

IxNetwork — Software Defined Network (SDN) Test Solution

Validate Diverse SDN Technologies to Meet Your Business Needs

Problem: SDN Revolutionizing How Networking is Done

SDN has emerged as a new networking paradigm that transforms the existing closed network into open and programmable components of a highly scalable cloud infrastructure. It redefines how networks are built to better support business agility. This paradigm shift requires extensive testing and validation to ensure that it can deliver the benefits promised by SDN. With multiple emerging and competing technologies addressing different deployment scenarios, it is critical for equipment makers, service providers, and enterprises to have the ability to quickly and thoroughly qualify products and services before deployment.

Solution: A Comprehensive Test Solution for Dynamic and Diverse SDN Networks

The IxNetwork SDN test solution delivers feature sets covering various SDN technology approaches, including green-field OpenFlow deployment, carrier network SDN technology, data center virtualization overlay, as well as overall orchestration and management. The IxNetwork SDN solution emulates carrier-scale, multi-service, complex SDN networks to stress device under test (DUT) or the end-to-end networks under dynamic conditions with flexibility and advanced operation to test every aspect of user scenarios.

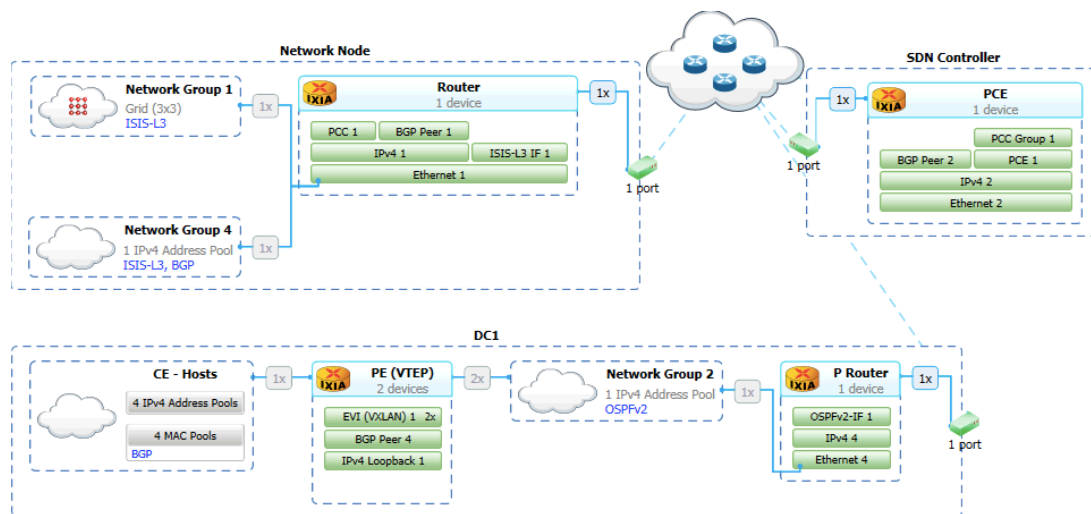
Key features

- OpenFlow controller and switch emulation supports OpenFlow version 1.0 and 1.3.1 for conformance, functional, scale and performance testing
- Segment Routing (SR) extension for OSPF, ISIS and BGP emulates realistic network topology to stress DUT SR implementation and validate data plane forwarding based on the instructions in the packet itself

Highlights

- Qualify SDN deployment scenarios and use cases with realistic networks and device emulation
- Ensure smooth deployment by testing with carrier class network emulation, dynamic service modeling at internet scale, and rapid isolation of service violations
- Accelerate time to market delivery and minimize financial risks of network migration with effective tool to validate cutting edge technology
- Ensure network design meets business demand by stressing hyper scale data center networks with peak load
- Automate end to end with REST and other APIs for continuous validation before rolling out new product and services

- Segment Routing IPv6 (SRv6) emulation validates SRv6 underlay and L3VPN/EVPN application overlay for network programmability
- PCEP and BGP-LS emulation validates Traffic Engineering Database (TED) distribution and existing Link State Database (LSDB) synchronization, programmability of optimized traffic engineering path based on network resource and constrains, as well as data forwarding performance along the TE path
- BGP SR TE Policy emulation validates SR TE policy advertisement and capability to direct traffic into explicit unequal cost multi-path (UCMP)
- ISIS Flexible Algorithm (Flex-Algo) emulation validates IGP constraint-based path computation for SR MPLS and SRv6 path
- VXLAN and GENEVE emulation stress-tests the ability of physical or virtual VTEP handling large number of remote VTEPs and VMs, as well as supporting VM mobility within or across data center
- EVPN with MPLS or VXLAN data plane emulates large number of PE or VTEPs to qualify virtualization overlay, L2/L3 services, advanced multi-homing capability of Data Center devices and Data Center Network
- OVSDB client and server emulation supports HW_VTEP schema to validate overlay network provision in Software Defined Data Center
- NETCONF client and server emulation executes command sets agnostic to Yang model to test NETCONF/YANG execution, as well as stress router/switch management plane and controller NETCONF session scale
- BIER emulation validates control plane operation of ISIS/OSPF underlay and MVPN service overlay operation, multicast traffic forwarding and replication, as well as scale/performance of BIER network
- In-Band Telemetry packet templates help to generate traffic mix to validate INT data insertion and measure the forwarding performance with telemetry load
- eCPRI message generation validates 5G fronthaul transport network with eCPRI messages along with other data traffic to ensure QoS and ultra-low latency



IxNetwork Test solution for Software Defined Core network and Data Center Network

Specifications

ISIS Segment Routing	
Standards	<ul style="list-style-type: none"> • RFC 8667 IS-IS Extensions for Segment Routing • draft-previdi-isis-ipv6-prefix-sid-02 • RFC 7794 IS-IS Prefix Attributes for Extended IPv4 and IPv6 Reachability • RFC 8570 IS-IS Traffic Engineering (TE) Metric Extensions • RFC 7308 Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE) • draft-ietf-isis-te-app-19 IS-IS TE Attributes per application • RFC 6119 IPv6 Traffic Engineering in IS-IS
Prefix/Node TLV	<ul style="list-style-type: none"> • TLV – 135 (IPv4) • TLV – 236 (IPv6) • TLV – 237 (MT-IPv6)
Neighbor/Adjacency TLV	<ul style="list-style-type: none"> • TLV – 22 (extended IS reachability) • TLV – 222 (MT IS TLV) • TLV – 23 (neighbor attribute) • TLV – 223 (MT neighbor attribute)
Sub – TLVs	<ul style="list-style-type: none"> • SR-Capabilities • SR-Algorithm • Prefix SID • Adjacency SID • LAN-Adj-SID • SID/Label • SRLB • SRMS Preference • SID/Label Binding • Prefix Attribute Flags (default values only, no user input)

OSPFv2 Segment Routing	
Standards	<ul style="list-style-type: none"> • RFC 8665 OSPF Extensions for Segment Routing • RFC 7684 OSPFv2 Prefix/Link Attribute Advertisement • draft-ietf-lsr-ospf-prefix-originator-00
OSPFv2 Router Information Opaque LSA	<ul style="list-style-type: none"> • SR-Algorithm TLV • SID/Label Range TLV • SRLB • SRMS Preference

OSPFv2 Segment Routing	
OSPFv2 Extended Prefix Opaque LSA	<ul style="list-style-type: none"> • OSPFv2 Extended Prefix TLV • OSPFv2 Extended Prefix Range TLV • Prefix SID Sub-TLV • Prefix Source Router-ID Sub-TLV
OSPFv2 Extended Link Opaque LSA	<ul style="list-style-type: none"> • OSPFv2 Extended Link TLV • Adj-SID Sub-TLV • LAN Adj-SID Sub-TLV

OSPFv3 Segment Routing	
Standards	<ul style="list-style-type: none"> • RFC 8666 OSPFv3 Extensions for Segment Routing
OSPFv3 Router Information Opaque LSA	<ul style="list-style-type: none"> • SR-Algorithm TLV • SID/Label Range TLV
OSPFv3 Extended Router LSA	<ul style="list-style-type: none"> • Router Link TLV • Adj-SID Sub-TLV • LAN Adj-SID/Label Sub-TLV
OSPFv3 LSAs and TLV/Sub-TLVs:	<p>LSAs</p> <ul style="list-style-type: none"> • E-Inter-Area-Prefix-LSA • E-Inter-Area-Router-LSA • E-AS-External-LSA • E-Type-7-LSA • E-Intra-Area-Prefix-LSA <p>TLV/Sub-TLVs</p> <ul style="list-style-type: none"> • Inter-Area-Prefix TLV • Inter-Area-Router TLV • External Prefix TLV • Intra-Area-Prefix TLV • SID/Label Sub-TLV

BGP Segment Routing	
Standards	<ul style="list-style-type: none"> • RFC 8669 Segment Routing Prefix Segment Identifier Extensions for BGP • draft-ietf-idr-bgp-prefix-sid-03 • RFC3107-Carrying Label Information in BGP-4

BGP Segment Routing	
BGP-Prefix-SID Attribute	<ul style="list-style-type: none"> • Label-Index-TLV • Originator SRGB TLV

BGP Link State Emulation	
Standards	<ul style="list-style-type: none"> • RFC 7752 – North-Bound Distribution of Link-State and Traffic Engineering (TE) Information Using BGP • draft-ietf-idr-bgp-ls-segment-routing-ext-16 • draft-ietf-idr-bgpls-segment-routing-epe-19 • draft-ietf-idr-bgpls-srv6-ext-00 • draft-ietf-idr-bgp-ls-segment-routing-msd-05
Capability	<ul style="list-style-type: none"> • Non-VPN: AFI 16388 / SAFI 71
Link-State NLRI	<ul style="list-style-type: none"> • Node • Link • IPv4 Prefix • IPv6 Prefix
Node Descriptors TLV	<ul style="list-style-type: none"> • Local Node Descriptors • Remote Node descriptors
Node Descriptor Sub-TLV	<ul style="list-style-type: none"> • AS • BGP-LS ID • OSPF Area-ID • IGP Router-ID
Multi-Topology ID TLV (ISIS only)	<ul style="list-style-type: none"> • MT ID 0 (IPv4 Unicast) • MT ID 2 (IPv6 Unicast)
Link Descriptors TLV	<ul style="list-style-type: none"> • IPv4 interface address • IPv4 neighbor address • IPv6 interface address • IPv6 neighbor address
Prefix Descriptors TLV	<ul style="list-style-type: none"> • OSPF Route Type • IP Reachability Information
Node Attribute TLV	<ul style="list-style-type: none"> • Multi-Topology ID (ISIS only) • Node Flag Bits • Node Name (ISIS only) • ISIS Area ID

BGP Link State Emulation	
	<ul style="list-style-type: none"> • IPv4 Router ID of Local Node • SID/Label Binding • SR Capabilities • SR Algorithm • SRLB • SRMS Preference
Link Attribute TLV	<ul style="list-style-type: none"> • Local IPv4/IPv6 Router ID • Remote IPv4/IPv6 Router ID • Administrative group • Maximum link bandwidth • Max reservable link bandwidth • Unreserved bandwidth • TE Default Metric • IGP Metric • Adjacency Segment Identifier • LAN Adjacency Segment Identifier
Prefix Attribute TLV	<ul style="list-style-type: none"> • IGP Flag • Prefix Metric • Prefix SID • Range • Prefix Attribute Flags • Source Router-ID
SRv6 SID NLRI	<ul style="list-style-type: none"> • SRv6 SID Information TLV • SRv6 Endpoint Function TLV
SRv6 TLVs	<ul style="list-style-type: none"> • SRv6 Capabilities TLV • SRv6 Node MSDs <ul style="list-style-type: none"> ◦ Maximum Segments Left ◦ Maximum End Pop ◦ Maximum T.Insert ◦ Maximum T.Encaps ◦ Maximum End D • SRv6 End.X SID TLV • SRv6 LAN End.X SID TLV • SRv6 Link MSDs [same as Node MSDs] • SRv6 Locator TLV

PCEP Emulation	
Standards	<ul style="list-style-type: none"> • RFC 4655 – A path Computation Element (PCE)-Based Architecture • RFC 4657 – Path Computation Element (PCE) Communication Protocol Generic Requirements • RFC 5440 – Path Computation Element (PCE) Communication Protocol (PCEP) • RFC5521 – Extensions to the Path Computation Element Communication Protocol (PCEP) for Route Exclusions • RFC 8231 – PCEP Extensions for Stateful PCE • RFC 8281 – PCEP Extensions for PCE-initiated LSP Setup in a Stateful PCE Model • RFC 8408 - Conveying Path Setup Type in PCE Communication Protocol (PCEP) Messages (for SRv6 path only) • draft-ietf-pce-segment-routing-07 • draft-ietf-pce-lsp-setup-type-03 • draft-ietf-pce-association-group-05 • draft-ietf-pce-stateful-path-protection-01 • draft-ietf-pce-binding-label-sid-03 • draft-negi-pce-segment-routing-ipv6-03
PCEP Capabilities	<ul style="list-style-type: none"> • Stateful PCE • LSP Update • LSP Instantiation • SR PCE • SRv6 PCE
PCEP - Stateful PCE	<p>Messages</p> <ul style="list-style-type: none"> • Open, Keepalive, PCReq, PCRep, PCRpt, PCUpd, Error, Close <p>Objects</p> <ul style="list-style-type: none"> • RP • SRP • LSP • END POINT (IPv4/IPv6) • ERO • RRO • IRO • XRO • BANDWIDTH • LSPA • METRIC • NO-PATH • PCEP-ERROR • CLOSE • ASSOCIATION

PCEP Emulation	
	<p>TLVs</p> <ul style="list-style-type: none"> • Stateful-PCE-Capability • Path Setup Type • IPv4-LSP-Identifiers • IPv6-LSP-Identifiers • Symbolic Path Name
PCEP - PCE initiated LSP (Add-on to Stateful PCE)	<p>Messages</p> <ul style="list-style-type: none"> • PCInitiate <p>Objects</p> <ul style="list-style-type: none"> • SRP (R flag) • LSP (C flag) • End-Points • ERO • XRO • ASSOCIATION <p>TLVs</p> <ul style="list-style-type: none"> • Symbolic-Path-Name TLV • Path Setup Type TLV • TE-PATH-Binding TLV
PCEP - Segment Routing	<p>TLV</p> <ul style="list-style-type: none"> • SR PCE Capability TLV (for SR-TE Path) • PATH-SETUP-TYPE-CAPABILITY TLV (for SRv6 Path) • SRv6-PCE-CAPABILITY Sub-TLV • TE-PATH-Binding TLV • Path Setup Type TLV <p>Object/Sub-Object</p> <ul style="list-style-type: none"> • SR-ERO <ul style="list-style-type: none"> ◦ SID ◦ NAI <ul style="list-style-type: none"> - IPv4 Node ID - IPv6 Node ID - IPv4 Adjacency ID - IPv6 Adjacency ID - Unnumbered Adjacency with IPv4 NodeIDs ◦ SRv6 SID ◦ SRv6 NAI Type <ul style="list-style-type: none"> - IPv6 Adjacency ID - IPv6 Node ID - IPv6 Adjacency

VXLAN	
Standards	RFC 7348 – Virtual eXtensible Local Area Network (VXLAN): A Framework for Overlaying Virtualized Layer 2 Networks over Layer 3 Network
Protocol Option	<ul style="list-style-type: none"> • Number of VTEP • Number of VNIs/VTEP (default 1) • UDP Port (default 8472) • VNI • IPv4 Multicast Address
Host Protocol support over VXLAN VTEPs	<ul style="list-style-type: none"> • Ethernet • ARP • IPv4 • ICMP/Ping • DHCP • IGMP • MLD
VTEP Discovery (Discovery Domain)	<ul style="list-style-type: none"> • Multicast (IGMP, PIM) • Unicast (Static VTEP configuration)
Routing Protocol Support to Advertise VTEP Reachability	<ul style="list-style-type: none"> • OSPF • BGP

OVSDB	
Standards	<ul style="list-style-type: none"> • RFC 7047 – The Open vSwitch Database Management Protocol • hardware_vtep schema - http://openvswitch.org/docs/vtep.5.pdf
Protocol Option	<p>OVSDB Server</p> <ul style="list-style-type: none"> • Schema – HW VTEP • Connection Type – TCP or TLS • TCP Port • Certificate Directory • Private Key File • Certificate File • CA Certificate File • Manager Count <p>Managers</p> <ul style="list-style-type: none"> • Active • IPv4 Address • TCP Port

OVSDB	
	<p>OVSDB Controller</p> <ul style="list-style-type: none"> • Schema – HW VTEP • Connection Type – TCP or TLS • TCP Port • Certificate Directory • Private Key File • Certificate File • Verify Peer Certificate • CA Certificate File <p>Cluster Data</p> <ul style="list-style-type: none"> • Attach at Start • Logical Switch Name • VNI • Physical_Switch name • Physical_Port name • VLAN ID

EVPN MPLS and EVPN VXLAN	
Standards	<ul style="list-style-type: none"> • RFC 7432 – EVPN • RFC 7623 – PBB-EVPN • draft-ietf-bess-evpn-overlay-01 • draft-ietf-bess-evpn-inter-subnet-forwarding-01 • draft-ietf-bess-evpn-prefix-advertisement-04 • RFC5512 • draft-ietf-bess-evpn-vpws-07 • draft-sajassi-bess-evpn-vpws-fxc-01 • draft-sharma-multi-site-evpn-03 • draft-sajassi-bess-evpn-mvpn-seamless-interop-03
Capability	<ul style="list-style-type: none"> • AFI = 25 (L2VPN) • SAFI 70 (EVPN)
Route Type	<ul style="list-style-type: none"> • Type 1 – Ethernet Auto-Discovery (A-D) Route • Type 2 – MAC/IP Advertisement Route • Type 3 – Inclusive Multicast Ethernet Tag Route • Type 4 – Ethernet Segment Route • Type 5 – IP Prefix Route

EVPN MPLS and EVPN VXLAN	
Extended Community	<ul style="list-style-type: none"> • ESI Label Extended Community • ES Import Route Target • MAC Mobility Extended Community • Default Gateway Extended Community • BGP encapsulation Extended Community • Router MAC Extended Community • Layer 2 attributes Extended Community
Multi-Homing Functions	<ul style="list-style-type: none"> • All-Active Ethernet Segment • Single-Active Ethernet Segment • Fast Convergence • Split Horizon • Aliasing and Back-Up Path • Designated Forwarder Election
L2 BUM Traffic Forwarding	<ul style="list-style-type: none"> • Ingress Replication • RSVP-TE P2MP (MPLS data plane only) • mLDP P2MP (MPLS data plane only) • PIM-SM/SSM (VXLAN data plane only)
L3 Multicast Forwarding (Tenant Routed Multicast)	<ul style="list-style-type: none"> • Ingress Replication (I-PMSI only) • PIM-SM (I-PMSI and S-PMSI) • PIM-SSM (I-PMSI and S-PMSI)

BGP Segment Routing Traffic Engineering Policy	
Standards	<ul style="list-style-type: none"> • draft-ietf-idr-segment-routing-te-policy-08 • draft-ietf-idr-tunnel-encaps-04 • RFC 5512 –The BGP Encapsulation Subsequent Address Family Identifier (SAFI) and the BGP Tunnel Encapsulation Attribute
Capability	<ul style="list-style-type: none"> • AFI 1 / SAFI 73 (IPv4 SR TE Policy) • AFI 2 / SAFI 73 (IPv6 SR TE Policy)
SR TE Policy Sub-TLVs	<ul style="list-style-type: none"> • Remote Endpoint • Color • Preference • Binding SID • Segment List • Weight • Segment

BGP Segment Routing Traffic Engineering Policy	
	<ul style="list-style-type: none"> • Explicit NULL Label Policy • Policy Priority • Policy Name
Extended Community for Actions	<ul style="list-style-type: none"> • Extended Color Community
Segment Sub-TLV Type	<ul style="list-style-type: none"> • Type 1: SID only, in the form of MPLS Label • Type 2: SID only, in the form of IPv6 address • Type 3: IPv4 Node Address with optional SID • Type 4: IPv6 Node Address with optional SID • Type 5: IPv4 Address + index with optional SID • Type 6: IPv4 Local and Remote addresses with optional SID • Type 7: IPv6 Address + index with optional SID • Type 8: IPv6 Local and Remote addresses with optional SID

Segment Routing v6	
Standards	<ul style="list-style-type: none"> • draft-ietf-6man-segment-routing-header-11 • draft-filsfils-spring-srv6-network-programming-04 • RFC 7794 IS-IS Prefix Attributes for Extended IPv4 and IPv6 Reachability • draft-ietf-lsr-isis-srv6-extensions-03 • RFC 6119 IPv6 Traffic Engineering in IS-IS • draft-dawra-idr-srv6-vpn-04 • draft-ietf-bess-srv6-services-01 • RFC 5549 Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop • draft-ietf-idr-bgpls-srv6-ext-00 • draft-ietf-idr-bgp-ls-segment-routing-msd-05 • draft-negi-pce-segment-routing-ipv6-03
ISIS SRv6 Capability	<ul style="list-style-type: none"> • SRv6 Capability TLV • Maximum SL sub-sub-TLV (1) • Maximum End Pop SRH sub-sub-TLV (2) • Maximum T.Insert SRH sub-sub-TLV (3) • Maximum T.Encap SRH sub-sub-TLV (4) • Maximum End D SRH sub-sub-TLV (5)
ISIS SRv6 TLV	<ul style="list-style-type: none"> • SRv6 Node SID • SRv6 Adjacency SID

Segment Routing v6	
	<ul style="list-style-type: none"> • SRv6 LAN Adjacency SID • SRv6 SID Structure
Endpoint Function	<ul style="list-style-type: none"> • End (no PSP, no USP) (1) • End with PSP (2) • End with USP (3) • End with PSP and USP (4) • End.X (no PSP, no USP) (5) • End.X with PSP (6) • End.X with USP (7) • End.X with PSP and USP (8) • End.T (no PSP, no USP) (9) • End.T with PSP (10) • End.T with USP (11) • End.T with PSPS and USP (12) • End.DX6 (16) • End.DT6 (18) • End.OTP (25) (advertise only) • Custom (user defined value)
L3VPN	<ul style="list-style-type: none"> • SRv6-VPN SID TLV • SRv6 SID Structure
EVPN	<ul style="list-style-type: none"> • VPWS • VPLS Type 1 Route • VPLS Type 2 Route • VPLS Type 3 Route • VPLS Type 5 Route
BGP-LS	<p>SRv6 SID NLRI</p> <ul style="list-style-type: none"> • SRv6 SID Information TLV • SRv6 Endpoint Function TLV <p>SRv6 TLVs</p> <ul style="list-style-type: none"> • SRv6 Capabilities TLV • SRv6 Node MSDs <ul style="list-style-type: none"> ◦ Maximum Segments Left ◦ Maximum End Pop ◦ Maximum T.Insert ◦ Maximum T.Encaps ◦ Maximum End D • SRv6 End.X SID TLV • SRv6 LAN End.X SID TLV

Segment Routing v6	
	<ul style="list-style-type: none"> • SRv6 Link MSDs [same as Node MSDs] SRv6 Locator TLV
PCEP	<ul style="list-style-type: none"> • PATH-SETUP-TYPE-CAPABILITY TLV • SRv6 PCE Capability Sub-TLV • SR-ERO <ul style="list-style-type: none"> ◦ SRv6 SID ◦ SRv6 NAI Type <ul style="list-style-type: none"> - IPv6 Node ID - IPv6 Adjacency

ISIS Flexible Algorithm (Flex-Argo)	
Standards	<ul style="list-style-type: none"> • draft-ietf-lsr-flex-algo-10
ISIS Router Capability TLV (TLV 242)	<ul style="list-style-type: none"> • Flex-Argo Definition Sub-TLV <ul style="list-style-type: none"> ◦ Calculation type ◦ Metric type ◦ Priority • FAD TLV <ul style="list-style-type: none"> ◦ FA Exclude AG Sub-TLV ◦ FA Include-Any AG Sub-TLV ◦ FA Include-All AG Sub-TLV ◦ FAD Flags Sub-TLV • FAPM TLV

BGP Flow Specification	
Standards	<ul style="list-style-type: none"> • RFC 5575 – Dissemination of Flow Specification Rules • draft-ietf-idr-flow-spec-v6-08 - Dissemination of Flow Specification Rules for IPv6 • RFC 7674 – Clarification of the Flowspec Redirect Extended Community • draft-ietf-idr-flowspec-redirect-ip-02 • RFC 8092 – BGP Large Communities Attribute
Capability	<ul style="list-style-type: none"> • AFI 1 / SAFI 133 (IPv4 Unicast Flowspec) • AFI 2 / SAFI 133 (IPv6 Unicast Flowspec)
Match Components Type (IPv4)	<ul style="list-style-type: none"> • Type 1 – Destination Prefix • Type 2 – Source Prefix

BGP Flow Specification	
	<ul style="list-style-type: none"> • Type 3 – IP Protocol • Type 4 – Port • Type 5 – Destination port • Type 6 – Source port • 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)	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Traffic-Rate (0x8006) • Traffic-Action (0x8007) • Redirect: <ul style="list-style-type: none"> ◦ AS-2byte (0x8008) ◦ IPv4 (0x8108) ◦ AS-4byte (0x8208) ◦ IP Next-Hop (0x0800) • Traffic Marking (0x8009)

Multicast Using Bit Index Explicit Replication (BIER)	
Standards	<ul style="list-style-type: none"> • RFC 8279 BIER architecture • RFC 8296 BIER MPLS Encapsulation • RFC 8401 BIER support via IS-IS • draft-ietf-bier-mvpn-11.txt • draft-ietf-bier-ospf-bier-extensions-18
ISIS	<ul style="list-style-type: none"> • BIER Info sub-TLV • BIER MPLS Encapsulation sub-sub-TLV
OSPF	<ul style="list-style-type: none"> • BIER sub-TLV • BIER MPLS Encapsulation sub-sub-TLV
mVPN	<ul style="list-style-type: none"> • PMSI Tunnel Attribute for BIER

Network Configuration Protocol (NETCONF)	
Standards	<ul style="list-style-type: none"> • RFC 6241 Network Configuration Protocol • RFC 6242 Using the NETCONF Protocol over Secure Shell (SSH)
Capability	<ul style="list-style-type: none"> • base1.0/1.1 • Writeable-running • Candidate configuration • Confirmed commit • Rollback-on-Error • Validate • Distinct startup • URL • XPath
Operation	<ul style="list-style-type: none"> • get • get-config • edit-config • copy-config • delete-config • lock • unlock • close-session • kill-session
SSH Authentication	<ul style="list-style-type: none"> • No authentication • Username/password • Key based

Seamless BFD	
Standards	<ul style="list-style-type: none"> • RFC 7880 • RFC 7881 • RFC 7882
Supported Protocols	<ul style="list-style-type: none"> • ISIS SR (Ixia is egress of SR LSP) • Any MPLS protocols (Ixia is ingress of MPLS LSP)
Supported Mode	<ul style="list-style-type: none"> • IPv4 MPLS

OpenFlow	
Standards	<ul style="list-style-type: none"> • OpenFlow v 1.0 • OpenFlow v 1.3.1 • RFC 4346/RFC 5246 – TLS 1.1/1.2
Message Type	<ul style="list-style-type: none"> • TCP/TLS (OF-Channel) • Hello • Feature Request/Reply • Echo Request/Reply/Pause/Resume • Vendor/Experimenter Message • Barrier • Flow Modification (Add, Delete, Modify) • Switch Config
Flow	<p>OpenFlow 1.0 Controller Emulation</p> <ul style="list-style-type: none"> • Full 12 tuple Match Support • All Actions Including Output (Port, All, Controller, In_Port, Local, Normal, Flood) and Vendor (0xffff) <p>OpenFlow 1.3.1 Controller Emulation (Specific)</p> <ul style="list-style-type: none"> • Flow Table with Full OXM Extensible Match Support, Including IPv4/v6 Support, IPv6 Extension Header, Multiple Levels of VLAN Tagging, MPLS Support, Tunnel ID Metadata, PBB Tagging • Instructions • OXM Extensible Set-Field Actions • Experimenter
Stats Request/Reply	<p>OpenFlow Controller Emulation</p> <ul style="list-style-type: none"> • Flow Stats (Individual/Aggregated) • Port Stats • Vendor/Experimenter Stat • Description Stat • Table Stat • Queue Config/Stat • Vendor Stats • Port Features • Group Stat • Meter Stat
Learned Info	<p>OpenFlow Controller Emulation</p> <ul style="list-style-type: none"> • Feature Reply • Port Status • Error Message • Switch Capabilities

OpenFlow	
	<ul style="list-style-type: none"> • Action Supported • Flow Stat • Port Stat • Vendor Stat • Description Stat • Table Stat • Queue Stat • Queue Config Stat • Topology Learned Info (via LLDP) <p>OpenFlow Switch Emulation</p> <ul style="list-style-type: none"> • OF-Channel Learned Info • Flow Learned Info • Host Topology Information
Test Composer OpenFlow Events	<ul style="list-style-type: none"> • OpenFlow 1.0 Controller Emulation • Pause/Resume Request/Reply • Send Request • Stat Request • Barrier • Flow • Config • Description • Feature • Queue • Table • Vendor, Vendor Message • LLDP – Packet out • Flow Add, Delete, Modify • OpenFlow 1.3.1 Controller Emulation • Description stat • Port stat • Table stat • Experimenter message • Queue config • Queue Stat
Benchmarking QT (Optional)	<p>OpenFlow Benchmarking QuickTest</p> <ul style="list-style-type: none"> • OpenFlow Switch Flow Table Capacity Test • L2/L3 Address Learning Rate of OpenFlow Network • OpenFlow Switch Flow Failover Performance

OpenFlow	
	<ul style="list-style-type: none"> • RFC2544 – Benchmarking Methodology for Network Interconnect Devices • RFC2889 – Benchmarking Methodology for LAN Switching Devices • RFC3918 – Methodology for IP Multicast Benchmarking

eCPRI	
Standards	<ul style="list-style-type: none"> • eCPRI Specification V1.1 (2018)
Device Role	<ul style="list-style-type: none"> • RE and Redio Channels/Users • REC
Transport	<ul style="list-style-type: none"> • eCPRI over Ethernet • eCPRI over UDP
Message Types	<ul style="list-style-type: none"> • IQ Data • Bit Sequence • Generic Data Transfer • Real-Time Control Data • Remote Memory Access • One-way Delay Measurement • Remote Reset • Event Indication

In-Band Network Telemetry (INT)	
Standards	<ul style="list-style-type: none"> • In-band Network Telemetry Dataplane Specification
Templates	<ul style="list-style-type: none"> • Gevene With INT • INT Metadata • INT Shim Header • INT Probe Marker

Platform Options

Visit keysight.com for More Information on IxNetwork Platform Options	
Virtual Platform	<ul style="list-style-type: none"> • IxNetwork Virtual Edition (VE)
Chassis	<ul style="list-style-type: none"> • XGS12-HSL/SDL/SD Chassis • XGS2-HSL/SDL/SD Chassis
Fixed Chassis	<ul style="list-style-type: none"> • AresONE-400G QSFP-DD 400/200/100/50GE • AresONE-400G OSFP 400/200/100/50GE • AresONE-400G High Performance QSFP-DD 400/200/100/50GE • NOVUS ONE PLUS 10GE/5GE/2.5GE/1GE/100M
Appliances	<ul style="list-style-type: none"> • NOVUS ONE 10GE/1GE/100M
Load Modules	<ul style="list-style-type: none"> • K400 QSFP-DD 400/200/100/50GE • K400 CFP8 400GE • NOVUS High Density QSPF28 100/50/40/25/10GE • NOVUS 10GE/1GE/100M • NOVUS 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 • NGY SFP+/BASE-T 10GE • XMVDC Dual PHY 1GE <p>Note VXLAN, EVPN VXLAN, OVSDDB, and GENEVE are not supported on:</p> <ul style="list-style-type: none"> • NGY SFP+/BASE-T 10GE • XMVDC Dual PHY 1GE

IxNetwork Technology Solutions

Visit www.keysight.com for More Information on IxNetwork Technology Solutions

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

Ordering Information

OpenFlow Emulation

930-2104

IxNetwork, Optional Software, OpenFlow Controller Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM

930-2105

IxNetwork, Optional Software, OpenFlow Switch Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM

930-2107

IxNetwork, Optional Software Bundle, OpenFlow Protocol Bundle; INCLUDES 930-2104 OpenFlow Controller Emulation; 930-2105 OpenFlow Switch Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM

930-2412

IxNetwork, Optional Software, OpenFlow QuickTest; OpenFlow Benchmarking test; Flow Table Capacity, Flow Learning Rate, Flow Failover Test; REQUIRES IxNetwork OpenFlow Emulation License (930-2107)

OpenFlow Conformance

924-442-10PBF

IxANVL, Protocol Test Package, SDN bundle

Segment Routing Emulation

930-2114

IxNetwork, Optional Software, IS-IS Segment Routing Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM; AND 930-2010 IS-IS Emulation, and 930-2011 IS-IS v6 Emulation

930-2117

IxNetwork, Optional Software, OSPFv2 Segment Routing Emulation REQUIRES 930-2008 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)

930-2116

IxNetwork, Optional Software, BGP Link State (BGP-LS) and BGP Segment Routing Emulation REQUIRES 930-2005 BGP4 Emulation, AND/OR 930-2007 BGP v6 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)

930-2123

IXIA IxNetwork, Optional Software, IPv6 Segment Routing Emulation (930-2123); Enable Segment Routing Support for IPv6 data plane (SRv6); REQUIRES: 930-2010 IS-IS Emulation AND 930-2011 IS-IS Emulation with additional 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); Recommend with: 930-2122 BGP SR TE Policy Emulation for SRv6 Traffic Engineering

930-2134

IxNetwork, Optional Software, OSPFv3 Segment Routing Emulation; REQUIRES: 930-2009 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)

PCEP Emulation

930-2118

IxNetwork, Optional Software, Path Computation Element Communication Protocol (PCEP) 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) Recommend with: 930-2114 ISIS Segment Routing, OR 930-2117 OSPFv2 Segment Routing, OR 930-2116 BGP Link State Emulation

BGP SR TE Policy Emulation

930-2122

IxNetwork, Optional Software, BGP SR TE Policy 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)

IGP Flexible Algorithm Emulation

930-2133

IxNetwork, Optional Software, ISIS Flexible Algorithm Protocol Emulation; Enable ISIS Flexible Algorithm for SR MPLS or SRv6; REQUIRES: 930-2010 IS-IS Emulation, AND/OR 930-2011 IS-IS v6 Emulation; REQUIRES: 930-2114 ISIS Segment Routing for SR MPLS OR 930-2123 IPv6 Segment Routing Emulation for SRv6; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

Seamless BFD

930-2130

IxNetwork, Optional Software, Seamless Bidirectional Forwarding Detection (S-BFD) Emulation; REQUIRES: 930-2010 IS-IS Emulation AND 930-2011 IS-IS Emulation with additional IPv6 support AND 930-2114 ISIS Segment Routing 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)

Segment Routing Bundle

930-2518

IxNetwork, Optional Software Bundle, Segment Routing Bundle (930-2518); INCLUDES; IxNetwork IS-IS Segment Routing (930-2114), IxNetwork BGP Link State (BGP-LS) (930-2116), IxNetwork OSPFv2 Segment Routing (930-2117), IxNetwork Path Computation Element Communication Protocol (PCEP) (930-2118); REQUIRES BGP4 Emulation (930-2005), AND/OR BGPv6 Emulation, AND OSPFv2 Emulation (930-2008), AND ISIS Emulation (930-2010), AND/OR ISIS v6 Emulation (930-3011); 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)

EVPN Emulation

930-2102

IxNetwork, Optional Software, BGP Extension to support EVPN and PBB-EVPN Emulation; REQUIRES 930-2005 BGP 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)

VXLAN Emulation

930-2103

IxNetwork, Optional Software, VXLAN Emulation; Supports functional and performance testing of VXLAN Gateways; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

OVSDB Emulation

930-2109

IxNetwork, Optional Software, OVSDB Emulation. Supports Open vSwitch Database Management protocol (OVSDB) for hardware VTEP schema. REQUIRES 930-2103 VXLAN 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)

NETCONF Emulation

930-2124

IXIA IxNetwork, Optional Software, Network Configuration Protocol (NETCONF) 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)

BIER Emulation

930-2125

IXIA IxNetwork, Optional Software, Bit Index Explicit Replication (BIER) Emulation; REQUIRES 930-2005 BGP4 Emulation AND 930-2006 BGP extensions to support MPLS L3VPN/VPLS; 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)

eCPRI Emulation

930-2128

IxNetwork, Optional Software, eCPRI (Common Public Radio Interface) Messages Generation; Enable generation of eCPRI messages for eRE and eREC; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

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

