

IxNetwork—Routing and Switching Test Solution

Validate Internet Backbone Routing and Switching

Problem: Existing Network Strained with Increased Bandwidth Demand and Complexity

Routing and switching are fundamental Internet backbone infrastructure, providing Ethernet and IP underlay for value-added overlay networks and services. To handle the heterogeneous requirement of the Internet, a set of protocols provide Layer 2 and Layer 3 connectivity across different networks, apply traffic engineering aspects to optimize routing, connect multiple administration domains with policy control, implement fast failure detection and recovery mechanisms, handle abnormal condition, etc. These are all essential to provide a scalable and highly available backbone network. With exploding Internet users and services, as well as the complexity of the network, it is critical to ensure the core network infrastructure can be scaled out with robustness to meet today's business demand with satisfied service level agreement (SLA).

Solution: Comprehensive Testing to Ensure Highly-Available and Robust Network Infrastructure

The IxNetwork Routing and Switching test solution provides a rich set of routing and switching protocol emulations to qualify performance at Internet scale, convergence and failover, restart capability, as well as benchmarking suites for data forwarding performance.

It enables users to stress devices and networks under realistic conditions, measure key performance indicators (KPIs) to meet deployment requirements, validate IPv6 readiness of core network infrastructure to ensure smooth network upgrade and new network creation supporting value-added services.

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Highlights

- Test Internet infrastructure under realistic conditions with mixed routing and switching protocols running simultaneously
- Test Internet scale with emulation and real Internet routing table import
- Ensure core network high availability by validating the robustness of devices handling abnormal behaviors, through session and route flapping test, as well as long duration test
- Qualify the ability of fast failure detection and sub-second recovery
- Validate graceful restart and routing convergence capability to reduce network instability and downtime
- Assess network readiness to handle mixed IPv4 and IPv6 Internet routes and traffic
- Benchmark data forwarding performance to ensure satisfied latency/jitter and other KPIs
- Characterize performance of multicast infrastructure to efficiently deliver multicast traffic with replication

Key Features

- Emulates IGP speaking routers, supporting ISIS, OSPF, EIGRP and RIP, advertises a large number of routes, and simulates complex IGP topology to test protocol functionality, scale, and performance
- Emulates both IBGP and EBGP advertising large number of routes to stress test DUT performance and policy control, as well as importing real internet routes to validate DUT performance under real internet routing table
- BFD emulates heartbeat sessions along with routing protocols to validate quick failure detection and failover recovery to ensure minimum interruption on network failure
- BGP FlowSpec emulation validates DDoS mitigation as well as policy enforcement in SDN networks at scale with flow match and actions.
- Flexible action sets simulate dynamic network condition with routing sessions and routes flapping to validate the stability and robustness of the implementation handling abnormal behavior of internet network.
- Running multiple protocols simultaneously over one or multiple ports along with line-rate traffic to simulate real network condition
- Emulates Link Aggregation with LACP bundle or static bundle to qualify routing protocols and traffic over LAG
- Emulates Micro-BFDv4/v6 on individual member links of an LACP LAG to validate faster failure detection and failover of both control and data traffic running over the LAG.
- Supports IPv6 version of above-mentioned routing protocols to test IPv6 control and data plane performance and mixed v4/v6 support to ensure IPv6 readiness of core network
- Emulates PIM-SM/SSM, IGMP/MLD querier and receiver to qualify multicast infrastructure forwarding and replicating multicast traffic
- Emulates NTP client to validate NTP server function and scale/performance to support large number of NTP clients
- Packaged RFC 2554, 2889, 3918 QuickTest to benchmark data forwarding performance of routing and switching devices and end-to-end networks

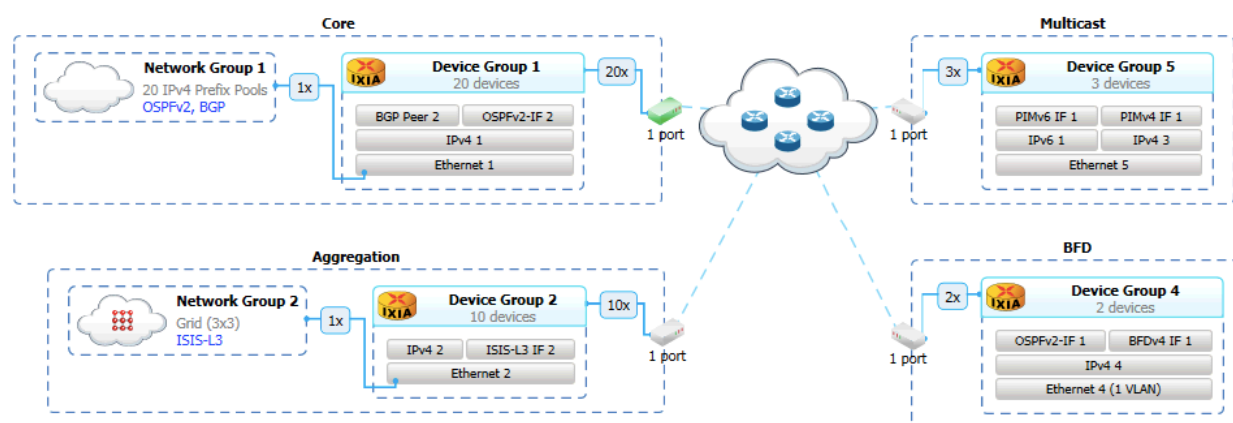


Figure 1. IxNetwork scaled routing topology emulation

Specifications

BGP

Standards	• RFC4271 - A Border Gateway Protocol 4 (BGP-4) • RFC2545 - Use of BGP-4 Multiprotocol Extensions for IPv6 • Inter-Domain Routing • RFC4456 - BGP Route Reflection: An Alternative to Full Mesh • Internal BGP (IBGP) • RFC1997 - BGP Communities Attribute • RFC5065 - Autonomous System Confederations for BGP • RFC4724 - Graceful Restart Mechanism for BGP • RFC6793 - BGP Support for Four-octet AS Number Space • RFC 7311 The Accumulated IGP Metric Attribute for BGP • RFC 7911 Advertisement of Multiple Paths in BGP • draft-uttaro-idr-bgp-persistence-03 BGP Long-lived BGP • Graceful Restart • RFC 8092 – BGP Large Communities Attribute • draft-ietf-idr-link-bandwidth-07 Link Bandwidth Extended Community • RFC 8654 - Extended Message Support for BGP
Protocol Messages	• OPEN • UPDATE • KEEPALIVE • NOTIFICATION
Capabilities	• IPv4 Unicast • IPv4 Multicast • IPv4 MPLS VPN • IPv6 Unicast • IPv6 Multicast • IPv6 MPLS VPN • IPv4 MDT • VPLS • IPv4 Multicast VPN • IPv6 Multicast VPN • Route Refresh • Route Constraint • Link State Non-VPN • EVPN
Path Attributes	• ORIGIN • AS_PATH • NEXT_HOP • MULTI_EXIT_DISC • LOCAL_PREF • ATOMIC_AGGREGATE • AGGREGATOR

BGP

Graceful Restart (GR)

- IPv4 Unicast (AFI/SAFI 1/1)
 - IPv6 Unicast (AFI/SAFI 2/1)
-

OSPFv2 and OSPFv3

Standards

- RFC 2328: OSPF Version 2
 - RFC3101: The OSPF Not-So-Stubby Area (NSSA)
 - RFC3623: Graceful OSPF Restart
 - RFC 4203: OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS) (SRLG, Link Protection)
 - RFC4811: OSPF Out-of-band Link State Database (LSDB) Resynchronization
 - RFC4812: OSPF Restart Signaling
 - RFC4813: OSPF Link-local Signaling
 - RFC 5250: The OSPF Opaque LSA Option
 - RFC 5340: OSPF for IPv6
 - RFC 3630 : Traffic Engineering (TE) Extensions to OSPF Version 2
 - RFC 7166: Supporting Authentication Trailer for OSPFv3
 - RFC 7308: Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE) for OSPFv2
-

OSPFv2 LSAs

- Router
 - Network
 - Summary
 - Summary type 4
 - AS-External
 - Traffic Engineering
 - Opaque LSA
 - NSSA
-

OSPFv3 LSAs

- Router
 - Network
 - Inter-Area-Prefix
 - Inter-Area-Router
 - AS-External
 - Link
 - Intra-Area-Prefix
-

Protocol Message Types

- Hello
 - Database Description
 - Link State Request
 - Link State Update
 - Link State Acknowledgement
-

OSPFv2 and OSPFv3

Router Types Supported

- Intra-Area Routers
 - Area Border Routers
 - Autonomous System Border Routers
 - Boundary Routers
-

Configuration Options

- Hello interval
 - Dead Interval
 - Area ID (decimal or IP notation)
 - Network Type (Point-to-Point, Broadcast)
 - MD5
 - Password
 - Enable/Disable Graceful Restart
 - Enable/Disable DR/BDR
-

Statistics

- OSPF Sessions Configured
 - OSPF Neighbors in full state
 - Down State Count
 - Attempt State Count
 - Init State Count
 - Two Way State Count
 - ExStart State Count
 - Exchange State Count
 - Loading State Count
 - Full State Count
 - Hellos TX/RX
 - DBD TX/RX
 - LS Request TX/RX
 - LS Update TX/RX
 - LS Ack TX/RX
 - LinkState Advertisement TX/RX
 - LSA Acknowledge TX/RX
 - Router LSA TX/RX
 - Network LSA TX/RX
 - Summary IP LSA TX/RX
 - Summary AS LSA TX/RX
 - External LSA TX/RX
 - NSSA LSA TX/RX
 - Opaque Local LSA TX/RX
 - Opaque Area LSA TX/RX
 - Opaque Domain LSA TX/RX
 - GraceLSA Rx
 - HelperMode Attempted
 - HelperMode Failed
-

OSPFv2 and OSPFv3

Learned Information

- Link State ID
- Advertising Router
- Link Type
- Sequence Number
- LSA age.

ISIS v4/v6

Standards

- ISO/IEC 10589: IS-IS intra-domain routing protocol
- RFC 1195: Use of OSI IS-IS for Routing in TCP/IP and Dual Environments
- draft-ietf-isis-ipv6-02.txt: Routing IPv6 with IS-IS
- draft-ietf-isis-traffic-04.txt: IS-IS extensions for Traffic Engineering
- draft-ietf-isis-restart-os.txt: Restart signaling for IS-IS
- RFC 5307: ISIS Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS) (SRLG, Link Protection)
- RFC 5305
- RFC 8202: IS-IS Multi-Instance
- RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions
- RFC 7308: Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE)
- RFC 6119: IPv6 Traffic Engineering in IS-IS
- draft-ietf-isis-te-app-05: IS-IS TE Attributes per application

Configuration Option

Router Types

- Level 1
- Level 2
- Level 1+2

Network Types

- Point-to-Point
- Broadcast

Area Address

Adjacency Parameters

- Interface IP addresses
- Mask
- Metric
- ID
- Hello Interval
- Dead Interval
- LSP Refresh Rate
- LSP Lifetime
- Max LSP Size

	Route Range Parameters • Route IP addresses • Mask • Metric • IP Type (IPv4 or IPv6) • Router Origin Network Range (Grid) Parameters • Route IP addresses • Mask • Metric • Router IDs • number of Rows • number of Columns • Entry Row • Entry Column • Link Type • IP Type (IPv4 or IPv6) Traffic Engineering • Link Metric • Administrator Group • Maximum Bandwidth • Maximum Reservable Bandwidth • Unreserved Bandwidth (Priority 0-7) • TE Path Authentication Graceful Restart Flapping
Statistics	• Session Configured • Session Up • Neighbors • DB Size • Hellos TX/RX • PTP Hellos TX/RX • LSP TX/RX • CSNP TX/RX • PSNP TX/RX
Traffic Engineering Metrics	• Administrative group (color) • Maximum link bandwidth • Maximum reservable link bandwidth • Unreserved bandwidth

ISIS v4/v6

	• TE Default Metric • Ext Admin Group • Extended Admin Group • Unidirectional Link Delay • Min/Max Unidirectional Link Delay • Unidirectional Delay Variation • Unidirectional Link Loss • Unidirectional Residual Bandwidth • Unidirectional Available Bandwidth • Unidirectional Utilized Bandwidth
Traffic Engineering identifier TLVs	• Traffic Engineering Router ID (TLV 134) • IPv4 interface address • IPv4 neighbor address • IPv6 TE Router ID (TLV 140) • IPv6 Local interface address • IPv6 Neighbor interface address
Application Specific Traffic Engineering	• Supports all Traffic Engineering Metrics listed above • L-Flag • Standard Application Bit Mask (SABM) ◦ R-bit: RSVP-TE ◦ S-bit: Segment Routing Traffic Engineering ◦ F-bit: Loop Free Alternate ◦ X-bit: Flex-Algo • User Defined Application Bit Mask (UDABM)

RIP/RIPng	
Standards	• RFC 2453 - RIP Version 2 • RFC 2080 - RIPng for IPv6 • RFC 2081 - RIPng Protocol Applicability Statement
Protocol Options	RIP Transmit Packet Mode • Multicast (default) • Broadcast V1 • Broadcast V2 RIP Transmit Packet Mode • Multicast (default) Response Mode: • Split Horizon • Split Horizon, Poison Reverse

RIP/RIPng

Others

- Update Interval
- Update Interval Offset

Route Ranges

- Router IP address
 - Route Tag
 - Network Mask
 - Next Hop
 - Metric
-

EIGRP

Standards

- Cisco EIGRP
-

Configuration Options

EIGRP Router:

- Router ID
- AS Number
- Active Timer, K1, K2, K3, K4, K5,
- EIGRP Major Version
- EIGRP Minor Version
- IOS Major Version
- IOS Major Version Asynchronous

Interfaces:

- Hello Interval
- Hold Time
- Poisoned Reverse (enable/disable)
- Bandwidth
- Delay
- Load
- Reliability
- Max TLV/Update

Route Ranges:

- First Route
 - Mask Width
 - Number of Routes
 - Next Hop
 - Hop Count
 - Internal/ External Type
 - Bandwidth
 - Delay
-

EIGRP

	• Load • Reliability • MTU size • Packing (enable/disable) • Destination Count
Statistics	General Statistics: • Routers Configured • Routers Running • Neighbors Learned • Hello TX/RX • Updates TX/RX • Queries TX/RX • Replies TX/RX • ACKs TX/RX • Packets TX/RX • Routes TX/RX • Routes Withdrawn TX/RX • Retransmission Count • Routes Learned
Learned Routes	• Destination • Prefix Length • Type • FD • RD • Neighbor • Hop Count • Next Hop
BFD	
Standards	• RFC 5880: Bidirectional Forwarding Detection (BFD) • RFC 5881: Bidirectional Forwarding Detection (BFD) for IPv4 and IPv6 (Single Hop) • RFC 5882: Generic Application of Bidirectional Forwarding Detection (BFD) • RFC 5883: Bidirectional Forwarding Detection (BFD) for Multihop Paths • RFC 5884: Bidirectional Forwarding Detection (BFD) for MPLS Label Switched Paths (LSP)
Supported Protocols	• BGP and BGP+ • OSPF v2+v3 • ISIS v4+v6 • EIGRP • PIM-SM v4+v6 • SRv6/GSRv6

BFD

Configuration Options	Modes: • Asynchronous • On-demand • Echo with user configuration interface and timeout Session: • Session Type (single or multi-hop), • End-point IP types (v4 or v6), • Remote IP address, • My Discriminator, • Enable auto chosen source, • Enable remote discriminator learnt
Statistics	General Statistics: • Routers Configured • Routers Running • Control Tx/Rx • Echo Self Tx/Rx • Echo DUT Loop Back • Echo DUT Received • Session Configured • Session Auto-Created • Configured UP-Sessions • Auto-Created UP-Sessions

BFD over LAG (Mirco-BFD)

Standards	• RFC 7130: Bidirectional Forwarding Detection (BFD) on Link Aggregation Group (LAG) Interfaces
Supported Protocols	• LACP
Configuration Options	Session: • Destination MAC • Source IP • Destination IP • Min Rx Interval • Tx Interval • Timeout Multiplier • Enable Demand Mode • Poll Interval
Statistics	General Statistics: • Sessions Up • Sessions Down • Sessions Not Started • Sessions Total • Sessions Auto Created

- Auto Created Up Sessions
- Session Flap Count
- Control Tx
- Control Rx

BGP Flow Specification

Standards	• RFC 8955: Dissemination of Flow Specification Rules • RFC 8956: Dissemination of Flow Specification Rules for IPv6 • draft-ietf-idr-flowspec-redirect-ip-02 • RFC 8092: BGP Large Communities Attribute • draft-jiang-idr-ts-flowspec-srv6-policy-07
Capability	• AFI 1 / SAFI 133 (IPv4 Unicast Flowspec) • AFI 2 / SAFI 133 (IPv6 Unicast Flowspec)
Match Components Type (IPv4)	• Type 1: Destination Prefix • Type 2: Source Prefix • Type 3: IP Protocol • Type 4: Port • Type 5: Destination port • Type 6: Source port

BGP Flow Specification

	• Type 7: ICMP • Type 8: ICMP code • Type 9: TCP flags • Type 10: Packet length • Type 11: DSCP (Diffserv Code Point) • Type 12: Fragment
Match Components changes (IPv6)	• Type 1: Destination IPv6 Prefix • Type 2: Source IPv6 Prefix • Type 3: Next Header IP • Type 12: Fragment • Type 13: Flow Label
Extended Community for Actions	• Traffic-Rate-Bytes (0x8006) • Traffic-Rate-Packets (0x800c) • Traffic-Action (0x8007) • Redirects: ◦ RT AS-2byte (0x8008) ◦ RT IPv4 (0x8108) ◦ RT AS-4byte (0x8208) ◦ IPv4 Next-Hop (0x010c) ◦ IPv6-Address-Specific Extended Community - IPv6 Next-Hop (0x000c) - RT Redirect IPv6 (0x000d) • Traffic Marking (0x8009)

IGMP/MLD

Standards	• RFC1112: IGMP v1 • RFC2236: IGMP v2 • RFC3376: IGMP v3 • RFC2710: MLD v1 • RFC3810: MLD v2
Message Type Supported	IGMP • Generate 'membership reports' (v1, v2, v3) and 'leave reports' (v2, v3) • Reply to membership queries • Emulate querier to test IGMP snooping MLD • Generate 'multicast listener reports' and 'multicast listener done' • Reply to 'multicast listener queries' • Emulate 'querier to test MLD snooping'
Configuration Options	Host Operational Settings: • router alert option (IGMPv2/v3 and MLDv1/v2)

- response to general query messages (all versions)
- response to group-specific query messages (IGMPv2/v3 and MLDv1/v2)
- unsolicited response mode (all versions)
- report frequency (seconds)
- suppress reports (all versions)
- membership reports not transmitted if learned from another host
- immediate response (all versions)
- packing for record/frame and source/record (IGMPv3 and MLDv2)

Querier Operational Settings:

- Version selection
- Startup query count
- Enable/disable router alert
- General query interval (s)
- General query response interval (ms)
- Specific query TX count
- Specific query response interval (ms)
- Support election
- Support older version host/querier
- Querier rate control

Statistics

Host Statistics:

- Membership reports TX/RX
- Leave TX
- General queries RX
- Group-specific queries RX
- Done TX
- Total frames TX/RX
- Invalid packets RX

Querier Statistics:

- Querier v1 membership rpts Rx
 - Querier v2 membership rpts Rx
 - V1/V2/V3 general query Tx
 - V2/V3 group-specific query Tx
 - V3 grp and src specific query Tx
 - Leave Rx
 - MLDv1 done Rx
 - V3 membership rpt Rx
 - Querier total frames Tx
 - Querier total frames Rx
 - Querier invalid packets Rx
 - General queries Rx
 - Group-specific queries Rx
-

IGMP/MLD

Supported Platforms

- All Ixia Ethernet load modules
 - IxVM
-

PIM-SM/SSM

Standards

- RFC 2362: Protocol Independent Multicast - Sparse Mode (PIM-SM)
-

Message Types

- Hello
 - Register
 - Join/Prune (*,*,RP), (*,G), (S,G), and (S,G,rpt)
- MLD
- Generate “multicast listener reports” and “multicast listener done”
 - Reply to “multicast listener queries”
 - Emulate “querier to test MLD snooping”
-

Configuration Options

Hello:

- Hold time
- LAN prune delay
- DR priority
- bidirectional capable (Bidir_Capable)
- Generation ID (GenID)
- Register
- Border bit (B) and null-register bit (N) automatically encoded by state machine if set as designated router

Join/Prune

- Hold time
- unicast upstream neighbor
- multicast group
- join source
- prune source addresses
- State machine will encode the number of groups, joined sources, and pruned sources based on configuration

Source:

- Version selection
 - Startup query count
 - Enable/disable router alert
 - General query interval (s)
 - General query response interval (ms)
 - Specific query TX count
 - Specific query response interval (ms)
 - Support election
 - Support older version host/querier
 - Querier rate control
-

Operational Behavior**Real-Time Configuration:**

- Emulated routers, interfaces, multicast groups, and sender sources
- can be created, deleted, or flapped in real-time while the state machine is running

Timed Switching:

- Auto switch a range of multicast groups from (*,G) to (S,G) based on a delay time (sec) interval

Timed Flapping:

- Based on a timed interval. Default: 60 seconds

State Refresh:

- Three modes available:
- Constant mode keeps GenID fixed until a change is made to a configuration entry
- Incremental mode increments GenID on every hello message
- Random mode inserts a random GenID value on every hello message

Packed Groups:

- When enabled, all multicast groups are added to one joined/pruned message. Otherwise, a join/pruned message is created for every multicast group

Register Encapsulation Traffic:

- For each emulated multicast sender enabled, Ixia will transmit source traffic encapsulated in register message packets until a "RegisterStop" message is received. Native multicast data packets can be configured and generated from the traffic wizard.

Statistics

- Hello TX/RX
- Register TX/RX
- Rtrs. Configured
- Rtrs. Running
- Neighbor Learned
- Register Stop TX/RX
- Register Null TX/RX
- Join (S,G) TX/RX
- Join (*,G) TX/RX
- Join (*,*,RP) TX/RX
- Join (S,G,RPT) TX/RX
- Prune (*,G) TX/RX
- Prune (S,G) TX/RX
- Prune (*,*,RP) TX/RX
- Prune (S,G,RPT) TX/RX

Link Aggregation Control Protocol (LACP)

Standards	• IEEE 802.3ad
Supported Protocols	• BGP and BGP+ • OSPF v2+v3 • ISIS v4+v6 • EIGRP • PIM-SM v4+v6
Configuration Options	Modes: • Asynchronous • On-demand • Echo with user configuration interface and timeout Session: • Session Type (single or multi-hop), • End-point IP types (v4 or v6), • Remote IP address, • My Discriminator, • Enable auto chosen source, • Enable remote discriminator learnt
Statistics	• Link State • LAG ID • Total LAG Member Ports • LAG Member Ports UP • Session Flap Count • LACPDU Tx • LACPDU Rx • LACPDU Malformed Rx • Marker PDU Tx • Marker PDU Rx • Marker Response PDU Tx • Marker Response PDU Rx • Marker Response Timeout Count • LACPDU Tx Rate Violation Count • Marker Tx Rate Violation Count
Spanning Tree Protocols	
Standards	• IEEE 802.1D - 2004 • IEEE 802.1S • IEEE 802.1Q - 2003 • Cisco PVST+/RPVST+
Supported Protocols	• STP • RSTP • MSTP • PVST • RPVST

Spanning Tree Protocols

Configuration Options

Emulated Bridge

- Hello Interval
- Max Age
- Message Age
- Forward Delay
- Priority
- System ID
- Mac Address

Emulated Root Bridge

- Root Cost
- Priority
- System ID
- Mac Address
- VLAN Port Priority

Interface

- Inter BPDU Gap
- BPDU Jitter (enable, %)
- Point-to-Point Interface
- Shared Interface

Emulated CIST

- Regional Root Priority
- Regional Root MAC Address
- Regional Root Cost
- External Root Priority
- External Root MAC Address
- External Root Cost, Remaining Hops

Emulated MSTIs

- Priority
 - MAC Address
 - Root Cost
 - Start VLAN ID
 - End VLAN ID
 - Remaining Hops
 - Port Priority
-

Spanning Tree Protocols

	Emulated PVST +/RPVST+ VLANs • VLAN ID • Root Priority • Root MAC Address • Root Path Cost • VLAN Port Priority
Learned Information	• Root Priority • Root Mac Address • Designated Cost • Designated Priority • Designated MAC Address • Designated Port ID • Interface Role (Disable, Root, Designated, Alternate, Backup) • Interface State (Discarding, Learning, Forwarding)
Statistics	• BPDUs TX/RX • BPDU Config TC TX/RX • BPDU Config TCA TX/RX • BPDU TCN TX/RX

Network Time Protocol (NTP)

Standards	• RFC 5905 – Network Time Protocol Version 4: Protocol and Algorithms Specification
Configuration Options	Protocol Option – NTP • Start Rate • Stop Rate NTP Clock • Active • Precision (log2 seconds) • Maximum frequency tolerance (ppm) • NTP sever count • Minimum survivor count • Accept NTP packets with Crypto-NAK • NTP Server • Active • Sever IP Address • Server IPv6 Address • Burst Mode • Initial Burst Mode

Network Time Protocol (NTP)

- Min Poll Interval (log2 seconds)
- Max Poll Interval (log2 seconds)
- Participate in Clock Select
- Authentication – NULL, MD5, SHA1
- Authention Key
- Key Identifier
- Delay (us)

Platform Options

Visit www.keysight.com for more information on IxNetwork platform options

Virtual Platform	• IxNetwork Virtual Edition (VE)
Chassis	• XGS12-HSL/SDL/SD Chassis • XGS2-HSL/SDL/SD Chassis
Fixed Chassis	• AresONE-M 800GE QSFP-DD800 • AresONE-M 800GE OSPF800 • AresONE-M 800GE Dual Interface Model • AresONE-S 400G QSFP-DD • AresONE 400G QSFP-DD • AresONE 400G OSFP • AresONE 400G High Performance QSFP-DD • NOVUS ONE PLUS 3- and 5-Speed 10GE/5GE/2.5GE/1GE/100M
Appliances	• NOVUS ONE 10GE/1GE/100M
Load Modules	• K400 QSFP-DD 400/200/100/50GE • K400 CFP8 400GE • NOVUS QSFP28 100/50/40/25/10GE • NOVUS SFP28/QSPF28 100/50/25/10GE • NOVUS 3-Speed 10GE/1GE/100M • NOVUS 5-Speed 10GE/5GE/2.5GE/1GE/100M • Xcellon-Multis QSFP28 100/50/25GE • Xcellon-Multis CFP4 100GE • Xcellon-Multis CXP 100/40/10GE • Xcellon-Multis QSFP 40/10GE • Xcellon-Lava CFP 100/40GE • Xcellon-Flex QSFP/SFP+ 40/10GE

IxNetwork Technology Solutions

Visit www.keysight.com for more information on IxNetwork platform options

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

Routing

930-2004

IxNetwork, Optional Software, Multicast Emulation, includes IGMPv1/v2/v3, MLDv1/v2, PIM-SM/SSMv4/v6, and Multicast VPN support; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2005

IxNetwork, Optional Software, BGP4 Emulation; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2007

IxNetwork, Optional Software, BGP4 Emulation with additional IPv6 support; **REQUIRES** 930-2005 BGP4 emulation; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2008

IxNetwork, Optional Software, OSPFv2 Emulation; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2009

IxNetwork, Optional Software, OSPFv3 Emulation; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2010

IxNetwork, Optional Software, IS-IS Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2011

IxNetwork, Optional Software, IS-IS Emulation with additional IPv6 support; REQUIRES 930-2010 IS-IS emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2012

IxNetwork, Optional Software, RIPv2 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2013

IxNetwork, Optional Software, RIPv6 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2020

IxNetwork, Optional Software, EIGRP Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2023

IxNetwork, Optional Software, BFD Emulation for use with OSPF, BGP, or ISIS; REQUIRES either 930-2008 OSPFv2 Emulation, OR 930-2009 OSPFv3 Emulation, OR 930-2005 BGP4 Emulation, OR 930-2006 BGP4 Emulation with Layer 3 MPLS/VPN & Multicast VPN Support, OR 930-2007 BGP4 Emulation with IPv6 support, OR 930-2010 IS-IS Emulation, OR 930-2011 IS-IS Emulation with IPv6 support. REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2035

IxNetwork, Optional Software, LACP IEEE 802.3ad Protocol Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2051

IxNetwork, Optional Software, Protocol emulation over IEEE 802.3ad (LACP); REQUIRES 930-2035 LACP IEEE 802.3ad Protocol Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2067

IxNetwork, Optional Software, IGMP/MLD Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2068

IxNetwork, Optional Software, PIM-SM/SSM Emulation; Includes PIM-SM/SSMv4/v6 and Multicast VPN emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2097

IxNetwork, Optional Software, LISP MS/MR and xTR Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

BGP Flowspec emulation

930-2121

IxNetwork, Optional Software, BGP FlowSpec Emulation; REQUIRES 930-2005 BGP4 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

Bundles

930-2001

IxNetwork, Optional Software Bundle, IPv4 Routing Protocols; includes 930-2005 BGP-4 Emulation, 930-2008 OSPFV2 Emulation, 930-2010 IS-IS Emulation, 930-2012 RIPv2 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2002

IxNetwork, Optional Software Bundle, IPv6 Routing Protocols; includes 930-2007 BGP4 with IPv6 Support, 930-2009 OSPFv3 with IPv6 Emulation, 930-2011 IS-IS IPv6 Support, 930-2013 RIPv6 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076) and 930-2001 Optional Software Bundle, IPv4 Routing Protocols; includes Media Kit

Switching

930-2017

IxNetwork, Optional Software, STP/RSTP Emulation; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2018

IxNetwork, Optional Software, MSTP Emulation; **REQUIRES** 930-2017 STP/RSTP Emulation; **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2055

IxNetwork, Optional Software, Spanning Tree protocol emulation per VLAN (PVST); **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076) **AND** 930-2017 STP/RSTP Emulation

930-2126

IXIA IxNetwork, Optional Software, Network Time Protocol (NTP) Emulation (930-2126); **REQUIRES** pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

QuickTest

930-2022

IxNetwork, Optional Software, RFC2544 and Custom Integrated Tests over Advertised Topologies; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2401

IxNetwork, Optional Software, RFC 2889 QuickTest; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2403

IxNetwork, Optional Software, IP Multicast RFC 3918 QuickTest; REQUIRES 930-2067 IGMP/MLD Emulation (or 930-2004 IxNetwork Multicast Emulation); REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2409

IxNetwork, Optional Software, Asymmetric Data Performance QuickTest; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

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