FlexE, SPN, and G.mtn: Transport Network for 5G and Beyond

What is Flex Ethernet?

FlexE is a key technology used in various industries for high density requirements to deliver faster network speeds vs emerging Ethernet solutions. It provides a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) Ethernet PHY rates used to carry FlexE.

FlexE dissociates Ethernet rate on the client end from the actual physical interface by introducing a new shim through IEEE defined MAC and PCS layers. Flex Ethernet



FlexE Benefits

Bonding of Ethernet PHYs

- Ability to bond multiple PHY's to create larger port groups
- Combine a group interface to create higher rate clients
- Support higher bandwidth service



Sub-rating of Ethernet PHYs

- Service rates can be dynamically changed without changing network conditions
- Ability to under-fill an interface
- Ability to match the client or service rate to transport network



Channelization within a PHY or a group of bonded PHYs

- Aggregate lower rate clients onto an interface
- Scalable alternative to VLANs
- Scalable provisioning onto a single group interface



FlexE Shim Use Cases

FlexE Calendar Switch **Client MAC Rate Distribution** PHY/Group Configuration

FlexE Overhead Status Alarm Status and Generation Management Channel Calendar Configuration

Set transmit and verify Calendar A/B switch functionality Set, modify, move Client bandwidth between Calendar slots for all client rates

Modify and configure FlexE Group number, PHY number for sub-rating, bonding and channelization scenarios

Monitor FlexE Overhead and FlexE Overhead Multiframe Verify and force overhead fault conditions, inject bit errors to generate FlexE Shim alarms Configure and verify management channel Tx/Rx

Verify transmit and receive calendars match between devices



SPN Channel Layer OAM Use Cases Parformanco and Scalability

Performance and Scalability	
OAM service control	
OAM service operation	
OAM with fixed time interval	(
Event triggered OAM	
Multi code block OAM	(
CRC validation	(
OAM priority scheduling	(
OAM function control	
Basic code block function	(
APS	(
Connectivity verification	(
Client signal	(
Delay measurement	(
,	

OAM data is not inserted

OAM data is inserted



Solving your FlexE and High Speed Ethernet Testing Challenges

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	Statistic L2 / L3 VPN	Dynamic L3 VPN		
SPL (Slicing Packet Layer)	Packet Tunnel MPLS-TP	Packet Tunnel (SR-TP)		
	icing Packet Layer)	MAC		Manage
SCL (Slicing Channel Layer)	Slicing Ethernet (SE)		SDN Slicing Control	Frequency and Time
	OIF Flex	E Interface	Plane	Sync.
STL (Slicing Transport Layer)	802.3 Ethernet MAC			
	DWDM+sim	plified ROADM		

How to Test FlexE and SPN?

lability	Validate DUT channel layer OAM performance and scalability with large number of emulated FlexE clients
	Enable and disable channel layer OAM on individual FlexE client
n	FlexE client channel layer OAM insertion and extraction using idle blocks
interval	Sending and receiving channel layer OAM messages at user configurable fixed block or time interval
	Event triggered and on demand channel layer OAM messages
Λ	Sequence numbers in multi code block channel layer OAM messages
	CRC generation and validation for channel layer OAM messages
ing	Channel layer OAM packet scheduling with different priorities
	Enable and disable individual channel layer OAM function per FlexE client
tion	Channel layer OAM BAS (basic code block) functions such as REI, RDI, CS_LF, CS_RF, BIP
	Channel layer OAM APS (automatic protection switching) function
ion	Channel layer OAM CV (connectivity verification) function
	Channel layer OAM CS (client signal) function
	Channel layer OAM one way and two-way DM (delay measurement) functions

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• Fixed period OAM • Non-fixed period OAM • I IDLE block

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SPN Layer 3 Routing Use Cases	
Performance and scalability	Validate
High availability and fast convergence	FlexE in
Service creation and deletion	In-servi
Service elasticity, QoS, and traffic isolation	Bandwi
Time synchronization	IEEE 15
Network slice with SR transport	Networl
Network slice with MPLS transport	Networl
Network slice with SR TE	Networl
Network slice for business MPLS VPN services	Networl
Network slice for EVPN based services	Networl
Network slice for data center interconnect	Data cei
Network slice for 5G fronthaul	5G fron
Network slice for residential high speed internet	PPPoE,
Network slice for IoT	Networl
101 201 401	**** *
102	FlexE

Slicing requirements of 5G Transport Network

- Network-Slicing-as-a-Service: Multiple slices can be created on a physical transport network for different services and customers
- Hard and Soft Network Slicing: Both hard pipe network slicing based on FlexE and soft network slicing based on VPN and segment routing are needed to solve different problems and they can be used together



Slicing Channel Layer (SCL) Technology



e DUT control plane and data plane performance and scalability with protocol and traffic emulation on a large number of emulated FlexE clients nterface bonding for network resiliency and fast convergence with link and node failure ice FlexE client addition and deletion

idth resizing, bandwidth oversubscription, and congestion isolation with multiple FlexE clients

- 588 v2 PTP on FlexE clients
- ork slice for sub-operator with segment routing transport and MPLS or IPv6 data plane on FlexE clients ork slice for sub-operator with MPLS LDP and RSVP traffic engineering on FlexE clients

FlexE

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- ork slice for L3VPN, L2VPN, VPWS business VPN services with MPLS or segment routing transport on FlexE clients
- rk slice for EVPN based IP VPN service with MPLS or segment routing transport on FlexE clients
- enter interconnect with VxLAN overlay and EVPN service on FlexE clients
- nthaul with eCPRI/NGFI/XRAN on FlexE clients

IPoE, DHCP, ANCP and L2TP services on FlexE clients with control plane and user plane separation



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FlexE