management group

TPIId	Purpose
TP/PKM/TEK/BV-1-PI	Verify that a SS is able to successfully complete the TEK exchange process for all the active SAs with the BS when no other SS has completed the network entry process with such BS.
TP/PKM/TEK/BV-2-PI	Verify that a SS is able to successfully complete the TEK exchange process for all the active SAs with the BS when another SS from a different vendor has already completed the network entry process with such BS.
TP/PKM/TEK/BV-3-PI	Verify that a SS is able to successfully complete the TEK exchange process for all the active SAs with the BS when two other SSs from different vendors have already completed the network entry process with such BS.

Figure 8: Test Purposes for encryption and key transfer

The execution procedure for each one of the test cases is explained in the corresponding test procedure. Figure 9 shows the test procedure for the test case TP/PKM/TEK/BV-3-PI. The test procedure template is also used as a form for recording the results of the test during the Plugfest.

TPId: TP/PKM/TEK/BV-3-PI Version 1.0		Run: Yes No	
WiMAX Certification Profile Employed 3.5T1 3.5T2 3.5F1 3.5F2 5.8T			
Test Purpose: Verify that a SS is able to successfully complete the TEK exchange process for all the active SAs with the BS when two other SSs from different vendors have already completed the network entry process with such BS.			
SUTs: SUT4			
Pre-test conditions: BS is switched on. SS1 is authorized. SS2 and SS3 have already completed the network entry process. There is not any other SS scanning for broadcast messages.			
Test set-up: <div style="text-align: center;"> </div>			
Step	Test description	Verdict	
		Pass	Fail
1	Capture the messages exchanged by the BS and SS1 until BS sends a PKM-RSP (key reply).		
2	Has the SS1 sent PKM-REQ (key request)?	Yes	No
3	Has the BS sent, for each active SA, a PKM-RSP (key reply) containing the two necessary TEKs?	Yes	No
4	Final verdict Are all partial verdicts pass?	Yes	No
Observations:			
Expected behavior:	The BS sends, for each active SA, PKM-RSP (key reply) containing the two necessary TEKs.		
Unexpected Behavior observations			
SS1 id.	SS2 id.	SS3 id.	
BS id.	DATE (yyyy-mm-dd)		

Figure 9: Test procedure for test case TP/NEI/SYN/BV-4-PI

In order to insure that all the important functionalities needed to achieve interoperability among different vendors devices are considered, a total number of seventy nine test cases and test procedures were developed for the WiMAX Plugfest.

Key Learnings and Future Work

The certification process is divided into the development of conformance testing and interoperability testing. The Plugfest is a preview of full interoperability testing; allowing vendors to get an early look at how well their equipment interoperates.

During the Plugfest held at ETSI in Sophia Antipolis, the Forum had 10 vendors along with one test equipment vendor attending the event. The results of any given Plugfest are not published. This is understood as an operating procedure for Plugfests in order to foster technical discussions with respect to the interpretation of the standards and to resolve any potential ambiguity. However, there are key learning steps that we can take from this successful Plugfest.

This event has proven to be a very valuable tool not just for the improvement of the participant vendor's product, but also for detecting those areas of the specification where clarification is needed or where the vendors may have different interpretations. This event was an excellent opportunity for companies to bring together their prototypes or planned commercial hardware and work closely together to find and resolve any interoperability problems. In this way, vendors were provided with the opportunity to address potential ambiguities and to improve the testing scenarios and capabilities in a technology standard. The Plugfest venue also fulfils the promotion of interoperability amongst the participating vendors on behalf of the WiMAX community.

For the vendors, one week of work at the Plugfest means a level of improvement for their products similar to several months of in-house testing and development. The interoperability experience with other vendors at a given development stage can make the difference between a straight forward or a longer certification process in order to obtain the WiMAX Forum certification.

In addition, the Plugfest has also been very useful for the evolution of WiMAX testing methodology. Specific WiMAX test tools, enabling either the test of a WiMAX device protocol implementation or simultaneously monitoring the MAC and PHY from both an uplink and downlink are very advantageous in order to debug the connectivity problems between different vendors.

The challenges encountered include the recruitment of participants to come together at one venue, finance, resource and other scheduling issues. Therefore, in order to optimize the number or configurations tested during the Plugfest, the following improvements are planned for future sessions:

- Cases where code changes are required to continue testing necessitates that an engineer at a vendor's development lab needs to be available for faster response to optimize testing amongst the participating vendors in the Plugfest.
- The vendors must send product samples with a minimum of two test engineers to support 2 test benches or preferably 3 test benches at the same time.
- Vendors must commit to remain at the test lab throughout the entire session to ensure that their departure does not impact other participants in achieving their key objectives. A premature departure particularly impacts those vendors who are close to submitting a product for formal certification testing.

Acknowledgments

The WiMAX Forum Certification Working Group would like to acknowledge the support of Cetecom Labs and ETSI in hosting the Forum's 3rd WiMAX Plugfest which was the second Forum Public Plugfest. A lot of planning and preparation since the Beijing plugfest event proved to be instrumental in enabling vendors to participate and test with other vendors demonstrating that interoperability can be achieved.

Participating vendors included Airspan Networks Inc., Axxcelera Broadband Wireless, Delta Networks Inc., MITAC, Picochip Inc, Proxim, Redline Communications, Sequans Communications, Vcom Inc., and Wavesat Inc.

Participating test tool vendors included Invenova.

The WiMAX Forum Certification Working Group would like to extend profound thanks for the valuable technical insights and observations contributed by Jose de la Plaza - Cetecom, Hector Ruben Alba - Cetecom, Milan Zoric - ETSI and Ed Agis - Intel in writing this White Paper for the 3rd WiMAX Forum Plugfest.

For more information about WiMAX related technologies, visit the WiMAX Forum's website at www.wimaxforum.org.

Terminology

AES	Advanced Encryption Standard
BE	Best Effort
BS	Base Station
DES	Data Encryption Standard
FDD	Frequency Division Duplex
PCT	Protocol Conformance Tester
PKM	Privacy and Key Management
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RF	Radio Frequency
SA	Security Association
SS	Subscriber Station
SUT	System Under Test
TDD	Time Division Duplex
TEK	Transfer Encryption Key
VoIP	Voice over Internet Protocol
VSA	Vector Signal Analyzer