IxVeriWave Overview—Wi-Fi Infrastructure Testing

Achieve High-Quality Wi-Fi Through Comprehensive Testing

Problem: Wi-Fi Networks Failing to Meet Mission-Critical Needs

Wi-Fi is mission-critical in our personal and business lives. It's in our homes, offices, hospitals, coffee shops, and on our flights. Great Wi-Fi is no longer a luxury—it's a must have. Great Wi-Fi networks are stable, with high capacity and performance, that exceed our quality of experience (QoE) needs. However, most Wi-Fi networks today are only qualified for coverage, with basic element and interoperability testing. This woefully inadequate test strategy exposes companies to the risk of their business applications failing in the field. Testing after deployment is not sufficient due to high cost and negative feedback.

### Solution: Comprehensive Test to Validate Entire Wi-Fi Ecosystem

Keysight's IxVeriWave helps deliver great Wi-Fi networks through a comprehensive test approach—delivering powerful independent Wi-Fi benchmarking, real-world ecosystems, functional, soak, and stability testing for wireless local area networks (WLANs). This is done in a controlled, repeatable, automatable, and easily configured environment that provides extensive visibility and debugging of results. Enterprises, carriers, network equipment manufacturers (NEMs) and chipset manufacturers all have testing roles to play to ensure world-class delivery and operation. The business benefits of using IxVeriWave include faster time to market for products, superior networks, and proactive problem resolution.

- Build robust, high-performance WLAN equipment using an automated, repeatable, and easily controlled test environment

- Limit need and costs associated with real devices and their management using simplified test bed

- Easily scale and find maximum performance and capacity for improved marketing and deployment

- Reduce debugging cycles with extensive Layers 1-7 statistics and key performance indicators (KPIs)

- Improve release cycles with automatable, comprehensive test types and scenarios from functional to soak testing

Benchmark WaveApps

RF Generation WaveGen

Real World Ecosystem WaveQoE

DFS WaveDFS

Functional Test WaveDynamix

BYOD Scale ATA AppLibary

RF Analysis WaveAnalyze

Automation WaveAutomation

KEYSIGHT TECHNOLOGIES

Key features

- Extensive and comprehensive Wi-Fi access point (AP) and controller testing
- Detailed radio frequency (RF) generation and analysis
- Breakthrough 4 x 4 MIMO 802.11ac technology
- Vital and unique MU-MIMO testing and analysis that includes Beamforming accuracy
- BYOD real application and fingerprinted device emulation
- Detailed performance metrics to assess the quality of voice, video, unified communications, web, and industry-specific applications
- Professional-quality test reports with Pass/Fail results and advanced result analysis
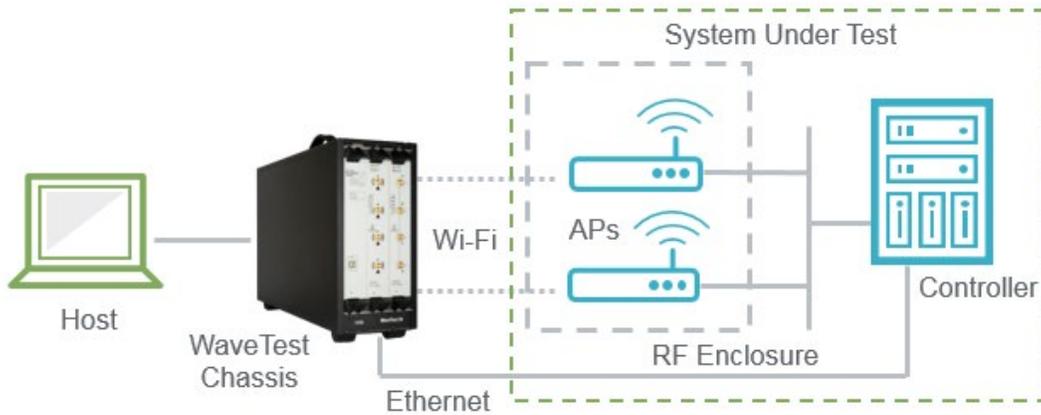
Wi-Fi Test Configuration

IxVeriWave is composted of the following software test suites:

Test Suite	Product Name	Description
Benchmark	**WaveApps**	Industry-standard AP benchmarking of throughput, capacity, packet loss, roaming, and other key metrics
Real-World Ecosystem	**WaveQoE**	Validate WLAN handling of modeled real-world ecosystems
Functional Test	**WaveDynamix**	Functional and negative testing through granular test control and extensive statistics
RF Analysis	**WaveAnalyze**	Comprehensive Wi-Fi vector signal analysis
RF Generation	**WaveGen**	Complete Wi-Fi RF vector generation with channel models applied per packet

Test Suite	Product Name	Description
DFS Certification	WaveDFS	DFS certification with automated radar pulse generation
BYOD Scale	ATA AppLibrary	Automated long-duration, high-scale testing with real traffic and fingerprinted clients
Automation	WaveAutomation	Automation of benchmark and real-world ecosystem tests

Benchmark (WaveApps)

The IxVeriWave WaveApps Benchmark Test Suite comes with several canned tests that runs with very minimal test configuration and provides insightful test reports in a fully automated fashion.

IEEE P802.11.2 Standard WLAN Benchmarking Test

The IEEE P802.11.2 Standard WLAN Benchmarking Test offers the complete set of Layer 2 and Layer 3 performance metrics defined by the IEEE P802.11.2 WLAN benchmarking methodology for APs, WLAN controllers, and WLAN switches. The focus of this test is on providing WLAN performance metrics through automated tests with scalable client-traffic generation. This enables users to quickly baseline the behavior of WLAN infrastructure network devices and expose any bottlenecks that might cause performance and scalability problems.

Key features

- Validate key system metrics: Throughput, Maximum Forwarding Rate, Packet Loss, Latency
- Automatically generated test reports convey results to management and customers
- Key parameters such as the number of Stateful clients, security type, frame type, and frame size can be controlled to provide comprehensive characterization of the system
- Test bed scales from a single AP to hundreds of APs and multiple WLAN controllers or switches
- Automation framework facilitates testing over long periods of time including regression testing

WLAN Roaming Test

The Wireless LAN (WLAN) Roaming Test offers a complete set of automated tests used to analyze the ability of infrastructure-class WLAN networks and network components to handle hundreds of mobile clients roaming between APs. Testing provides precise measurements of roaming delay, call quality during roaming, and the network's overall capacity to handle mobile clients.

Key features

- Tests scale from single to hundreds of roaming clients to stress the system under test (SUT) under real-world conditions
- Creates complex roaming scenarios in which clients roam between multiple APs, ensuring per-client precise and repeatable mobility behavior that includes signal strength and distance-related impairments
- Validates an SUT's ability to handle mobile clients characterized using a variety of security and encryption schemes
- Determine key metrics of SUT including maximum roaming client load, per-client/per-BSS roaming delay, and packet loss
- Automated testing to facilitate testing over long periods, ideal for regression testing
- Automatically generated test reports convey results to management and customers
- Real-time status of client connections, counters, and metric graphs help the user track test progress
- Complete test results available in HTML and CSV file formats for easy analysis and reporting
- Automatically generated PDF test reports provide comprehensive view of tests including an executive summary, graphical test setup, description of test methodology, results graphs, and drill-down details in tabular format
- Integrated capture functionality provides for bidirectional traffic capture while test is executing
- Roaming Delay & Packet Loss Test determines the minimum, maximum, and average delays and packet loss experienced by clients when roaming between APs
- Roaming Load Test determines the maximum number of clients that can be supported by the SUT without dropped connections at user-defined roaming delays

VoIP QoS Assurance Test

The VoIP QoS Service Assurance Test validates and ensures maintenance of service level agreements (SLAs) in high performance voice-over-wireless LAN (VoWLAN) networks. IxVeriWave offers an automated approach to determining a network's service-level capacity, performance, call quality metrics, and service-level assurance offered by infrastructure WLAN equipment in the presence of multiple VoIP calls and data traffic.

The Service Level Capacity Test determines the capacity of the WLAN infrastructure to support a specified level of high-priority VoIP traffic for a given service level by measuring the maximum number of voice calls supported for a given SLA (voice call R-value / MOS score) in the presence of a given low-priority background and best-effort traffic load.

The Service Level Assurance Test determines the SLA break-point of WLAN infrastructure equipment handling a constant VoIP call load in the presence of changing best-effort traffic load by measuring the achieved service level of high-priority (voice and video) traffic as background and best-effort (low priority) traffic changes. This validates complex use scenarios through changing traffic patterns.

Real-World Ecosystem (WaveQoE)

The WaveQoE End-User (QoE) Test offers network developers, quality assurance (QA) engineers, installers, and IT staff the capability to accurately determine how well business applications will perform in different use environments such as healthcare, education, corporate office, and carrier networks. WaveQoE is designed for testing of edge network devices such as access routers, gateways, security-enabled switches, application accelerators, and WAN accelerators.

Application performance metrics provide the means for determining whether the system measures up to desired quality levels. These metrics precisely quantify results, define as SLA in terms of quality thresholds, and compare actual measured test results to the desired SLAs. Using WaveQoE, it is easy to model real-world deployment scenarios and study end-users' actual QoE. Creating "what if" scenarios to effectively plan for changes or added services, makes this an ideal solution for network managers, service providers, and network equipment vendors.
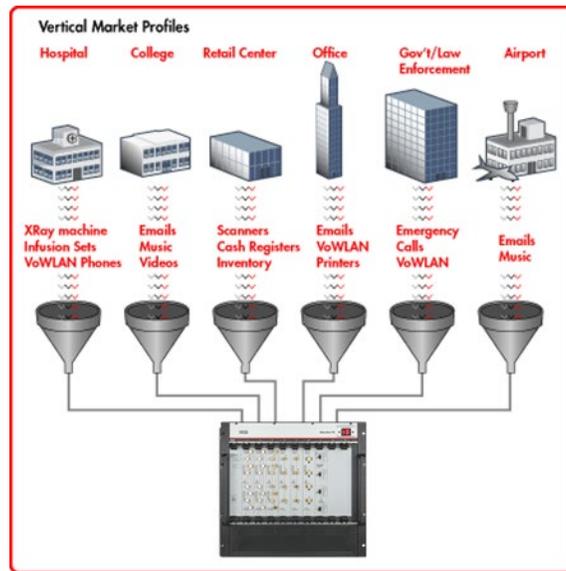

WaveQoE Real Ecosystem Models

Key features

- Ready-to-use traffic models representing virtually all LAN and WLAN network applications with associated user mix and behavior characteristics
- Create unique use models to fit a particular network behavior
- Effectively ensure the performance of critical applications before rolling them out on the production network
- Discover equipment design flaws affecting application performance early in the development cycle
- Reproduce intermittent performance problems in the lab to ease troubleshooting and improve service levels
- Generate controlled RF interference to assess the impact on application delivery

- Identify and fix security holes in network deployments exposed by complex interaction of different client and application security schemes
- Dramatically reduce test and support costs, and increase test/debug/fix cycle efficiency thereby improving time-to-market
- Autonomous testing of converged wired and wireless networks

Video Test

WaveVideo is a part of the WaveQoE test framework. It can accurately measure video quality of hundreds of video flows being transported over virtually any network. The user picks from a library of available video clips, assigns them to LAN or WLAN clients, and chooses whether the video will be played upstream or downstream. An expected service-level requirement (SLR) can be assigned to each video stream.
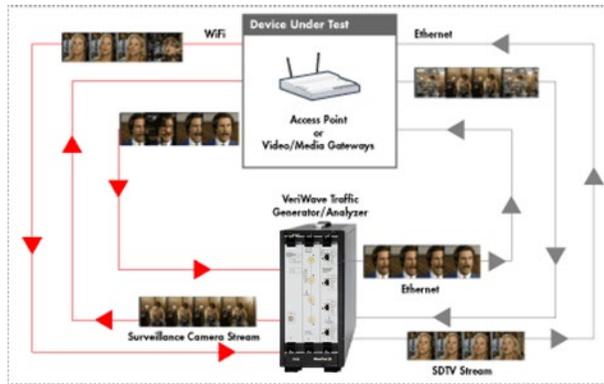

Video Test

The user may choose from a library of pre-defined traffic profiles representing various vertical environments that include corporate offices, healthcare, residential, and education. These profiles mix representative video types with data, voice, and machine-to-machine traffic as applicable for each environment. For each video clip, industry-standard media descriptors, such as the coding type, frame rate, and aspect ratio, as well as I, P, and B frame distribution over time, are monitored.

At the conclusion of the test, each video flow is scored for quality using the media delivery index (MDI) as well as individual average latency and jitter measurements. The quality is compared to user-set SLR. To aid in pinpointing transient effects and to map the raw packet loss on the network over time to perceivable effects on the video quality, the percentage of I, P, and B frames corrupted over time is reported. Test recording makes it simple for the user to identify degraded video and view the resulting clip/clips for visual inspection.

Interference Generation

The interference generation capability is built into several test suites including WaveQoE to create real-world but highly-controlled interference effect during a test run. The interference generation feature has 2 modes:

- Wi-Fi Frame Interference Generation Mode
  - Detects frames in the environment and corrupts a specific percentage
  - Targets frames generated by any device including Keysight and non-Keysight devices
  - Selectable between 25%, 50%, and 75%
- RF Interference Generation Mode
  - RF interference sources that are uncorrelated with Wi-Fi activity
  - Continuous sine wave, pulsed sine wave, and Gaussian white noise
  - Microwave oven and Bluetooth-like patterns emulating in-band device noise
  - Can be used as part of a WaveQoE test or used as a noise source for other testing
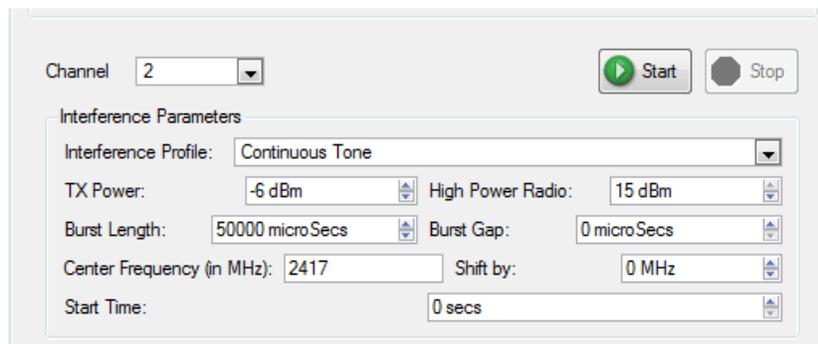
WaveQoE RF Interference

Function Test (WaveDynamix)

WaveDynamix helps development and test engineers at NEMs and service providers quickly create a broad range of functional and scalability tests for 802.11 and Ethernet devices. More than 2500 pages in length, the base 802.11, 802.11n, and 802.11ac standards encompass a great deal of complexity, necessitating new high-quality products to be thoroughly tested to verify performance and stability. WaveDynamix greatly simplifies this process by allowing functional components to be easily tested in isolation and then integrated and tested as part of the complete system.
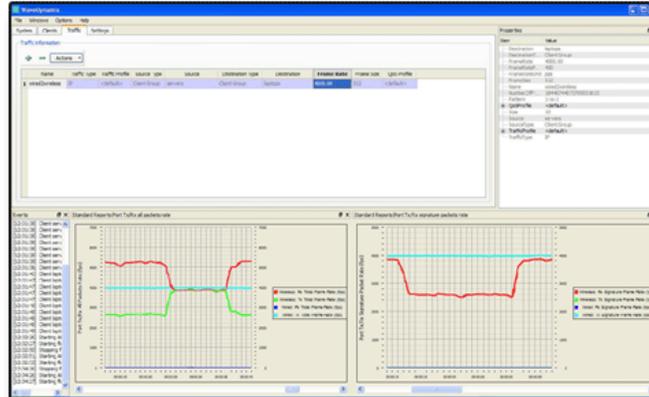
WaveDynamix Statistics and Graphs

Key features

- Functional and negative testing through granular control
- Decoupled management and data planes allows non-associated testing
- Highly interactive interface allows changing test configuration on the fly
- Custom traffic generation helps test content-specific features such as filters, rogue AP detection, denial of service (DoS) attacks
- Integrated troubleshooting to analyze, debug, and solve issues rapidly
- Flexibility to trial different configurations quickly
- Results over time that validate graceful system operation
- 802.11ac testing with immediate key metric statistics and graphs
- MU/SU-MIMO comprehensive analysis with Angles, SNR, and Delta SNR configuration

RF Analysis (WaveAnalyze)

WaveAnalyze performs vector signal analysis used to test and qualify 802.11ac Wi-Fi transmitters. Combining the real-time measurement capability of Keysight's RF WaveBlades with constellation, power, and spectrum measurements of performance and compliance testing, WaveAnalyze delivers detailed analysis for every frame in real-time, or in recorded form, for future assessment.

This IxVeriWave approach vastly improves upon traditional vector signal analyzers (VSAs) that digitize short records, typically of a single frame, thereby limiting analysis to a small fraction of the transmitted frames. Designed to receive and decode Wi-Fi frames at IEEE line-rate, IxVeriWave RF WaveBlades interface with WaveAnalyze to provide real-time measurements on each frame at the maximum frame rate available with 802.11ac.

With its measurement-grade receiver, IxVeriWave provides minimum, maximum, and average measurement values for every frame received during a prescribed interval. This enables WaveAnalyze to achieve the high-quality measurements required for calibration, characterization, and analysis of Wi-Fi transmitters, 2500 times faster than alternative approaches. WaveAnalyze measures every frame compared to a traditional VSA that measures 1 frame in every 2500 at the fastest frame rates available in 802.11ac.

WaveAnalyze RF Statistics

First-time assessments can provide calibration and analysis with automated approaches, under full-rate traffic conditions. Measurements reflect actual performance and no problems go undetected.

The WaveAnalyze interface provides an easy-to-use measurement viewer, with results presented for each frame in a tabular format or obtained via a command-line interface (CLI). RF measurement is integrated with the baseband to ensure measurements are made simultaneously with frame decoding.

Key features

- Convenient GUI
- Easy setup; analyzer is purpose-built to test 802.11 transmitters
- Measures every frame even at the fastest frame rates
- Provides 15 key measurements needed for transmitter testing:
  - EVM Data RMS, EVM Signal RMS
  - Per Subcarrier EVM RMS
  - Preamble Frequency Error
  - Transmit Average Power
  - Transmit Center Frequency Tolerance
  - Transmit Constellation Spatial Stream
  - Transmit Peak Power
  - Transmit Power Peak Excursion
  - Transmit Power Ramp
  - Transmit Power Spectral Density
  - MU-MIMO beamforming accuracy

RF Generation (WaveGen)

IxVeriWave offers the industry's only complete, integrated solution for 4x4 MIMO receiver testing encompassing one to four spatial streams. Using a single WaveBlade traffic generator/analyzer module and point-and-click GUI, Keysight's WaveGen receiver test software allows users to create and present every conceivable combination of 802.11 a/b/g/n/ac frames to a device under test (DUT) in order to evaluate performance.

Simultaneously, IEEE-defined channel models can be set on a per-packet basis. Unlike solutions composed of single-output generators, WaveGen provides true line-rate signal, tone, and waveform generation for all encodings from legacy to 802.11ac traffic—without requiring knowledge of DSP modulation software packages, tedious construction and download of I/Q, or the stringing together of multiple devices with specialized synchronization hardware.

Keysight's modular, single-card approach introduces an easy-to-use push-button 4x4 MIMO signal generation solution. Purpose-built by MIMO radio engineers for MIMO radio engineers, WaveGen addresses the needs of designers and testers of 802.11 radio and baseband functions during design, production validation testing (PVT), large-scale interoperability testing (IOT), and system integration.

Key features

- Industry's only integrated true line-rate, 4x4 MIMO 802.11 a/b/g/n/ac signal generator: eliminates ganging of single-stream signal generators and complex software interfaces
- Purpose-built for testing 802.11ac: minimal effort required to create waveforms and any combination of packets
- Infinitely variable packet generation; eliminates memory constraints
- Compact size: complete 4x4 MIMO solution within one WaveBlade
- No need to download or install waveform files on the test system
- Unmatched scalability: up to 9 WaveBlades combined within a single WaveTest chassis to create 9 independent MIMO signal generators; WT90 chassis can be daisy-chained to further increase scale
- RF WaveBlades allow moving to functional and performance test with full Layers 1 through 7 traffic generation and analysis
- Multi-user control allows one WaveBlade to be used for signal generation while another within the same chassis is used for function and performance test

DFS Certification (WaveDFS)

A fully automated and simple-to-use application that tests compliance of 802.11 APs to the dynamic frequency selection (DFS) regulations, WaveDFS creates regulatory-specified radar pulses and measures the AP's response to these pulses. WaveDFS provides real-time feedback as well as detailed reports documenting the AP's behavior in the presence of radar pulses.

The Detection Probability Test repeatedly presents the DUT with a given radar pulse type to measure the probability of detection in the presence of traffic. The test follows Sections 6.1, 6.2, and 6.3 of FCC 03 287 (Nov 2003). In automatic detection mode, the application monitors the traffic port for the control packets, indicating the DUT saw the pulse. In manual detection mode, the user must manually check the DUT for radar pulse detection.

The Bandwidth Detection Test subjects the DUT to a Type 1 FCC radar pulse while moving the frequency of the radar signal through the channel to characterize the range of frequencies over which the DUT can detect the radar pulse. This test is performed on a single channel. In automatic detection mode, the application monitors the traffic port for the control packets, indicating the DUT saw the pulse. In manual detection mode, the user must manually check the DUT for radar pulse detection.

The Radar Pulse Functional Test offers the user more control over the parameters of each radar pulse to create a customized test with a number of radar pulses defined by the user and allow the user to generate the pulses in any given order at any given time.

WaveDFS Test Configuration

Key features

- Single, integrated system creates radar pulses and client traffic; monitors and reports channel changes
- Fast and automated – no user interaction required
- Manual operation available
- Library of radar pulses as defined by FCC 2006, FCC 2014, ETSI v1.5.1, ETSI v1.6.1, ETSI v1.7.1, ETSI v1.8.1, Korea and Japan's MIC
- Supports FCC 2014 Type 1 Weather Radar
- I/Q file generation not required

BYOD Scale (ATA AppLibrary)

Faced with the complexities of today's Wi-Fi environments, manufacturers are enhancing the ability of the WLAN infrastructure to more closely monitor and control user and application behavior. For example, the addition of deep packet inspection (DPI) to key components of the WLAN infrastructure.

The Keysight BYOD test solution introduces critical test capabilities including device fingerprinting, enabling more precise, realistic testing. IxVeriWave device fingerprinting allows users to identify unique devices and operation for specific devices such as Samsung Galaxy Tablets, Apple iPhones, and Android devices.

The BYOD Web App Soak allows the easy configuration of existing IxVeriWave ATA capabilities and new BYOD tests over the ATA platform.
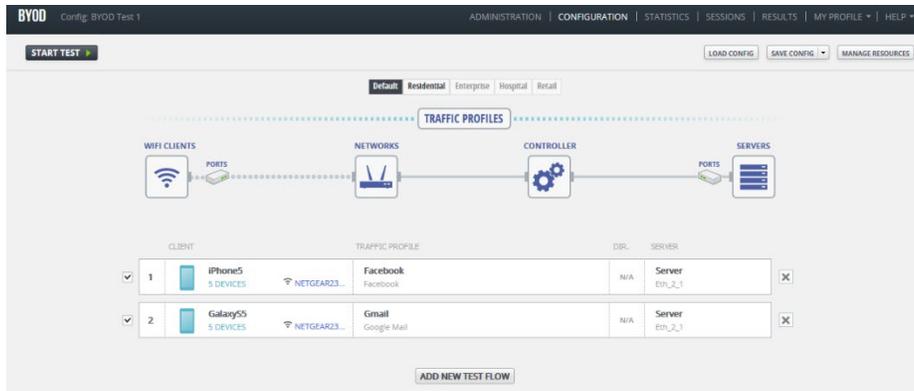
ATA Test Configuration

The BYOD Web App Monitor lets users monitor a test session and provide a detailed breakdown of application and device performance as a whole and on specific WLAN networks.
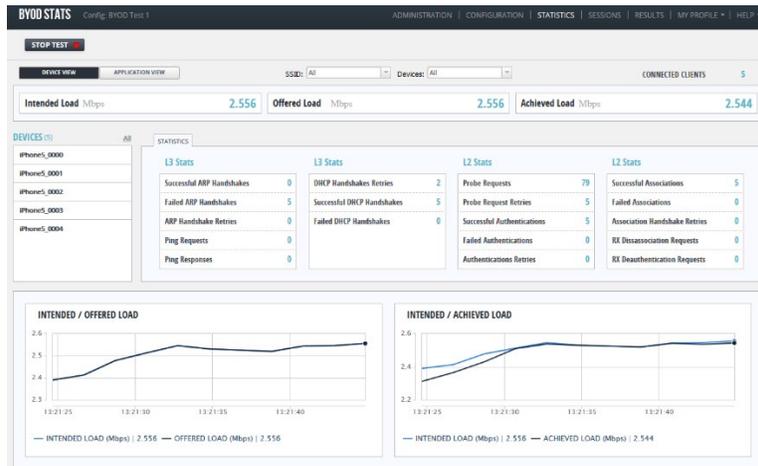
ATA Monitor Results

BYOD AppLibrary simulates popular application profiles including AppUpdate, Authentication, Chat/IM, Data Transfer/File Sharing, Database, Distributed Computing, Email/WebMail, Enterprise applications, Financial, Games, Mobility, P2P ,Remote access, SCADA, Secure Data Transfer, Security, Social Networking, Search Storage, System / Network Administration, Telephony/Cable TV, Voice/Video/Media

The ATA allows extensive capacity and media QoE testing. The BYOD offering extends those tests with realistic clients and application traffic. Here is an outline of ATA test scenarios.

Category	Metric	Details
Capacity	Max Client Support	Determine the max. number of active clients
	Max Throughput/Client Level	Determine the max. throughput for different client levels
	Max Connection Rate	Determine the max. connection rate
	Traffic Model Performance	Confirm accurate behavior with roaming
	Power Save	Performance of WMM/Legacy Power Save clients
Media QoE	Triple-Play QoS Validation	Performance & correct prioritization of voice, video, data
	Web Browsing Goodput	Single client maximum HTTP throughput (TCP)
	VoIP Admission Control	Client VoIP capacity with WMM admission control
	Streaming Video QoS	Video quality (MDI) degradation and client load increases
	Mixed Client Environment	Performance under mixed b/g/n/ac clients
	Multicast Video	Performance with multiple multicast video streams
BYOD	Device Recognition	Connect a mix of devices and validate proper ID
	Application Recognition	DPI recognition of specific AppLibrary traffic
	Real-World Application Mix	Confirm accurate behavior & defined distribution
	Application Traffic Management	Validate application rate-limiting, blocking, and prioritizing
	High-Scale Validation	Overall robust operation at high client and traffic scales

WaveAutomation

WaveAutomation makes it possible to configure fully automated test suites, which can either stand alone or be integrated into any existing automation system. Documentation and sample configurations are provided, enabling new users to quickly become oriented and productive with WaveAutomation. All aspects of the tests are controlled by WaveAutomation, including:

- Configuring test-specific parameters such as client topology, traffic patterns, frame sizes, and authentication types

- User configuration of DUT, such as APs, WLAN controllers, switches, and RADIUS servers from WaveAutomation, using their own subroutines
- Executing multiple tests while monitoring hardware status and results
- Comprehensive error checking and event reporting
- Detailed reports showing statistics counters, graphs, and historical test logs

WaveAutomation provides an easy-to-use Tcl-based configuration interface that allows the user to specify test sequences to execute. In addition, multiple parameters for each test can be specified for the hardware components on the SUT such as APs, WLAN controllers, switches, or RADIUS servers. The configuration interface files can be shared between users and are easily modifiable.

Key features

- Powerful reports that reduce manual analysis of test results
- Multiple test sequences executed with the ability to change parameters
- Extensive test coverage in a short amount of time
- Test setup, execution time, and labor cost dramatically reduced
- Control WaveTest and SUT parameters
- Replaces many of the repetitive, time-consuming tasks associated with testing new software releases
- Tests run unattended for days or weeks
- Front-end Tcl script interfaces easily customizable to support new test beds
- Highly suitable for regression testing
- Complete integration with APs, WLAN controllers, switches, and RADIUS servers that eliminates manual device configuration

Platform options

Visit keysight.com for more information	
Chassis	• WT93 – 9 Slot Chassis (980-1006) • WT22 – 2 Slot Chassis (980-1005)
Load Modules (Note: RF Modules are required for Layer 1 analysis)	• RFX5: 4-port modular card (AP/Client/Interference) with RF analysis option (980-2071) • WBX5/WBL5: 4-port modular card (AP/Client/Interference) (980-2070/2072)

Ordering Information

980-3081

IxVeriWave Base Software Bundle. Includes 1 port license for Benchmark, Roaming, VoIP QoS, L4-L7 Stateful Clients, WaveDynamix, WaveTest, WaveQoE, WaveVideo, Interference Generation. License sold on a per WaveBlade Port basis.

980-3082

IxVeriWave BYOD Software Bundle. Includes 1 Port License for App Library and ATA Web Applications for Soak and Monitor. Includes the AppLibrary framework and subscription service to access new application flows for one year. License sold on a per WaveBlade Port basis.

980-3083

IxVeriWave RF Software Bundle. Includes 1 Port License for WaveGen and WaveAnalyze. License sold on a per WaveBlade Port basis.

980-3021

IxVeriWave WaveDFS + Radar Pulse Generator capability, GUI to create radar pulses and to conduct FCC, ETSI and MIC DFS compliance and functional tests. License includes ability to create precise and controlled Radar Pulses, ability to create test traffic, and ability to create test traffic on one Ethernet port (supported on WBE). Includes 1 port of Radar Pulse Generation license and 3 ports of WaveDFS software license.

980-3033

IxVeriWave WaveAutomation product that provides the software necessary to automate IxVeriWave software test suites and applications with valid licenses on the WaveTest system. Two days of Professional Services is recommended for customers unfamiliar with the use of this product. License is sold on a per Host basis.

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

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