# ACE-NIC Family

Ethernity's ACE-NIC family of SmartNICs enables true *"Router-on-NIC"* capabilities that offload CPU-intensive data networking forwarding functions directly to the network card. Conventional Network Interface Cards (NICs) and other SmartNICs pass most, if not all, data to the server to be processed by software. Ethernity's ACE-NIC SmartNICs can perform these functions directly on the card. Once configured, the ACE-NIC entirely offloads data forwarding tasks, bypassing the CPU and dramatically accelerating performance, while saving power, space, and expensive CPU cycles.
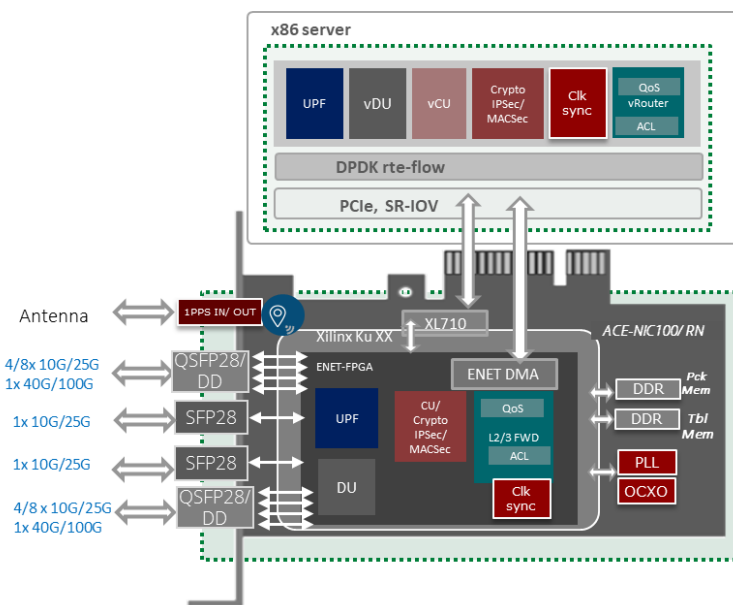
ACE-NIC50 and ACE-NIC100 SmartNICs with 10/25/40/100 Gigabit Ethernet connectivity, built using the FPGA-based Carrier-grade ENET Flow Processor technology, provide best-in-class performance and an unsurpassed feature set of acceleration and forwarding offload for 5G, telco, and enterprise NFV. Built to accelerate cloud and Multi-Access Edge Computing (MEC) infrastructure, the ACE-NIC family is optimized for carrier-level quality of experience, performance, and power at scale.

ACE-NIC Key Benefits

Offload, Acceleration & Low Power
A true hardware-forwarding SmartNIC, providing unmatched "Router-on-NIC" offload of forwarding tasks for networking and security applications, which frees valuable CPU resources, reduces power & physical space, and therefore operational expenses.

High Performance & Scale
ACE-NIC offers networking applications a simple way for hardware forwarding offload with line-rate high throughput as well as low latency.
On-board memory supports millions of traffic flows, and deep packet buffers handle large bursts of traffic without dropping packets.

Flexible & Programmable
ACE-NIC is a fully programmable FPGA-based SmartNIC that enables communication service providers a flexible, hardware-forwarding SmartNIC, built to adapt to hardware forwarding changes for different applications and use cases.

Advanced QoS
Prioritize, police, shape and steer traffic flows in hardware based on hierarchical Quality of Service (QoS) levels, with dedicated hardware queues and sophisticated traffic scheduler.

The ACE-NIC provides flexible network interface capabilities, advanced network and security hardware accelerators, and a comprehensive software suite, all of which are easily integrated in both telco and enterprise customer environments. The growing demand for security in the cloud and at the network edge requires both crypto and filters to be integrated for various types of data. The ACE-NIC delivers security acceleration with IPSec tunnel offload that works together with additional overlay methods, such as VxLAN and NVGRE inline processing, freeing the CPU from intense security processing and thereby improving performance.
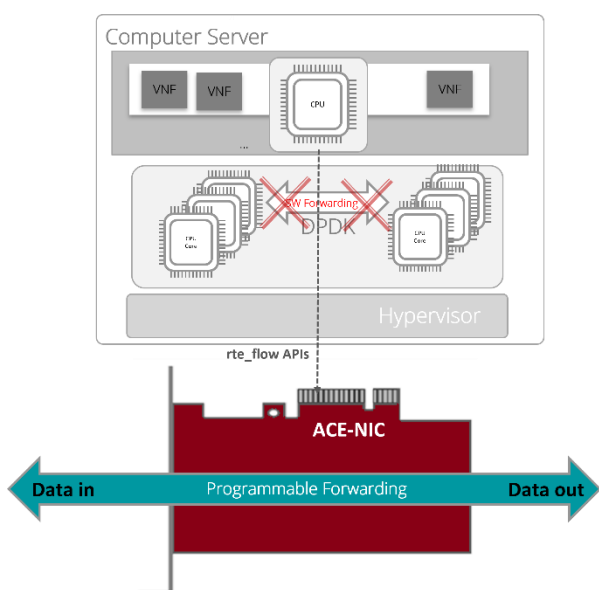
The result is optimized high-performance data forwarding on programmable, futureproof hardware. ACE-NICs provide deterministic throughput of up to 100G and sub-3µs latency without CPU intervention, freeing up those resources for running the control functions and applications for which they were designed, as well as saving physical space and power. The result is to save up to 80% on both operating and capital expenditures.

Router-on-NIC

The ACE-NIC Router-on-NIC feature uses DPDK as well as the ENET API adaptor to enable a high-performance switch/router data plane forwarding offload, including Carrier Ethernet Switch, Layer 3 forwarding, protocol interworking, and traffic management, ideal for any application that requires the agility of a virtual router with the performance of a physical router appliance.

Product Highlights

- Carrier-grade, high performance, high scale SmartNIC solution
- True Router-on-NIC hardware offload forwarding capabilities
- Ideal for 5G, telco, and cloud applications for platform, covering solutions from CO to MEC
- 10/25/40/100G connectivity
- L2-L4 forwarding in hardware to offload and accelerate workloads
- Flows configured by DPDK
- Quality of Service (QoS) with millions of flows
- Can scale up to 18 x 10/25G interfaces
- Supports on-board GPS with various options for clock sync accuracy
- Applications:
  - 5G UPF offload
  - MPLS and L3 features
  - 1588
  - Routing
  - Encryption
  - Layer 2 features
  - IPSec tunnel offload
  - Multi-tenant VNF

Router-on-NIC includes support for all Layer 3 routing protocols and methods, including unicast and multicast, with both IPv4 and IPv6. Router-on-NIC handles network address translation (NAT) and provides full support for VRRP and BFD.

Router-on-NIC has a complete suite of management features and also supports network virtualization overlays and tunneling, such as VxLAN, GRE, and GTP (for 5G). It comes with hierarchical traffic management to maintain the highest levels of quality of service, with features such as ACLs, queuing, policing, shaping, rate limiting, and QoS profiles. It maintains security with IPSec, while providing media access with PPP, PPPoE, and others.

In addition, Ethernity offers the ENET-D ACE-NIC add-on, which provides an FPGA Ethernet controller DMA engine IP core built to process millions of flows and accelerate networking and security appliances. Combined with ACE-NIC's ENET Flow Processor, ENET-D can connect to multiple virtual machines, containers, or virtual networking functions. Ethernity provides both Linux kernel drivers and DPDK drivers.

Clock Synchronization

The ACE-NIC family also provides clock synchronization, with support for IEEE 1588 timing, including PTPV2, Grandmaster, Boundary Clock, and Transparent Clock, as well as external GPS support. It can achieve class-C accuracy and a wide range of 1588 packet encapsulations. Synchronous Ethernet is also available with ACE-NIC, allowing for multiple input sources and end-to-end timing chain. ACE-NIC/RN provides the additional option of using a high-accuracy OXCO clock.

ENET Software Development Tools

ACE-NIC comes with several ENET development tools for the server side. DPDK APIs can be used to configure the FPGA for hardware-based acceleration of telco applications, using rte_flow. ACE-NIC DPDK uses rte_flow as the hardware API, and supports APIs for: LRO/TSO, filters, crypto, statistics, checksum, timing, flow API, tunnels, traffic management, and RSS. Other ENET development tools include: hardware adaptation layer (HAL), Metro Ethernet Adaptor (MEA) driver with ENET CLI, remote procedure calls, and ACE-NIC driver. Furthermore, complete L2/L3 MPLS protocol control software can be provided by Ethernity to deliver not just the routing offload, but also the complete routing protocol control software required for cell site router functions.
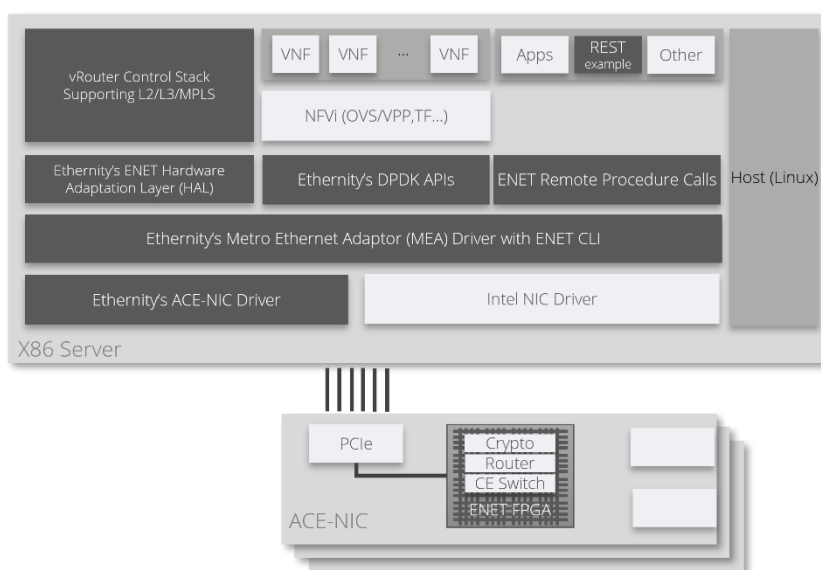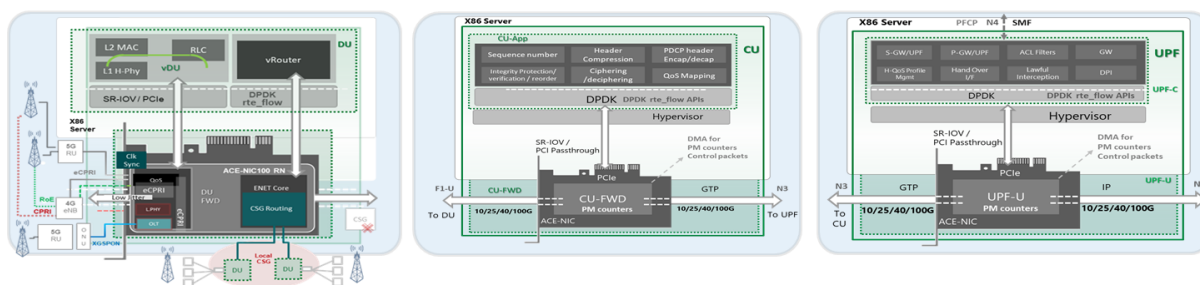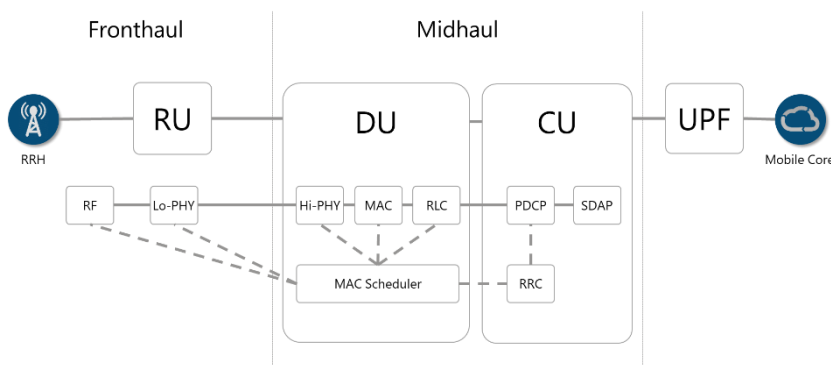
ACE-NIC Applications

Enabling 5G Radio Networks

ACE-NIC SmartNICs are well-suited to be used in key points of 5G radio networks. From the User Plane Function (UPF) block to the central unit (CU) and distributed unit (DU), ACE-NICs are built to offload data forwarding functionality of the radio network in the hardware. Among other features, Ethernity's leading technology delivers hardware-forwarding offload of L2-L4 switching and routing, tunneling like GTP and GRE, and security acceleration through IPSec, thereby reducing CPU overhead. Scalable, deterministic performance with very low latency can be achieved at a fraction of the space, power, and overall cost. GPS support is available in the ACE-NIC100/RN, along with 16 x 10/25G interfaces, or 18 x 10/25G without GPS.

As part of the data plane functions included within the ACE-NIC portfolio, the ACE-NIC can be quipped to support all data plane functions from the cell tower to the 5G core, as follows:

DU assist, L1, and vRouter offload
➤ QoS with deterministic latency
➤ High throughput
➤ Routing/ MPLS
➤ OAM/CFM, BFD
➤ SyncE/ 1588/ GPS
➤ Ring Topology

CU-UP (user plane)
➤ QoS mapping: QFI – DBR
➤ Sequence #, in-order deliver, duplication discard
➤ ROHC header compression
➤ AES crypto and IPSec to implement ciphering and integrity offload
➤ QFI to DBR ,PDCP header encap/decap

UPF-U (user plane)
➤ 2 Million flows classification and filtering
➤ GTP encap/decap
➤ ACL, Lawful interception, redirection, and traffic steering
➤ QoS, Packet buffering and Packet duplication
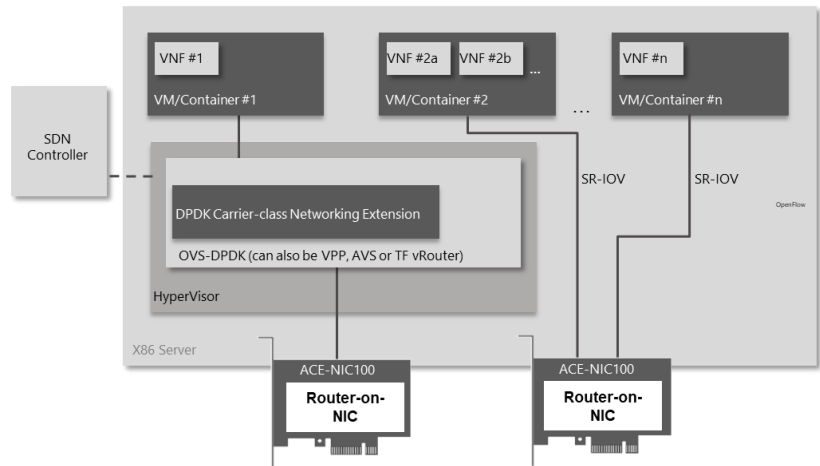➤ 10 Million PM counters for billing

5G Radio Networks Clock Synchronization

ACE-NIC's programmability is essential for the new connectivity in 5G. As broad radio channels in mid-band and high-band become available, user bandwidth will exceed multiple Gbit/s. While not all features need to be available on day one, mobile network operators favor transport network architectures that can be upgraded and extended as more demanding services are introduced. This drives a transformation from the current hardware-centric approaches toward programmable networks, leveraging standardized, server-based platforms with hardware-forwarding SmartNICs that also feature sophisticated timing capabilities. As synchronization becomes more important in many

networks, especially in 5G mobile and edge computing, these capabilities are all included in ACE-NIC SmartNICs as an integral part of the solution.

Accelerating NFV Workloads

Network functions have traditionally been handled by dedicated hardware, such as routers, load balancers, and firewalls. Network Function Virtualization has decoupled such services from the hardware, but at the expense of CPU efficiency. ACE-NIC uses FPGA programmability to enable a Router-on-NIC forwarding offload that effects multi-purpose smart hardware that accelerates performance, improves agility, and reduces expenses. ACE-NIC includes several features which enable it to offload NFV, such as L3 routing, encryption, IPSec, 5-tuple capabilities, deep packet inspection, and others.

Specifications Table

Specification	ACE-NIC50	ACE-NIC100-XL	ACE-NIC100/RN
Ports and Interfaces Options	• 2x SFP28 • 1 PPS for precision time stamping	• 2x QSFP28 • 1 PPS for precision time stamping	• 2x QSFP28 • 2x SFP28 • 1 PPS for precision time stamping

PCIe	• 2 x PCIe Gen3 (8 lanes)
	• DPDK & Kernel modes
	• SR-IOV ready
	  o 16 PFs (physical functions) [In ARI Mode, non-ARI mode allows for only 8]
	• 128 VFs (virtual functions)
		• 2 x PCIe Gen3 (8 lanes)
		• DPDK & Kernel modes
		• SR-IOV ready
		  o 16 PFs (physical functions) [In ARI Mode, non-ARI mode allows for only 8]
		• 128 VFs (virtual functions)
			• 2 x PCIe Gen3 (8 lanes)
			• DPDK & Kernel modes
			• SR-IOV ready
			  o 16 PFs (physical functions) [In ARI Mode, non-ARI mode allows for only 8]
			• 128 VFs (virtual functions)

Connectivity Options	2 x SFP28/SFP+
	• Each can be 25G or 10G
		2 x QSFP28
		• Each QSFP28 port can be supported with either:
		  o 40G or 4 x 10G (with 4x splitter cable) or
		  o 100G or 4 x 25G (with 4x splitter cable)
			2 x SFP28/SFP+
			• Each can be 25G or 10G
			2 x QSFP28
			• Each QSFP28 port can be :
			  o 4 x 10G (with 4x split cable)
			  o 4 x 25G (with 4x split cable)

Specification	ACE-NIC50	ACE-NIC100-XL	ACE-NIC100/RN

Clock Sync	• External GPS input with 1PPS in/out conntion
	• IEEE Y.1588 BC, TC
	• Sync-E
	• Class-C accuracy
		• External GPS input with 1PPS in/out conntion
		• IEEE Y.1588 BC, TC
		• Sync-E
		• Class-C accuracy
			• External GPS input with 1PPS in/out conntion
			   o Note: GPS option excludes the use of 2xSFP28 ports
			• IEEE Y.1588 BC, TC
			• Sync-E
			• Clock Sync: 1PPS IN, 1PPS OUT, TOD IN, TOD OUT
			   o Optional OXCO Oscillator
			• Class-C accuracy
			• Holdover of up to 24 Hours

Entries/Counters	128K/11	256K/11	256K/11
PM Counters	1,000,000	2,000,000	2,000,000
Flows	128K (service class)	256K (service class)	256K (service class)
Flow Matching	5-tuple – flow match & monitoring	5-tuple – flow match & monitoring	5-tuple – flow match & monitoring
Load Balancing	8 Link Aggregation Groups (LAG)	8 Link Aggregation Groups (LAG)	8 Link Aggregation Groups (LAG)
Policer	2 rate 3 color (2r3c) 32K up and 32K down	2 rate 3 color (2r3c) 128K policers	2 rate 3 color (2r3c) 128K policers
On-Board Memory Packet Buffer	Up to 10GB DDR4	Up to 10GB DDR4	Up to 10GB DDR4
OS	Linux (Ubuntu and CentOS)	Linux (Ubuntu and CentOS)	Linux (Ubuntu and CentOS)
Dimentions (H x W x D)	Standard height, half length: 167.65 x 111.15mm (6.7" x 4.376")	Standard height, half length: 167.65 x 111.15mm (6.7" x 4.376")	Standard height, half length: 167.65 x 111.15mm (6.7" x 4.376")
PCIe Voltage	+12V	+12V	+12V
Typical Power Consumption	50W - typically 2 ports operating at 40Gb/s	50W - typically 2 ports operating at 40Gb/s	50W - typically 2 ports operating at 40Gb/s
Operating Temperature	0°C to 50°C	0°C to 50°C	0°C to 50°C
Storage Temperature	-40°C to 65°C	-40°C to 65°C	-40°C to 65°C
Humidity	0%-90%, non-condensing	0%-90%, non-condensing	0%-90%, non-condensing

FPGA Firmware and SDK Feature List*

General
- Flow-based processor with L2/3/4 flow classification, hierarchical ACL
- Search engine up to 256K entries
- Timing with GPS input, 1PPS, PTP 1588, Sync-E
- Switch, router, MPLS and load balancing functions
- Five-level packet header & payload manipulation and marking:
  - MPLS
  - PBB
  - QinQ (PB)
- Different editing on duplicated packets/multicast
- Supported encapsulations:
  - L2TP, PPPoE
  - GRE, NVGRE, VxLAN
  - IPinIP
  - GTP for Mobile backhaul solutions*
  - L2TP and L2TPv3, PPPoE tunnels*
- LAG (L2, L3, L4 distribution)
- ERPS, ELPS
- Wire speed NAT/NAPT**
- IP fragmentation**

Connectors
- SFP+/SFP28/QSFP/QSFP28 (100G)/QSFP-DD
- Copper: SFP+ Direct Attached Twin-Ax Copper Interface Standards
- Optical: Optic 10GBASE-SR and 10GBASE-LR

Interfaces
- 2 x PCIe Gen3 x8 lanes
- 1 PPS for precision time stamping
- DPDK
- SR-IOV
  - 8 PFs (physical functions)
  - 128 VFs (virtual functions)

Stateless offloads
- TSO / LSO
- Enhanced RSS

MEF Services
- E-LINE, E-TREE, E-LAN, E-ACCESS
- MEF 2.0 certified

OAM
- Service OAM 802.1ag CFM (MEP, MIP)
- Service OAM ITU-T Y.1731 PM (latency, jitter)
- Link OAM -802.3ah EFM
- RFC 2544
- OAM fast protecting (failover in microseconds)
- Four ME levels of TR-101

Layer 1 Functionality
- Port mirroring
- Port protection
- Port reflection (LIN)
- Port advertising (Speed /Duplex)

Layer 2+ Functionality
- Non-blocking architecture
- MEF services and certifications
- All ports can serve as UNI/NNI
- Jumbo frames (up to 9,000 bytes) on all ports
- Bridge
  - 802.1d/q and PB with TR-101
  - Multicast
- Q-in-Q, (802.1q/802.1ad)
- ACL rules
- Tag swap
- Uni-directional link detection protocol (UDLD)
- Link layer discovery protocol (LLDP)
- <50ms protection LACP 1+1 (802.3ad)
- MSTP (802.1s)
- ELPS - G.8031/Y.1342
- ERPS - G.8032/Y.1344 v2
- OAM protection and fault recovery
- L2 tunnel protocols
- Learning table limit per VLAN/port
- Link aggregation (EtherChannel)
- Up to 256K MAC table
- L2 multicast up to 2K active multicast groups

Classification and Filtering
- Packet classification based on first 196 bytes in packet (can be extended)
- Configurable per-flow functional actions:
  - Filtering
  - Trapping
  - Mirroring
  - Packet editing
  - QoS remarking
- Hierarchical ACL, and mask configuration per field
- Rate dependent filters (e.g., limit rate of ingress IGMPv3 packets)

Traffic Management
- Support of jumbo frames up to 9KB
- Hierarchical QoS (H-QoS):
  - Three-level scheduler per MEF10
    - On port level
    - On service level
    - On flow level
  - Any combination can be mapped to a specific meter
- 1K virtual ports, each with 8 priority queues
- 8K queues
- Egress shaper per queue and each hierarchy:
  - Packet level
  - Byte level
- Configurable MTU per priority queues
- Scheduling
  - Strict priority
  - WFQ
- Policy per flow in profile can be applied to:
  - Port
  - VLAN (as part of the condition)
  - LAG
  - Policer on one port/LAG and aggregate policer

* Refer to an Ethernity Networks representative to determine whether your version is supported

** Hardware-ready

Packet Editing
- Mapping 802.1p and DSCP QoS to queues
- Marking Priority 802.1p, IP ToS / DSCP bits
- Byte counts and FCS calculation
- VLAN modification (push/pop/modify)
- Header modification up to 48 bytes
- L2 and L3 loopbacks, including swap of MAC SA and DA, swap of IP

Layer 3 Functionality
- IPv4/v6 forwarding both unicast & multicast
- NAT
- Protocols: OSPFv2, OSPFv3, BGP4/BGP4+, IS-IS
- VRRP, and IP tracking for VRRP
- Longest prefix match (LPM)
- IPv6 routing
- BFD (for OSPF, ISIS, LDP, RSVP)
- VRF
- DHCP (client, server, relay, snooping)
- Packet Storm Control:
  - Multicast
  - Broadcast
  - Unknown Unicast

IPSec
- 20G encryption and authentication
  - Option for 80Gbps with duplicated crypto blocks
- AES 128/256
- Firewall and DDoS engine

MPLS Support
- Layer 2 VPNs
- L3 VPN
- SR service over IP/MPLS
- EVPN over MPLS
- VPWS
- VPLS

Management
- Command line interface (CLI) via serial, TELNET, or SSH v1 and v2
- Simple network management protocol (SNMPv1, v2, and v3)
- Remote monitoring (RMON)
  - Ethernet statistics (Group 1)
  - History (Group 2)
  - Alarm (Group 3)
  - Event (Group 9)
- Configuration files upload with FTP and SCP
- Time of day + calendar + time zone
- Internal syslog

Timing
- Class-C 8 nanosecond accuracy
- Sync-E
- IEEE Y.1588v2 Transparent, and boundary clock
- Interface for GPS receiver
- 1PPS
- Up to 24 hours Holdover
- Option for OXCO Oscillator

Software
- ENET driver with ENET CLI with Application Guide
- ENET NPS full switch/router network protocol suite