IxVerify — Industry's First Solution Purpose-Built for Pre-Silicon Testing

Problem: Complexity of Verifying Ethernet Networking Chips Before Tape-Out

Trends such as cloud computing, mobile edge computing, and 5G are pushing the boundaries of network capacity. To support this demand, network equipment and semiconductor manufacturers need to keep up by delivering ultra-high-density devices powered by state-of-the-art application-specific integrated circuit (ASIC) and system-on-a-chip (SoC) solutions.

Producing a SoC capable of handling terabits of traffic across hundreds of ports at speeds up to 1.6Tbps is a costly and lengthy process. And with increased time-to-market pressures, all semiconductor and systems manufacturers are looking to optimize their development cycles. The costs associated with fixing bugs after chip tape-out are substantial and can easily be millions of dollars. To de-risk schedules, Ethernet testing needs to happen early and often in the chip lifecycle.

Solution: Virtualized, Scalable, and Automated Chip Testing

Introducing IxVerify, the industry's only test solution purpose-built for pre-silicon verification.

With IxVerify, Keysight and its partners are leading the way in transforming the EDA market by offering virtualized test solutions that work in conjunction with next-generation verification flows—leveraging virtualization to reduce costs and offer increased flexibility.

IxVerify extends Keysight's intellectual property and test expertise into the EDA space. It enables new and improved test methodologies to simplify pre-silicon testing and shifts testing 'further-left' into the chip lifecycle.

IxVerify provides hundreds of predefined packet templates for testing Ethernet based protocols and can generate high volumes of traffic. With its ability to run hundreds of virtualized test ports at once, it offers the unique ability to verify the largest chip designs with dynamically shaped traffic, ensuring zero packet loss at maximum emulation speeds.

IxVerify is the EDA-focused version of Keysight's award-winning IxExplorer VE and IxNetwork VE OSI Layer 2/3 test solution, and as a result, test configurations can be reused to test from the earliest stages of chip design and verification through post-silicon quality assurance (QA).

KEYSIGHT

IxVerify is the perfect solution for de-risking complex networking chips to ensure faster time to market for the next generation of networking devices.

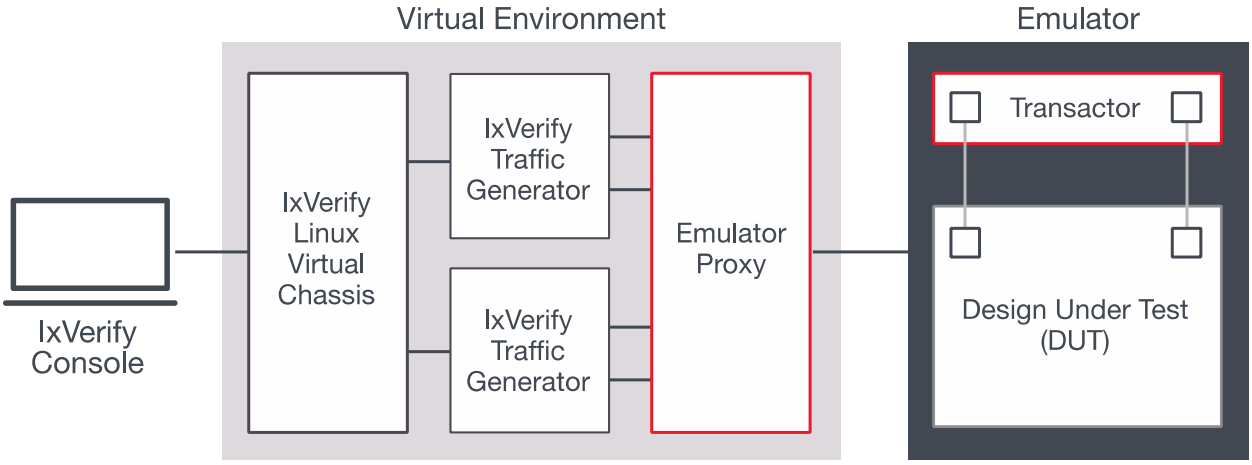

Figure 1. IxVerify Testing Architecture

IxVerify deployment in an emulation-based design verification environment. The IxVerify Console is powered by Keysight's industry standard tools IxExplorer and IxNetwork.

Highlights

- Verify networking chip design earlier in the development cycle
- Help developers verify SDK and driver software functionality before tape-out
- Send samples to OEM partners with confidence within days of fabrication
- Generate custom Ethernet traffic using dozens of predefined packet templates
- Leverage powerful statistics with bandwidth analysis and latency measurements
- Share test configurations between pre- and post-silicon teams using IxExplorer and IxNetwork
- Automate tests using multiple languages, including REST API
- Support multiple users with a flexible worldwide virtual test environment

IxVerify VE

Key Features

- Support for 10MbE, 100MbE, 1GE, 2.5GE, 5GE, 10GE, 25G, 40GE, 50GE, 100GE, 200GE, 400GE, 800GE and 1.6TE port speeds
- The IxVerify virtual test environment allows multiple simultaneous users anywhere in the world
- Support for Keysight's IxNetwork and IxExplorer for L2/3 traffic generation and analysis
- Generate custom Ethernet traffic with hundreds of predefined packet templates
- Powerful statistics, including bandwidth analysis and latency measurements based on emulation time
- High-resolution latency measurements, with 1 nanosecond (ns) accuracy
- Share IxExplorer and IxNetwork test configurations and automation scripts between pre-silicon and post-silicon testing teams
- Unique dynamic traffic shaping via backpressure ensures zero packet loss in the virtual environment
- IEEE 802.1AE MACsec encryption/ decryption at line speed
- Full TSN feature testing in emulation
- Extensive automation capabilities with REST, TCL, Perl, Python, and Ruby API support

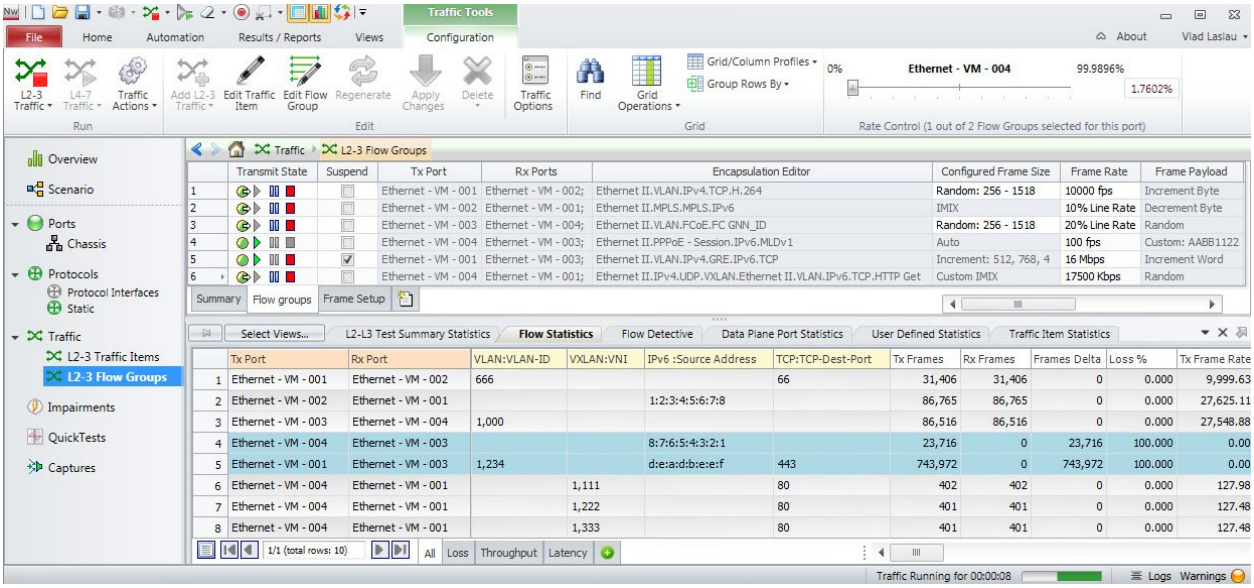

Figure 2. IxVerify real-world traffic and analysis

Specifications

IxVerify features, functions, and capacities for the Keysight Virtual Chassis and Virtual Load Modules.

Feature	Virtual Chassis	Virtual Load Module
Maximum # of Virtual Ports	128	32
Maximum # of Virtual Load Modules	32	N/A
Maximum # of Ports Per Test	1024	
Guest OS	CentOS 7 / Linux Kernel 3.10 enhanced kernel	
Distribution / Packaging	QCOW2	
Hypervisor and Host OS	KVM over RHEL 7.3 / CentOS 7.3 (or newer 7.x) KVM over Ubuntu 16.04 LTS, and 22.04 LTS	
Network Connection and vNIC Driver	Virtual Switch (with customized VIRTIO driver)	
Ethernet Port Speeds	Ethernet port speed support for 10MbE, 100MbE, 1GE, 2.5GE, 5GE, 10GE, 25G, 40GE, 50GE, 100GE, 200GE, 400GE, 800GE, 1.6TE	

Network Packet Templates

To validate traffic performance, IxVerify formulates and transmits a wide variety of Ethernet packet types, including custom packets.

OSI Layer	Included Packet Templates
Layer 2	Create any custom Ethernet II packet, including additional packet headers.
Layer 3	IPv4, IPv6, AMT, CGMP, DDP, GRE, GTPu, ICMP, IGMP, IPX, IS-IS, L2TP, Minimal IP, MLD, Mobile IPv6, NVGRE, OSPF, PIM, RGMP, RSVP, RTMP, VXLAN, custom.
Layer 4–7	TCP, UDP, BFD, DHCP, HTTP, IMAP, iSCSI, L2TP, LDP, LISP, MobileIP, MSDP, POP, PTP, RIP, RTP, RTSP, SMTP, TDS, custom.
Custom	Any custom Ethernet packet can be imported or created byte-by-byte.

Ethernet Traffic Generation

IxVerify supports traffic generation and measurement that ensures precision and performance.

The sophisticated traffic generator is also tightly integrated with the control-plane protocols.

Traffic Generator[1)]	Specification
Configuration	• Advanced Traffic Wizard—step-by-step wizard-assisted traffic configuration. • Quick FlowGroup—granular control of packet sequence and variations.
Scale	• Generate up to 4 million trackable flows by using IxNetwork. • Configure up to 16,000 unique Flow Groups—each supporting a unique transmit profile. • Up to 1024 Flow Groups per-port. • Up to 4,096 trackable receive flows per port.
Dynamic Packet Rate changes	Rate (load) changes on-the-fly without stopping transmission on the Keysight port.
Traffic Types	IPv4, IPv6, MPLS multi-labels, Ethernet, VLAN, provider bridges (Q-in-Q), provider backbone bridges (MAC-in-MAC), PPP, L2 MPLS VPN, L3 MPLS VPN, VPLS, 6PE, 6VPE, multicast, multicast VPN, custom packets.
Source/Destination Ports Mapping	One-to-one, many-to-many, fully meshed.
Routes Mapping between Peer Ports	One-to-one, fully meshed.
Flow Grouping	Build flow groups based on packet content (for example, QoS or VLAN ID).
Traffic Profile	• Ethernet II Frame size: Frame sizes from 17 bytes to 18000 bytes are supported. Fixed, increment, random, IMIX, custom IMIX, Quad Gaussian distribution, and automatic (based on content) frame sizes are available. • Rate: Percent line rate, packets/sec, IFG, L2 bit rate (bps, Bps, • KBps, MBps). • Payload pattern: Increment byte/word, decrement byte/word, random, custom, repeating. • QoS: TOS, DSCP, IPv6 traffic classes, 802.1p, MPLS EXP.
Sequential Stream Scheduler	Configuration of up to 1024 unique sequential streams on each port. Multiple streams can be defined in sequence, each containing multiple packet flows. After transmission of all packets in the first stream, control is passed to the next defined stream in the sequence.
Advanced Stream Scheduler	The transmission of stream groupings is interleaved. For example, a port is configured with three streams. Stream 1 is defined with IP packets at 20 percent of line rate, Stream 2 is defined with TCP packets at 50 percent of line rate, and Stream 3 is defined with MPLS packets at 30 percent of line rate. Packets on the port are transmitted at an aggregate usage of 100 percent with interleaved IP, TCP, and MPLS packets.
Synchronized Start Transmit	Starts the transmission of packets on all ports at the same time.
Staggered Start Transmit	Starts the transmission of packets on all ports, except the start operation is staggered across ports.
Per-Flow Traffic Tracking	Single or multi-field tracking of any field including: QoS (TOS/DSCP), VLAN, source MAC address, destination MAC address, source IP address, destination IP address, MPLS label, MPLS flow descriptor, streams, Src/Dst IP pair, Src/Dst MAC pair, custom packet tracking.

Traffic Generator[1)]	Specification
Real-Time Flow Filtering and Flow Detective	Real-time filtering of flows based on tracking settings with user defined criteria. Single out best/worst performing flows based on Rx count, min/max/average latency, timestamp, real-time packet loss by using sequence.
Packet Editor	Easy-to-use Packet Editor to modify all packet fields and payloads within a packet. • Add tracking: Increment, decrement, list, user defined, default, link/unlink with other header fields. • Payload editing: Track user-defined traffic flows. • Custom editing: Increment byte/word, decrement byte/word, repeat, fixed, and user defined fields (UDFs).
Sequential Transmit flows per port	Billions.
No-Loss Virtual Environment	Custom flow control between Keysight and the Emulator ensures zero packet loss from the virtual environment.
Accurate time synchronization with the emulation environment	Nanosecond time synchronization with emulation environment ensuring accurate latency measurements, timestamping, and time-sensitive protocols implementation
Per-interface independent port speed	Each virtual interface is connected to a transactor allowing different interface speeds on the same setup
Ethernet Preamble	Change/customize the Ethernet preamble size and value for Tx/ Rx traffic between 2 and 8 Bytes
Ethernet Interframe Gap (IFG) insertion	Hardware-based Layer 1 Ethernet Interframe Gap (IFG) inserted between frames to the Design Under Test (DUT) port.
IP/TCP/UDP Checksum Generation and Analysis	Provides per-packet real-time IP, TCP, and UDP checksum insertion, with receive-side checksum validation and statistics. Negative testing is also available by inserting bad checksums.
Loss	Track Tx frames, Rx expected frames, Rx frames, and Rx bytes frame delta loss %.
Rate	Tx frame rate, Rx frame rate, and Rx rate (bps, Bps, Kbps, Mbps) based on DUT port speed.
Timestamping and Latency	Inserts timestamp into each packet at certain offset, with 1ns resolution. Cut-through latency measurements, calculated by the chip emulator, with 1ns accuracy. Timestamp is inserted when the frame exits the transactor, to ensure accurate measurements.
Packet Loss Duration	Estimated time without received packets calculated by frames delta at the expected Rx rate.
Packet Error Injection	Ability to insert errored Checksums into each packet, including Bad CRC, No CRC, and Bad IP/ UDP/ TCP Checksums.
Basic/ Advanced Sequence Checking	Sequence numbers can be inserted at a user-defined offset in the payload of each transmitted packet. Upon receipt of the packets, IxVerify can measure packets out of sequence, duplicates, small errors, big errors, reverse errors, last sequence number, duplicate frames, sequence gaps, late frames, lost frames, and total errors.

Traffic Generator[1)]	Specification
Data Integrity	As packets traverse through networks, IP header contents may change, resulting in the recalculation of packet CRC values. The data integrity function allows packet payload contents to be verified with a unique CRC that is independent of the packet CRC. This ensures that the payload is not disturbed as the device changes header fields.
Capture buffer	Each IxVerify port has a 1MB buffer for packet capture. Packet filters are available to only capture packets of interest.
Real-time packet latency (per flow)	The receiving port measures the minimum, maximum, and average latency in real time for every packet belonging to unique traffic flows.
Real-time statistics	Real-time transmit and receive frame counts, with rates per flow and per port, Quality of Service (802.1p, DSCP, and IPv4 TOS) counters, user defined triggers/statistics, external logging-to-file for statistics and alerts.
Pause Flow Control IEEE 802.3x	IxVerify interfaces respond to IEEE 802.3x Pause frames. Custom defined Pause packets can also be built and transmitted to test the DUTs response.
Priority Flow Control (PFC) IEEE 802.1Qbb	IxVerify interfaces responds to IEEE 802.1Qbb priority-based flow control (PFC) frames, for each of the 8 queues. Custom-defined PFC packets can also be built and transmitted to test the DUTs response.
MACsec IEEE 802.1AE	• Line rate encryption/ decryption at 10MbE-1.6TE speeds • IEEE standard cyphers (GCM-AES-(XPN)-128, GCM-AES-(XPN)-256) • Confidentiality offset • Authentication (only) support • PN (32/64b) Sequence checking validation • SL, ICV, EtherType validation • Impairment options on most MACsec parameters
PTP/ gPTP IEEE 1588v2/ IEEE 802.1AS	• Master/ Slave role for ports • Multiple PTP sessions per port • Best Master Selection, Transparent Clock Correction Factor Error, Slave Scalability tests • Clock impairment
Audio Video Bridging (AVB)	• Support for IEEE 802.1Qat, IEEE 802.1Qav • Stream reservation based on MSRP (Talker/ Listener roles) • Multiple stream support, per stream statistics
Scheduled Traffic IEEE 802.1Qbv	• Scheduled traffic based on gPTP time • Accurate gate synchronization with the emulation environment • Negative testing
Frame Preemption IEEE 802.1Qbu and 802.3br	• Line rate Preemption traffic mix • Ability to configure hundreds of preempted flows on the same port • Automatic Frame Preemption peer support check with SMD-V and SMD-R frames • Impairment options and verification

Test Results—Statistics Viewer

IxVerify uses the IxExplorer and IxNetwork statistics viewer for viewing and analyzing real-time results and generating test reports.

- Aggregate statistics are displayed hierarchically, with the ability to drill down to group-level and flow-level statistics.
- Different modes to view traffic statistics—Instantaneous, Cumulative, or both.
- CSV files can be used to capture a single result view or, at the global level, to capture all results in real-time; an integrated CSV viewer is provided to view large-result files.

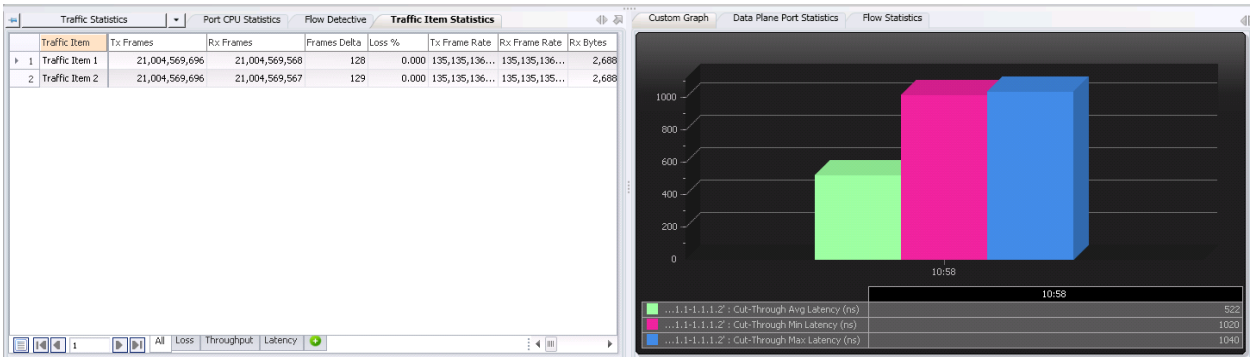

Figure 3. Statistics Viewer

Function	Statistics
Global Protocol	Port-level protocol counters
Port	Port mode, speed, frame and data rate
Tx-Rx Frame Rate	Tx-Rx frame rate graph
Port CPU	Port CPU utilization and statistics
Data Plane Port	Port-based frame counts and rate excluding control-plane traffic
Traffic Item	Statistics provide an aggregate of all the flows in the Traffic Item
User Defined	User-defined view is used for drill-down to user-defined tracking options
Flow Statistics	Flow-level measurements
Flow Detective	Filtering and sorting based results

Resource Manager

Often expertise for different protocols lies within different members of a testing team. A common pain-point for our customers was the lack of a collaboration tool to aid them in incrementally building configurations. With the Resource Manager, users can now piece-meal their configurations together. The Resource Manager allows users to save different pieces of their configurations, like protocols and traffic elements, and then build a configuration by re-using saved elements in their current configuration.

It also allows users to clearly see changes made to their resources/configurations by using a 'diff' functionality within the application. Using the Resource Manager is a powerful way to collaborate and quickly build expertise with a team.

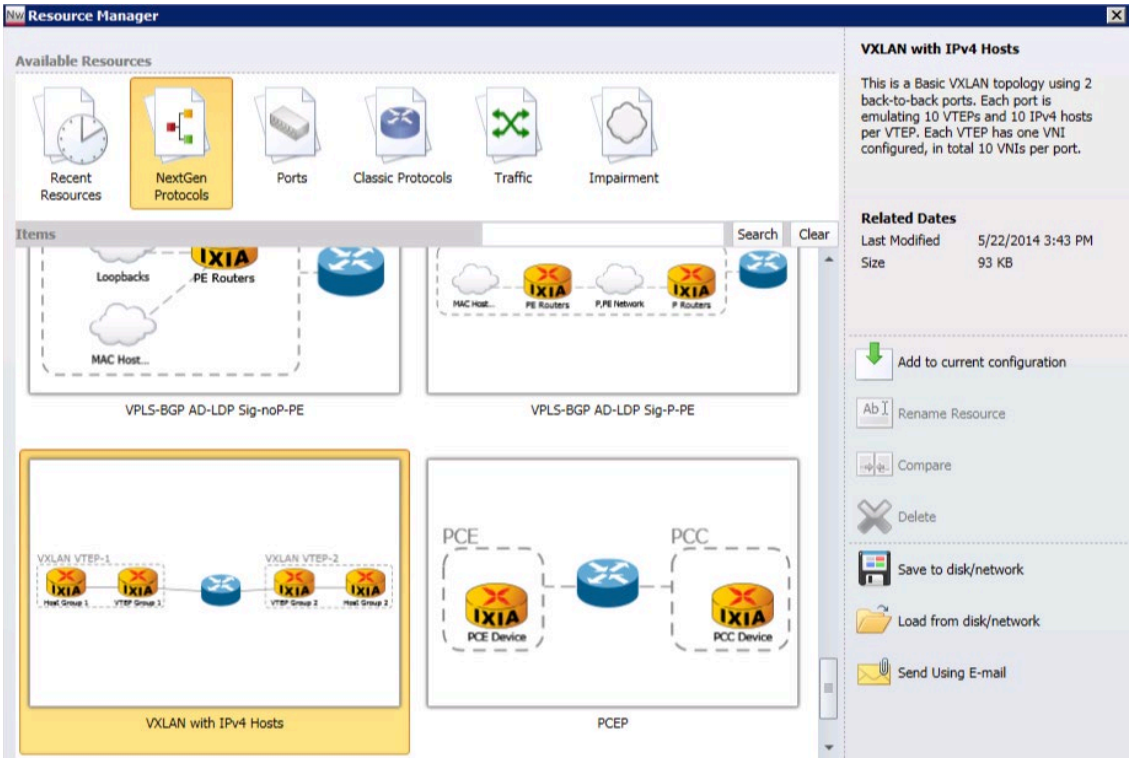

Figure 4. Resource Manager

Reports

Building a test-results report requires test data. IxReporter introduces a new database, referred to in the application as an 'object model.' The object model is populated with the test configuration parameters and the test results. All of these 'objects' can be included in a report, usually in a table or chart. With this powerful concept, tables and charts can be created that combine statistics and configuration information as well as have multiple protocols.

Automation

IxVerify uses IxNetwork's powerful GUI-based automation—Test Composer and QuickTests. It also has a robust feature set for GUI-to-script and API-based automation. Test scenarios are set up using a step-by-step GUI, and then a single button-press generates a Tcl test script. Scripts may be modified and combined in any fashion. When the script is run, the IxNetwork GUI watches the execution—providing real-time statistics and state information.

Types	Test Requirement	Detail
QuickTest	Scalability	• Standards-based IETF RFC test methodologies, as well as a custom mode for user-defined performance tests • Easy-to-use, configurable, pre-packaged tests • Generate detailed reports of results
Macro Recorder	Functionality	• 'Click-thru automation' means no more scripting • Rapid capture of manual test cases • Capture steps that cause a failure for reproducibility
Test Composer and Tweakables	Regression	• GUI-based solution to automate test actions • Detailed control over test execution without Tcl expertise • Complete access to the Tcl API with easy UI • Edit 'Macro Recorded' steps for customization of GUI captured events
ScriptGen	Regression	Provides an easy, one-click GUI-to-script generation
Low-Level and High-Level APIs	Functionality and regression	• For Tcl scripting experts • Complete access to and control over test configuration • REST, Tcl, Perl, Python, and Ruby API support
REST API / RESTPy / Robot/API Browser (IxNetwork only)	Functionality and regression	• Modern automation technologies like REST APIs, JSON data models, Robot keywords, and the Python programming language • RESTPy enables users to use REST API with built-in Python wrapper • API Browser enables users to browse IxNetwork • API hierarchy and expedites automation by using any language
Configuration and Script Re-use	Shared resources	IxVerify and Keysight Hardware configuration files and scripts can be shared and re-used between pre- and post-silicon validation teams

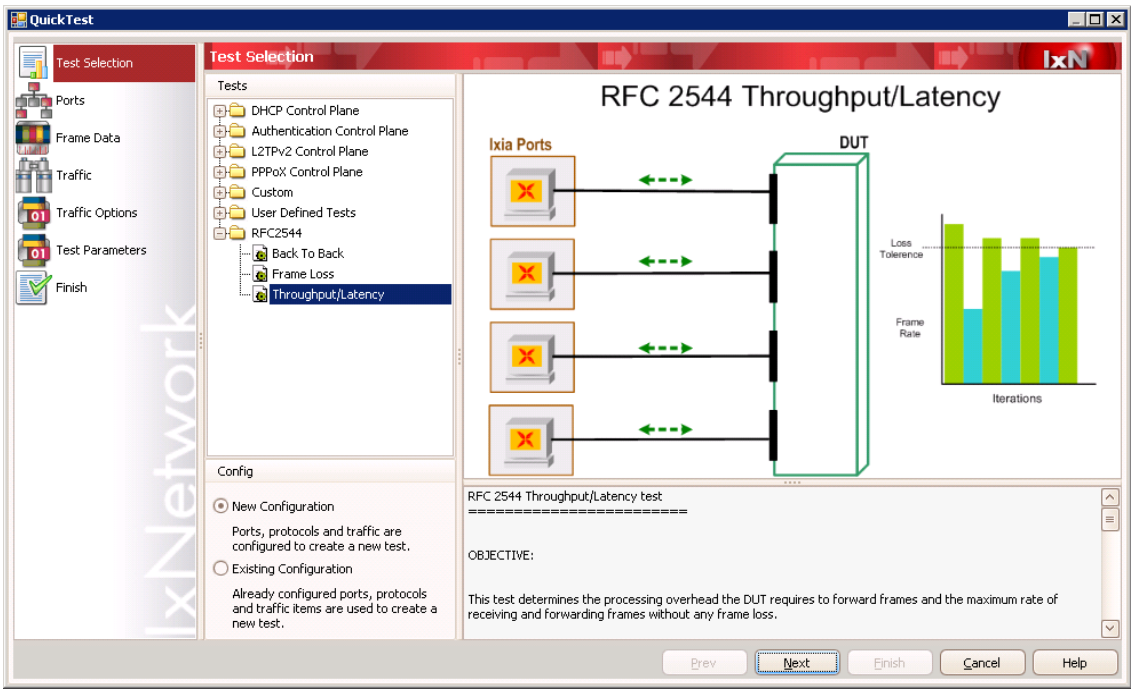

Figure 5. QuickTest end-to-end wizards

QuickTest	Tests
RFC 2544 Tests*	Layer 2 Throughput, Latency, Frame Loss, and Back-to-Back tests
RFC 2889 Tests*	Broadcast Rate, Congestion Control, Frame Error Filtering, Fully Meshed, Many to One, One to Many, Partially Meshed
RFC 3918 Tests*	Aggregated Multicast Throughput, Burdened Group Join Delay, Burdened Multicast Latency, Forwarding Latency, Group Join/Leave delay, Mixed Class throughput, Multicast Group Capacity, Multicast Group Pattern Verification, Scaled Group Forwarding
Custom Tests*	Continuous run, fixed duration run, incremental, throughput (binary search)
User-Defined Tests*	Tests defined in Test Composer

*Tests that support Raw/ Ethernet traffic only

Built-in Data Capture and Analysis

Internet protocols are complex—multi-protocol emulations even more so. IxVerify includes a built-in tool that captures the data-plane traffic. IxExplorer and IxNetwork allows you to trigger and filter data-plane packet captures based on user-defined packet field.

Application Support

IxVerify Combines Ixia Applications for EDA Testing

- **IxExplorer and IxNetwork**: OSI Layer 2–7 stateless Ethernet traffic generation that builds realistic, dynamically controllable data-plane traffic. IxNetwork offers the industry's best test solution for functional and performance testing.
- **IxNetwork Web UI**: IxNetwork Web Edition is built on the Linux API server platform that Keysight has supported in past releases and is inclusive of a full-fledged graphical user interface (GUI) to configure IxNetwork tests, QuickTest Web Edition, and REST API browser.
- **Automation**: Full automation capabilities with REST, TCL, Perl, Python, and Ruby API support.

Related Technology Solutions

Visit keysight.com for More Information on IxVerify and Keysight Virtualization Solutions

- IxNetwork Overview—L2/3 Network Infrastructure Performance Testing
- IxNetwork Software Defined Networking (SDN) Test Solution
- IxNetwork Automotive & Industrial Ethernet Test Solution
- IxNetwork Routing and Switching Test Solution
- IxNetwork Broadband and Authentication Test Solution
- IxNetwork Data Center Ethernet Test Solution
- IxNetwork MPLS Test Solution

Ordering Information

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IXIA IxVerify R&D services for customizing IxVerify solution.

[1)] The IxVerify features listed in this data sheet may not be supported by all emulation partners. Please contact your Keysight sales representative with any questions in this regard.