Agenda

- Introduction

- Overview: Carrier-grade Virtual Services at the Edge

- Carrier Ethernet: The Foundation for VNF Services

- Hardware Acceleration: Efficiency at the Edge

- An FPGA Platform for Programmable Hardware Acceleration

- Summary

Company Snapshot

- Public company traded on LSE, founded in 2004
  - $25m investment in technology development

- Holds secure, enforceable and renewable **Patents** on its technology
  - Patents are around extreme lower die size implementation of network processing architecture
  - Result in price competitive, mass deployable network processing solution on FPGAs

- More than **500,000 systems** already deployed based on ENET FPGA firmware

- Market Segment
  - Networking Infrastructure: Broadband access, Carrier Ethernet, mobile base stations, microwave backhaul
  - Smart network adapter and SDN switches for datacenters and NFV

- Company strategy and solutions are aligned with the vision and requirements of major tech companies that rely on FPGA for performance, including Amazon, Intel and Microsoft; and Communication Service Providers (CSPs) move to cloud-based Central Offices
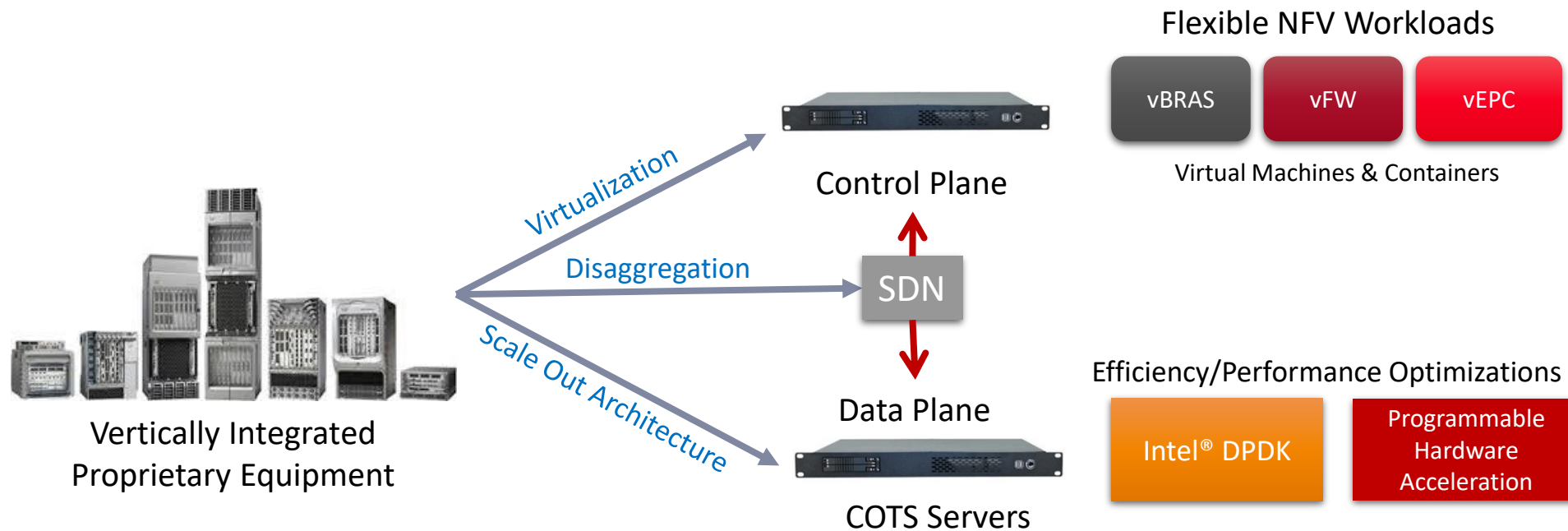
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CSP Network Virtualization

Cloud-based Central Offices

Transformation

Business drivers:

- Service agility – improve service experience of on-demand users
- Capture new revenue generating services – many are latency sensitive
- CAPEX reduction – COTS servers based on high volume merchant CPUs
- OPEX control – automation through cloud orchestration

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CSP Service Virtualization

Flexible NFV Workloads

vBRAS   vFW   vEPC

Virtual Machines & Containers

Control Plane

SDN

Data Plane

COTS Servers

Efficiency/Performance Optimizations

Intel® DPDK   Programmable Hardware Acceleration

Vertically Integrated Proprietary Equipment

Virtualization

Disaggregation

Scale Out Architecture

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Delivering Services at the Edge

Open source platform
modeled on cloud DC

Open source NFV platform
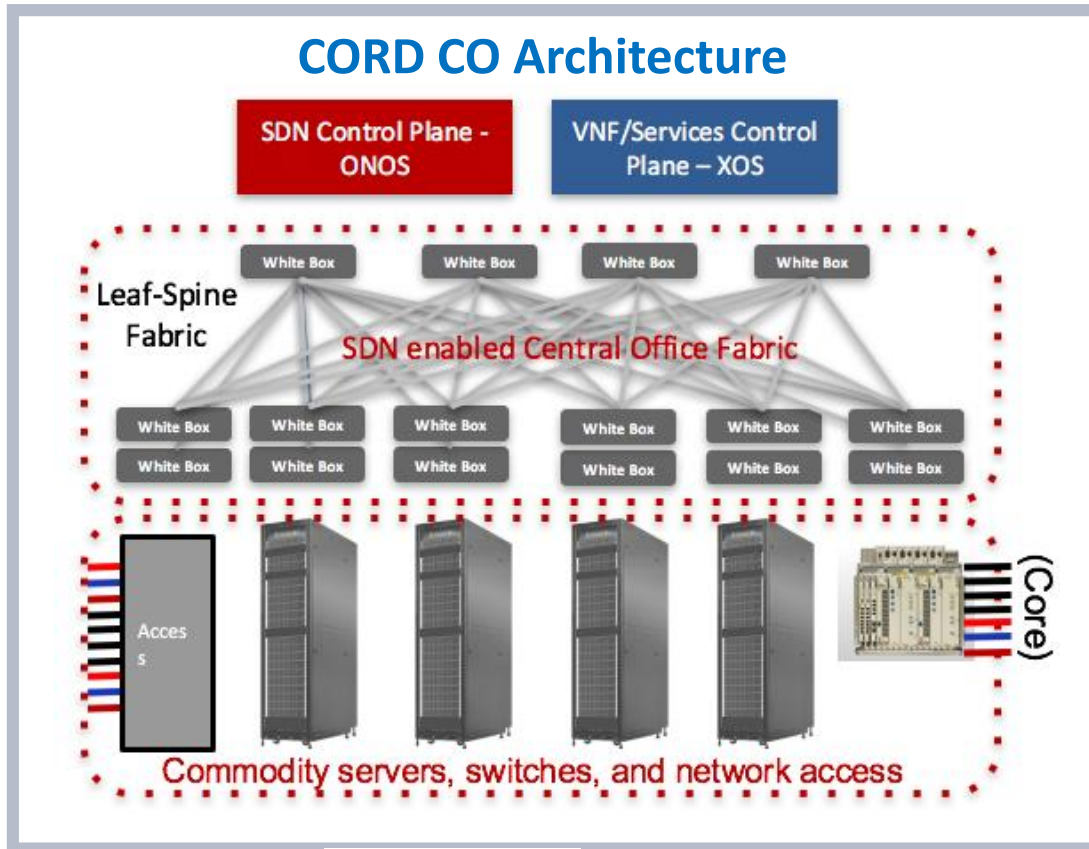for virtual network functions (VNFs)

Standardized NFV orchestration (MANO)
Multi-access (or Mobile) Edge Computing (MEC)

Central Offices (COs):
- House the edge of carrier networks
- Global footprint and a vital strategic asset of CSPs
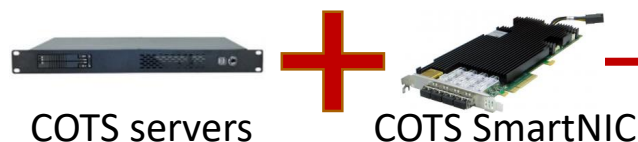- Customer proximity enables low-latency MEC services (vEPC, IoT, real-time control, AR/VR, content caching, etc.

Virtualized Central Office Architecture

CORD CO Architecture

COTS SmartNIC Programmable Hardware Acceleration

Benefits:

- Extend 100% COTS data plane solution
- Power efficiency versus software implementation
- Reduction in latency
- Conserves CPU cycles better spent on higher layer services
- Provides a scale-out solution tied to server deployment

COTS servers **+** COTS SmartNIC → **Accelerates packet processing, traffic management, OAM, etc.**

Add programmable hardware acceleration
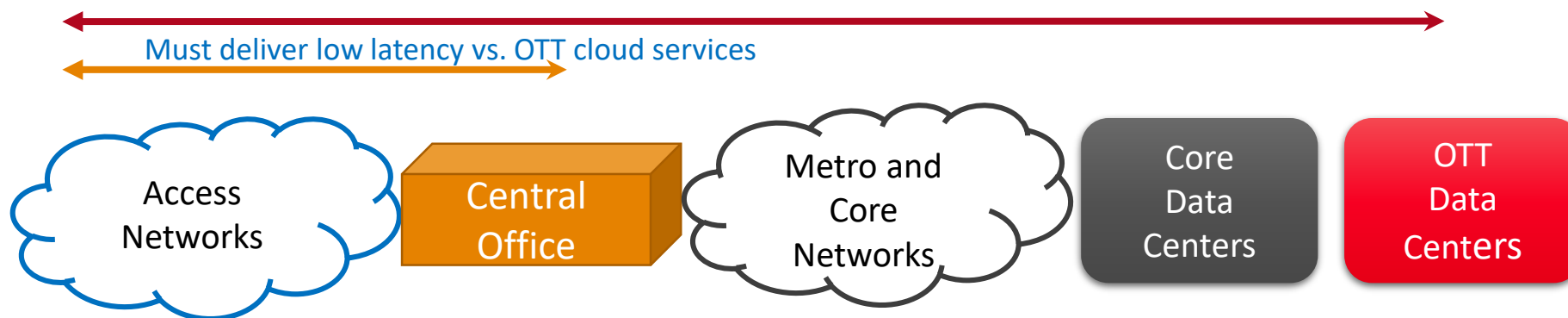
Carrier-Grade Edge Service Challenges

Enterprise

Mobile

Residential

Must deliver low latency vs. OTT cloud services

Access Networks

Central Office

Metro and Core Networks
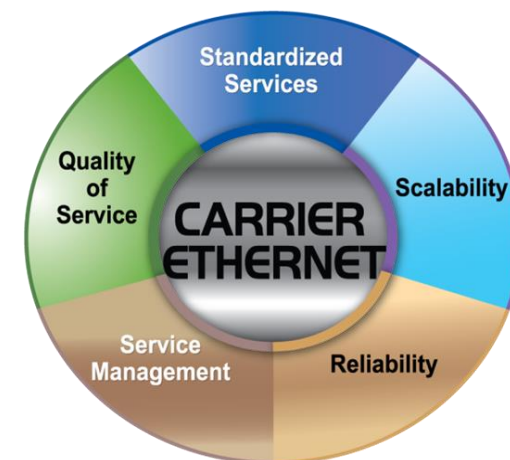
Core Data Centers

OTT Data Centers

Leverage infrastructure assets
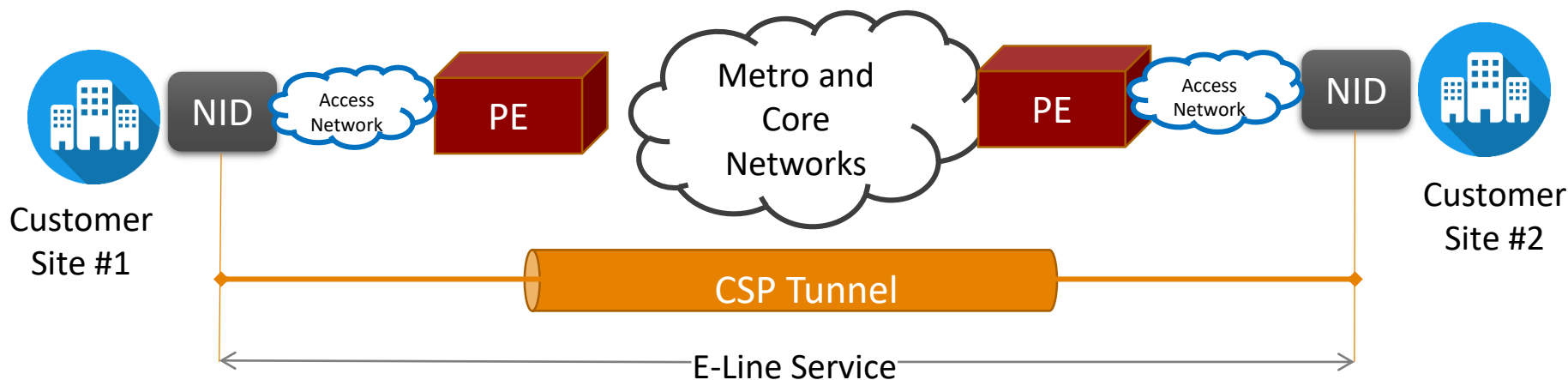CO power, cooling and space at a premium vs. core/OTT DCs
Deliver services over existing access networks, engineered for low cost and power

"Carrier-grade" requirements:
- Scalable to a very high number of services
- Reliability defined by high service availability (five 9s)
- Service Level Agreement (SLA) guarantees
- Sophisticated QoS to control bandwidth, latency and packet loss
- Per service accounting requires end-to-end statistics instrumentation
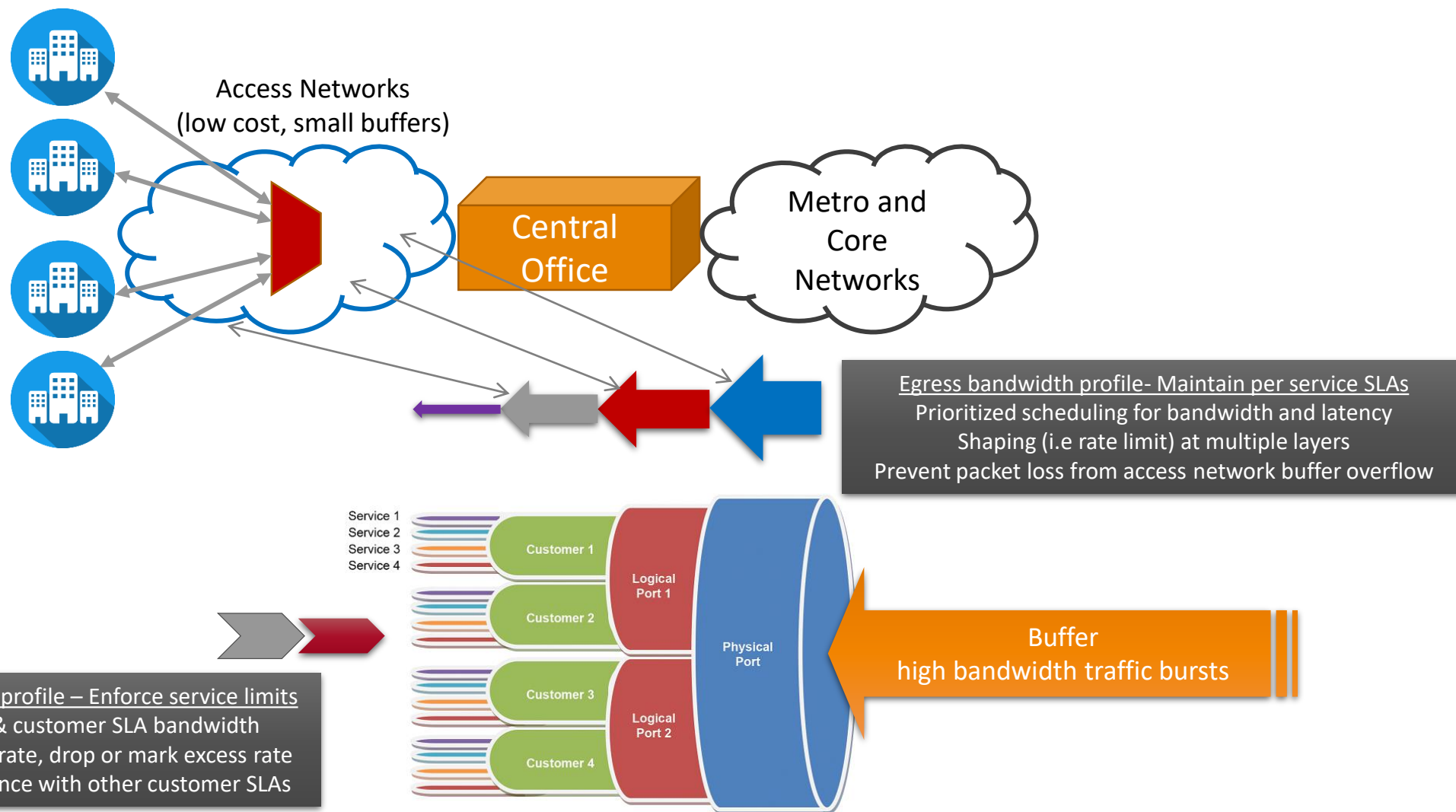- Security for many interfaces to untrusted/uncontrolled network elements

Standardized Services

Quality of Service

CARRIER ETHERNET

Scalability

Service Management

Reliability

Source: Metro Ethernet Forum (MEF)

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CE Packet Processing

Customer Site #1 — NID — Access Network — PE — Metro and Core Networks — PE — Access Network — NID — Customer Site #2

CSP Tunnel

E-Line Service

- **Service classification**
  - Identify service/flow based on multiple fields from Ethernet header
  - Identify customer CoS and map between provider CoS markings
- **Service accounting**
  - Count packets/bytes sent/dropped
  - Per service and per CoS

- **Operations, Administration and Maintenance (OAM)**
  - Continuity Fault Management (CFM)
  - Performance Monitoring (PM)
  - Service Activation (SA)

- **Tunnel processing - include:**
  - Provider Bridging - VLAN stacking
  - 3GPP, GTP, GRE , NVGRE VxLAN
  - Virtual Private LAN Service (VPLS) – MPLS tunneling
- **Security policy enforcement**
  - White lists & black lists
  - Multi-layer Access Control Lists (ACLs)

Performed deterministically at scale
Large # of services
Predictable, high bandwidth & low latency

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Traffic Management – Hierarchical QoS

Access Networks
(low cost, small buffers)

Central Office

Metro and Core Networks

Egress bandwidth profile- Maintain per service SLAs
Prioritized scheduling for bandwidth and latency
Shaping (i.e rate limit) at multiple layers
Prevent packet loss from access network buffer overflow

Service 1
Service 2
Service 3
Service 4

Customer 1

Customer 2

Logical Port 1

Physical Port

Buffer
high bandwidth traffic bursts

Customer 3

Customer 4

Logical Port 2

Ingress bandwidth profile – Enforce service limits
Police service & customer SLA bandwidth
Admit committed rate, drop or mark excess rate
Prevents interference with other customer SLAs

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Hierarchical Model of Services and Access Network

Today's Carrier Ethernet at the Edge:
Carrier Ethernet Switch Router (CESR)

Vertically Integrated
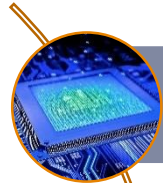Proprietary CESRs

Typical CESR general attributes:

- Proprietary systems can lead to vendor lock-in

- Control plane is integrated, proprietary software

- Data plane mostly proprietary ASICs and NPUs
  - Functionality includes packet processing, traffic management and OAM
  - Protocol evolution & carrier customization drive need for programmability

For the last 10 years Ethernity proposed and deployed NPU alternative based on low cost FPGA

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HW Acceleration: Efficiency at the Edge
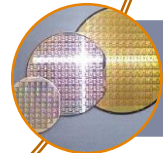
Edge Hardware Acceleration

Hardware Performance = Efficiency

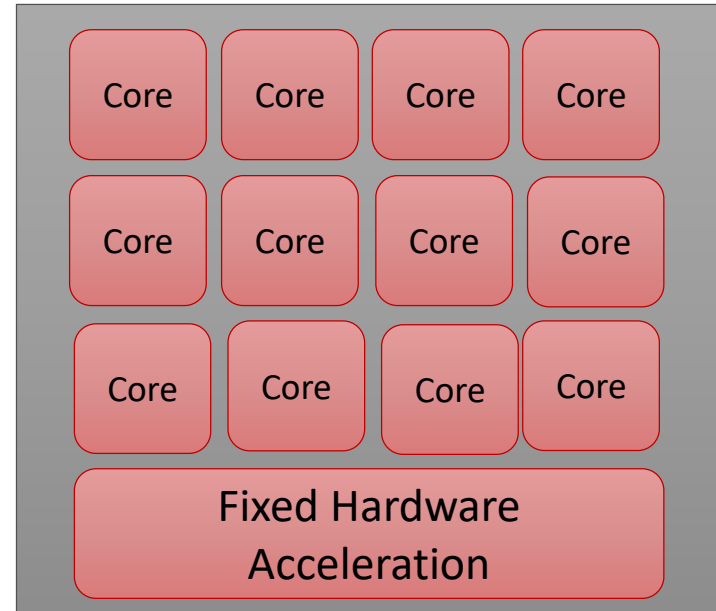Programmability = Agility to Match Virtual Software

Scalability = Address Various Deployment Sizes

COTS = High Volume Semiconductor Economics

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Multi-core CPU/NPU Acceleration Option

Proprietary NPU cores

Configurable, but accelerate
specific functions - Limited flexibility

Proprietary, relatively low volume

FPGAs – True Programmable Hardware

IPsec
SD-WAN
10G CE

vBRAS or vEPC
OVS & VxLAN Offload
Carrier Ethernet

Scalable Across Price/Performance
(e.g. uCPE NIC w/CE NID)

FPGA = Programmable Logic Array

Flexible SoC Resource Allocation
(e.g. SmartNIC w/CE+VNF)

COTS Platform with Broad Applications Beyond Networking

Storage

Machine Learning

Cloud RAN

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FPGA Adoption in Cloud Data Centers

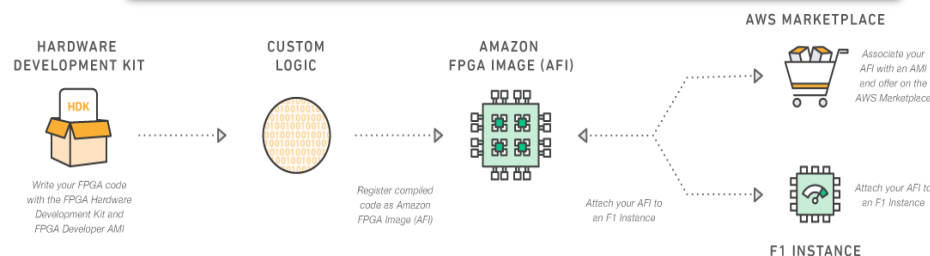**Azure SmartNIC with FPGA acceleration**

Network infrastructure uses:

- Packet processing
- Traffic management
- Crypto

"...allows hosts to use FPGAs for acceleration with low latency... improving the economics of the accelerator deployment, as hosts running services that do not use their local FPGAs can donate them to a global pool and extract value which would otherwise be stranded..."
("A Cloud-Scale Acceleration Architecture," Microsoft, October 2016)
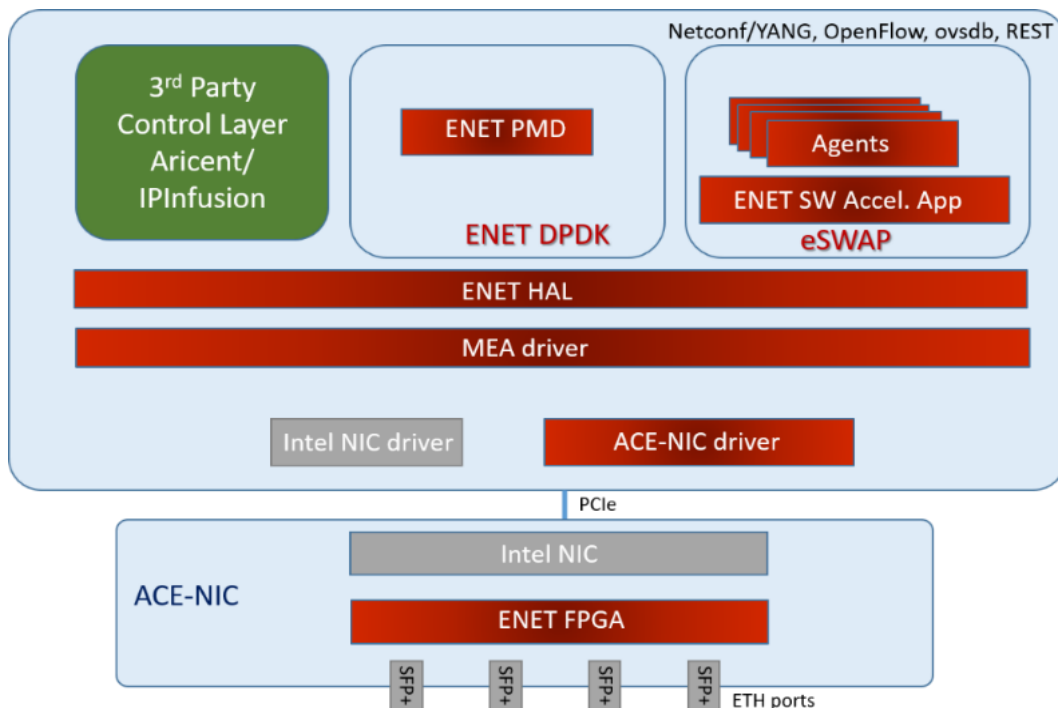
Amazon EC2 F1 – FPGA acceleration

Cloud FPGAs:

- AWS marketplace
- Application accessible
- General applications

Ethernity's Carrier Ethernet and VNF offload

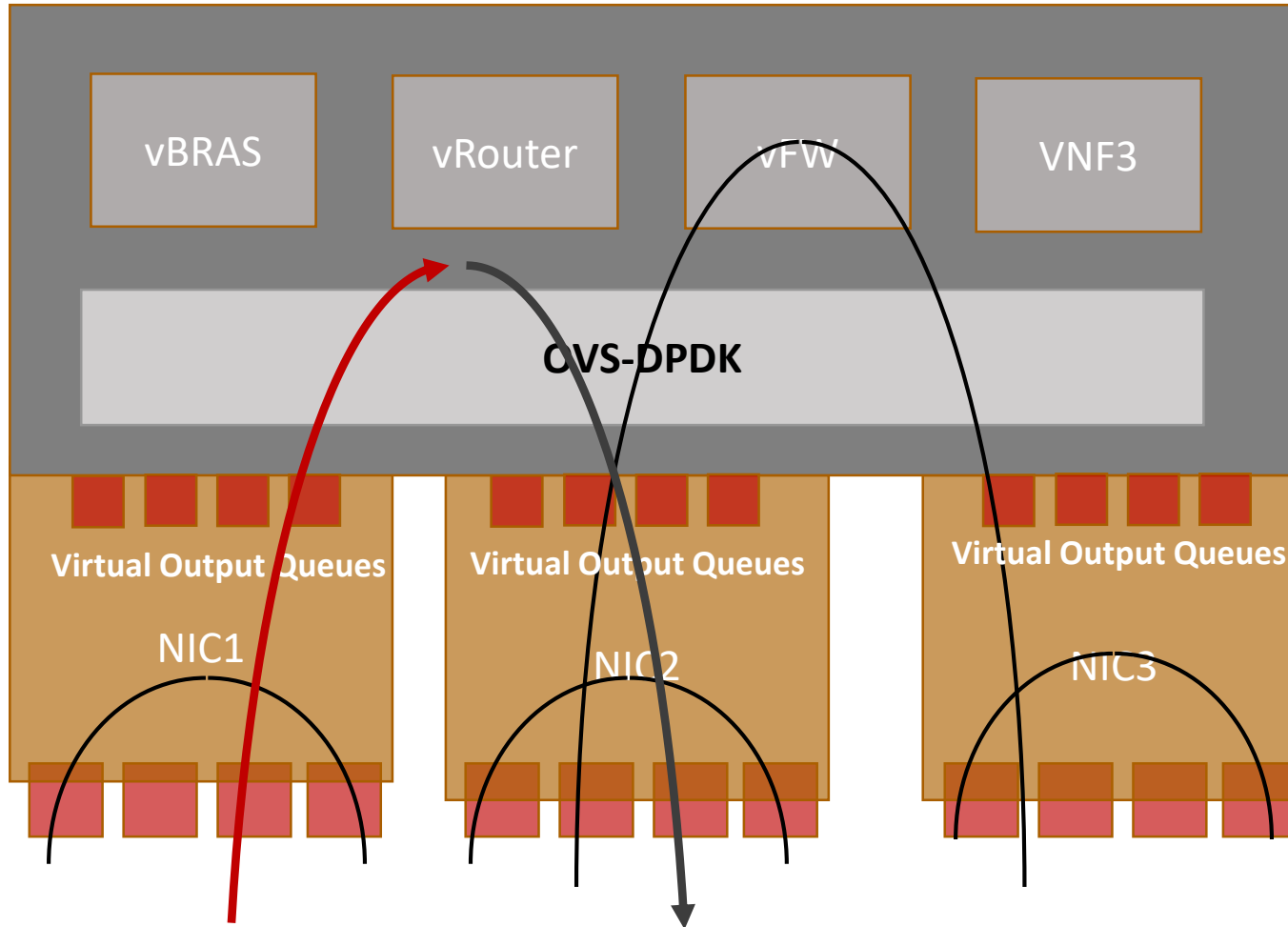## Telecom based SmartNIC – 40G/100G

- **Packet Processing Features**
  - MEF 2.0 Carrier Ethernet services
  - L3 including IPv4, IPv6 & MPLS
  - Tunnels, including VxLAN, GRE
  - Virtual routers
  - NAT & NAPT
  - TCP/UDP stateless offloads
  - Dynamic load balancing
  - 1M flows, 10M counters for flows/ports
  - IEEE1588 precision timestamping
  - ETH OAM/CFM, including Y.1731
  - IP Fragmentation, Link bonding
  - IPSec
- **Traffic Management Features**
  - Up to 100ms packet buffering
  - Hierarchical Scheduling & Shaping
  - Hierarchical Policing & Metering

Integrated Carrier Ethernet Switch and Aggregation as NFVi

- Carrier Ethernet features including:
  - H-QoS
  - Counters
  - Classification
  - External buffering
  - L2/L3/MPLS/Overlay forwarding

- Forwarding options
  - SW fast data path send data to relevant card according to decision (metadata).
  - Embedded PCI bridge
  - Embedded top of the rack switch with DCB features

- Option for IPsec on offload NIC, for use as coprocessor

Building VNFs on Carrier Ethernet & HW Acceleration

- CE provides connectivity guarantees & SLAs
  - Without CE guarantees, QoS of higher level VNF services is indeterminate

- MEF is currently extending CE-like service definitions to higher level VNF services
  - Reuse instead of reinvent

- Once Carrier Ethernet is integrated into the server with the ACE-NIC, the ENET Flow Processor can be used for further VNF offload and efficiency gains
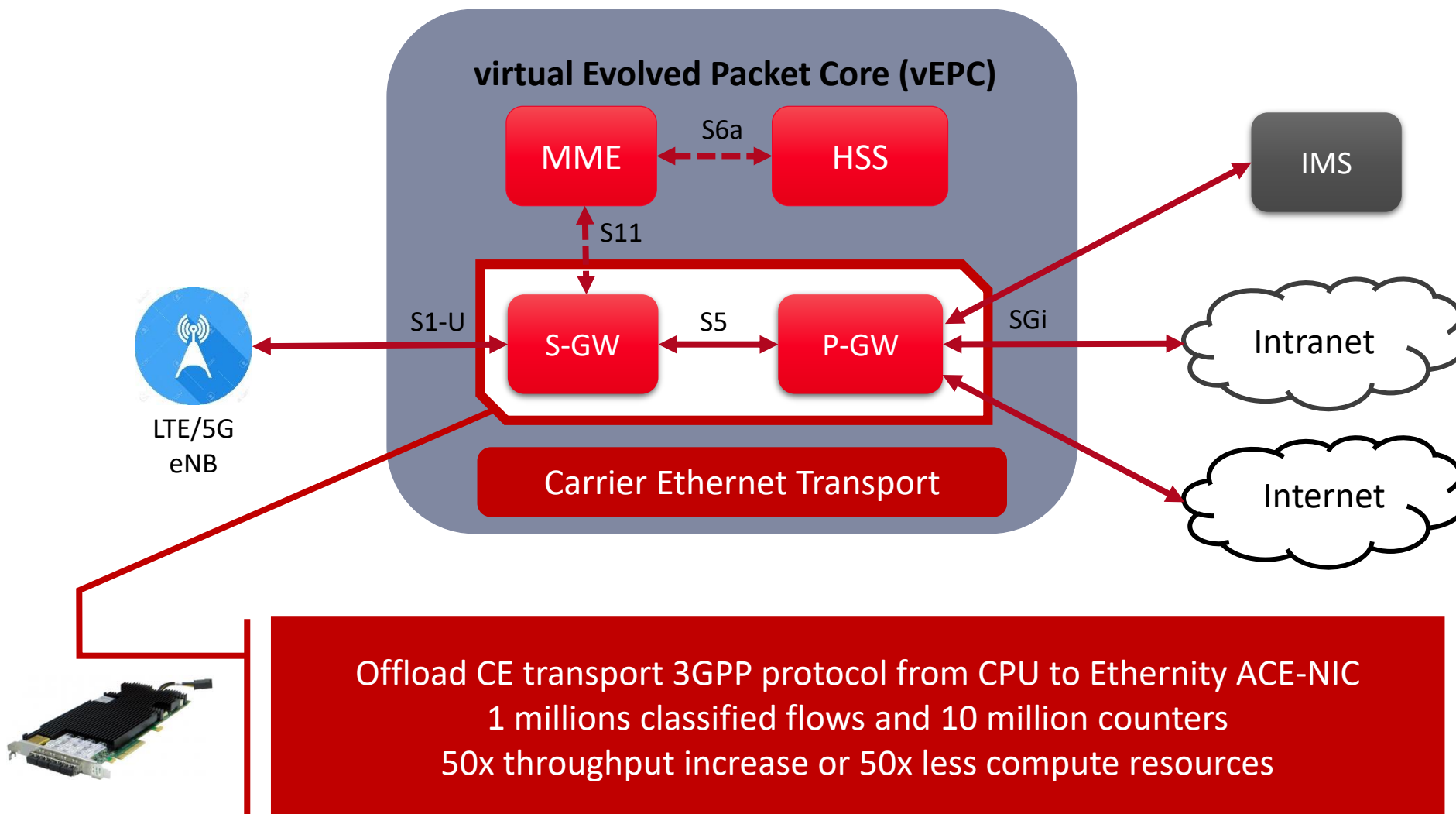
Opportunities for Hardware Acceleration

- L3-L4 packet processing & traffic management
  - Including: vBRAS, vFW, NAT, vBNG
- Deep packet inspection for SD-WAN & security monitoring
- Load balancing across scale out infrastructure
- Service monitoring – higher level OAM
- Cryptography such as IPSec
- NFV infrastructure acceleration
  - OVS offload to reduce VM-to-VM networking overhead
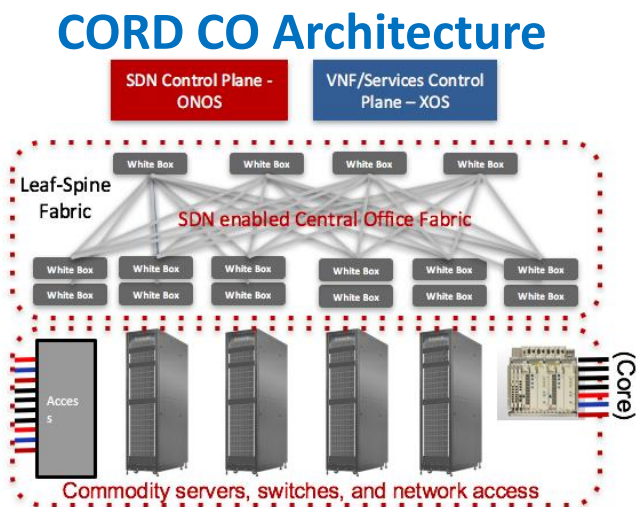 - VxLAN tunnel offload for intra-CO switching

Diverse Requirements and Scope Make Programmability Crucial

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VNF Acceleration Example: vEPC
Ideal Solution for MEC

virtual Evolved Packet Core (vEPC)

MME — S6a — HSS

S11

S1-U   S-GW — S5 — P-GW   SGi

LTE/5G eNB

Carrier Ethernet Transport

IMS

Intranet

Internet

Offload CE transport 3GPP protocol from CPU to Ethernity ACE-NIC
1 millions classified flows and 10 million counters
50x throughput increase or 50x less compute resources

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Turbocharge Edge DC with ACE-NIC

CORD CO Architecture

Multiple ACE-NIC per server

Add programmable hardware acceleration

Edge Server

vBRAS/vBNG VM

Aricent

CG-NAT

L3 Forwarding

Carrier Ethernet Transport

ACE-NIC · ACE-NIC · ACE-NIC · ACE-NIC · ACE-NIC · ACE-NIC

- **Accelerated VNF Platform**
  - Up to 6 NICs per server – 240Gbps
  - Scale out with multiple servers for multi-terabit performance
  - Acceleration adapts to workload
  - Partner with ISV to provide complete solution (e.g Aricent)
  - Conserves CPU cycles for MEC and other high value services

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Summary: VNFs need FPGA acceleration

- Edge amplifies need for efficiency & drives need for HW acceleration

- Carrier Ethernet is a logical foundation for NFV infrastructure (NFVi) for Carrier Grade NFV platforms

- FPGAs - the industry choice for programmable, COTS hardware

- Ethernity - FPGA & CE experts delivering solutions today

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Thank you for attending!

- Q&A

- Related whitepaper: http://www.ethernitynet.com/wp-content/uploads/2018/01/WP-Virtual-Carrier-Ethernet-on-COTS.pdf

- Live Demo at MWC 2018

Carrier Grade Switch and Ethernet Aggregation Platform on COTS Servers
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