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大量新兴业务的涌现对业务系统提出更高要求

工业 4.0	新零售	智慧城市	健康医疗	云游戏	视觉推理

80% 数据流量是视频相关的流量，by 2021[3]

75% 企业数据是在数据中心外产生并完成处理，by 2025[1]

43% AI任务发生在边缘设备上 (相对于云)，in 2023

▼ **Require New KPIs** ▼

高带宽	低时延低抖动	高可靠	本地数据安全	严格QoS保证	5G等多连接

多种因素驱动算力在边缘快速发展

高带宽	低时延低抖动	高可靠	本地数据安全	严格QoS保证	5G等多连接

设备

现场边缘

网络边缘

网络核心

云数据中心

边缘业务 (网络连接, AI, 媒体, 企业业务)

工业　医疗

交通　零售

SD-WAN
uCPE

无线接入
固网接入

vRAN

Edge
Servers

下一代接入
站点CO

MULTI-ACCESS EDGE COMPUTING

时延　　Varies <1 ms　　<5 ms　　　　　　<10-40 ms　　　　　< 60 ms　　~100 ms

现场边缘和网络边缘
是业务使能最重要的场所

基于CERA参考架构，构建5G现场边缘

intel

边缘应用要求业务能力融合

跨现场边缘和网络边缘的IT, OT & 网络能力融合

一个优化的业务平台：融合各类能力到统一的平台

IT & OT业务

端点数据抓取/汇集

数据预处理及处理

数据分析

端点安全

计算机视觉/AI

垂直行业业务

融合边缘平台
促进业务创新

网络业务

多接入计算(4G LTE, 5G, WIFI, IP)

私有无线

高吞吐量数据面

5G UPF/5G CORE

SD-WAN, FIREWALL

网络流量分流

边缘业务的部署复杂,耗时且成本高

Devops新业务部署时间: 几个月到一年

TCO: $ ⬆

Developer

Integrator

Network Engineer

IT Engineer

Idea for ervice

Develop a service from scratch

Assemble Cloud, Network, Edge Software Ingredients

Manually configure network and manually tune for performance

Deploy Service with load balancing

Service running

企业需要灵活，敏捷和经济高效的方法来部署边缘服务

企业业务创新痛点
需要开源云原生的边缘计算平台

⚠ 原有基础设施业务能力差，需要拆分

⚠ 巨型实体难以支持业务多样性

⚠ 网络复杂性

⚠ IOT领域创新难

如何帮助这些企业?

为业务创新而进行的基础设施变革要满足以下几个条件:

✓ 降低Total Cost of Ownership

✓ 加快TIME TO MARKET

✓ 减低网络与生态系统整合的复杂度
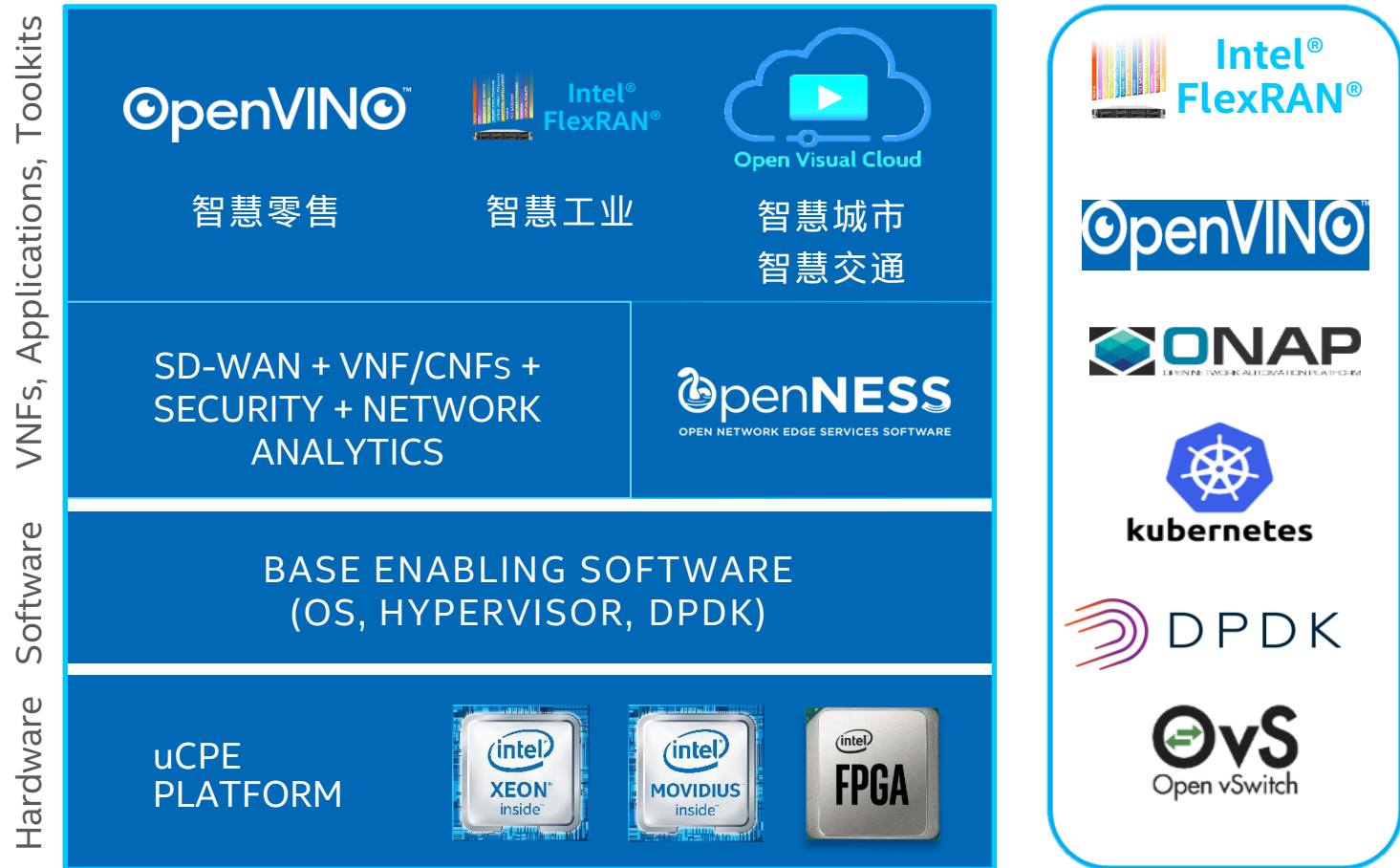
英特尔: 开源云原生融合边缘参考架构
Converged Edge Reference Architecture (CERA)

适用于现场边缘的参考架构CREA
Converged Edge Reference Architecture

基于优化平台的业务创新：

- 在统一的云原生基础设施上支持业务的多样性

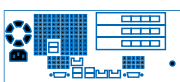- 提供丰富的网络 / IoT / AI / Media 功能，简化网络和应用部署复杂度

- 与实际业务对齐，提供预集成一体化方案

参考母版: 硬件规格/外观形态

Common Mother Board

1S Intel® Xeon® D Processor

- 64 GB RAM across 4x memory channels
- 4x 10GbE plus ≥ 4x GbE
- 2x SSD
- USB ports + VGA/HDMI port
- 2x PCIe FH,¾L with x16

1S 2nd Intel® Xeon® or Intel® Xeon® Scalable Processor

- 96 GB RAM across 6x memory channels
- 2x 10GbE
- 2x SSD
- USB ports + VGA/HDMI port
- 2x PCIe FH,¾L with x16

Available Form Factors

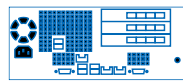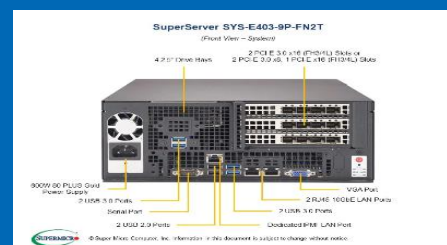Rack-mount   Wall-mount   Pole-mount

Available Form Factors

Rack-mount   Wall-mount

SuperServer SYS-E403-9P-FN2T

Wall-mount server (<300 mm wide) Indoor, wall or shelf

SuperServer SYS-1019P-FHN2T

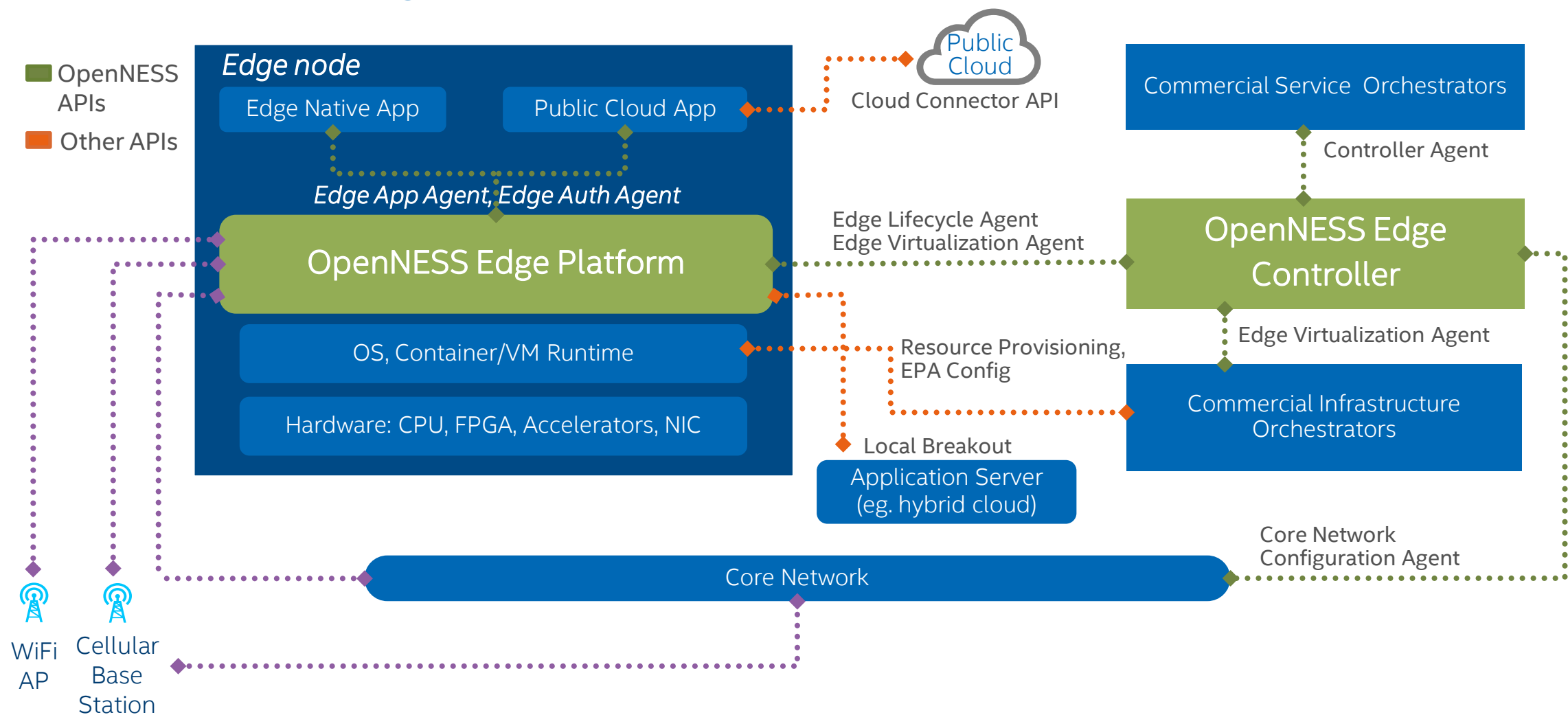1U, 19" Rack-mount server (<450 mm wide) Indoor IT Rack

Pole-mount server for Intel® Xeon® D Processor (<350 mm wide)

Intel® AVX-512 for enabling 4G and 5G RAN. RAN require a min of 16c CPU configuration

OpenNESS: 英特尔网络边缘业务软件套件

Open Network Edge Services Software

基于CERA参考架构，构建5G现场边缘

OpenNESS: 英特尔网络边缘业务软件套件

Open Network Edge Services Software

- **OpenNESS APIs**
- **Other APIs**

Edge node

Edge Native App

Public Cloud App

Public Cloud

Cloud Connector API

Commercial Service Orchestrators

Controller Agent

Edge App Agent, Edge Auth Agent

OpenNESS Edge Platform

Edge Lifecycle Agent
Edge Virtualization Agent

OpenNESS Edge Controller

OS, Container/VM Runtime

Resource Provisioning, EPA Config

Edge Virtualization Agent

Hardware: CPU, FPGA, Accelerators, NIC

Commercial Infrastructure Orchestrators

Local Breakout

Application Server (eg. hybrid cloud)

Core Network

Core Network Configuration Agent

WiFi AP

Cellular Base Station
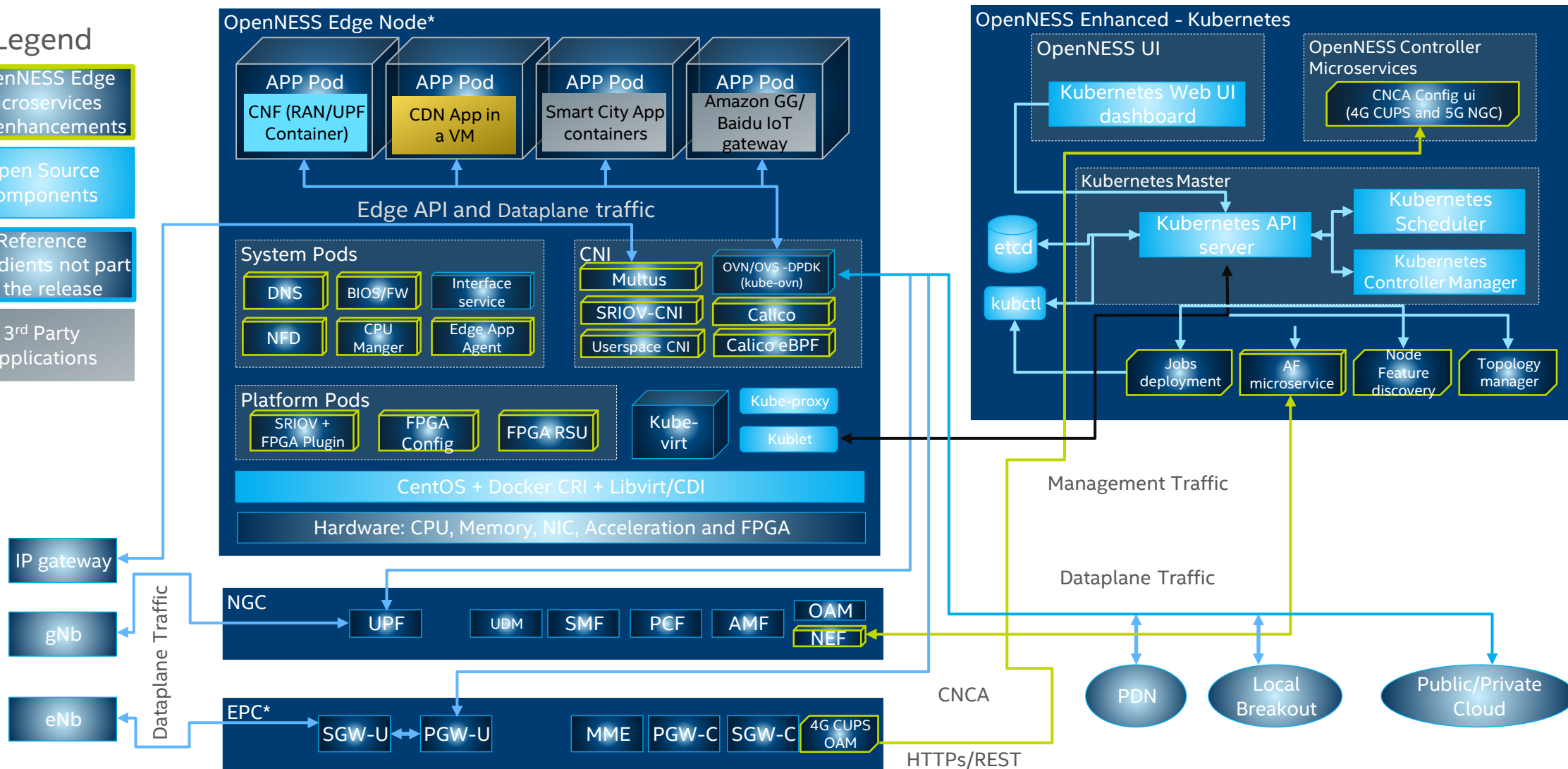
OpenNESS 微服务架构

Legend

- OpenNESS Edge Microservices and enhancements
- Open Source components
- Reference ingredients not part of the release
- 3rd Party Applications

OpenNESS Edge Node*

APP Pod — CNF (RAN/UPF Container)
APP Pod — CDN App in a VM
APP Pod — Smart City App containers
APP Pod — Amazon GG/ Baidu IoT gateway

Edge API and Dataplane traffic

System Pods
DNS | BIOS/FW | Interface service
NFD | CPU Manger | Edge App Agent

CNI
Multus | OVN/OVS -DPDK (kube-ovn)
SRIOV-CNI | Calico
Userspace CNI | Calico eBPF

Platform Pods
SRIOV + FPGA Plugin | FPGA Config | FPGA RSU

Kube-virt
Kube-proxy
Kublet

CentOS + Docker CRI + Libvirt/CDI

Hardware: CPU, Memory, NIC, Acceleration and FPGA

OpenNESS Enhanced - Kubernetes

OpenNESS UI
Kubernetes Web UI dashboard

OpenNESS Controller Microservices
CNCA Config ui (4G CUPS and 5G NGC)

Kubernetes Master
etcd
kubctl
Kubernetes API server
Kubernetes Scheduler
Kubernetes Controller Manager

Jobs deployment | AF microservice | Node Feature discovery | Topology manager

Management Traffic

Dataplane Traffic

IP gateway

gNb

eNb

Dataplane Traffic

NGC
UPF | UDM | SMF | PCF | AMF | OAM / NEF

EPC*
SGW-U ↔ PGW-U | MME | PGW-C | SGW-C | 4G CUPS OAM

CNCA

HTTPs/REST

PDN | Local Breakout | Public/Private Cloud

*OpenNESS Edge Node can be deployed on Network Edge or On-Premise Edge

基于CERA参考架构，构建5G现场边缘

intel

11

OpenNESS微服务:
Node Feature Discovery (NFD)

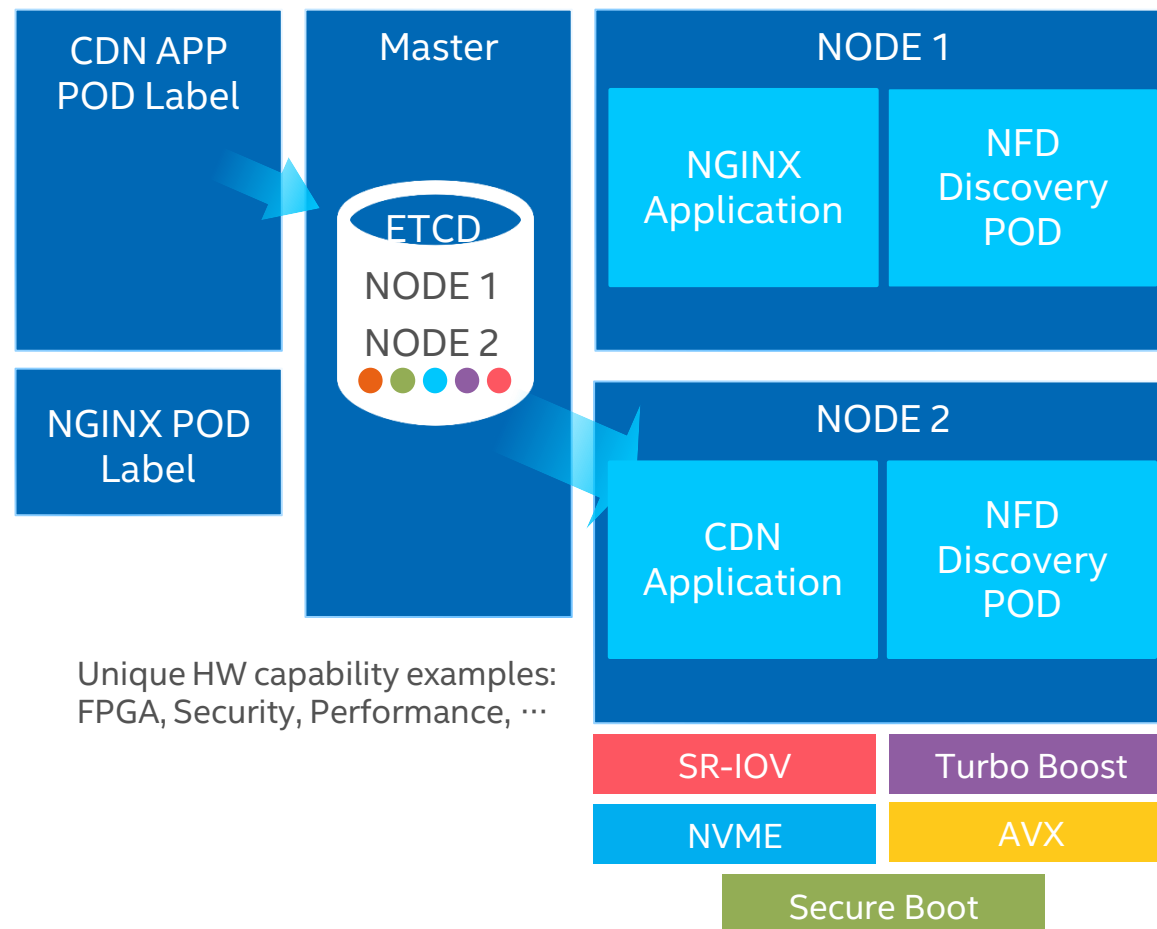**NFD是EPA(Enhanced Platform Awareness)组件的一部分:**

主要功能:

- NFD将边缘节点的能力通告给协调器

- 协调器将APP部署到最优的边缘节点上，实现最佳的边缘KPI

其他方案:

- 如果没有NFD，部署的应用程序性能会降低

- 或者实现某种自定义解决方案

通过提前收集节点的硬件资源功能特性，实现工作负载与特殊硬件资源的智能匹配，以优化应用程序的性能和可管理性。

CDN APP POD Label

NGINX POD Label

Master

ETCD
NODE 1
NODE 2

NODE 1

NGINX Application

NFD Discovery POD

NODE 2

CDN Application

NFD Discovery POD

Unique HW capability examples: FPGA, Security, Performance, …

SR-IOV

Turbo Boost

NVME

AVX

Secure Boot

OpenNESS微服务: NUMA Topology Manager

TM是EPA组件的一部分:

主要功能:

非平衡NUMA节点，网卡仅连接到一个socket上:

- TM微服务可以暴露网卡连到哪个socket上

- 协调器能够将对性能敏感的边缘应用程序部署到合适的socket上，满足吞吐量和延迟的性能要求。

其他方案:
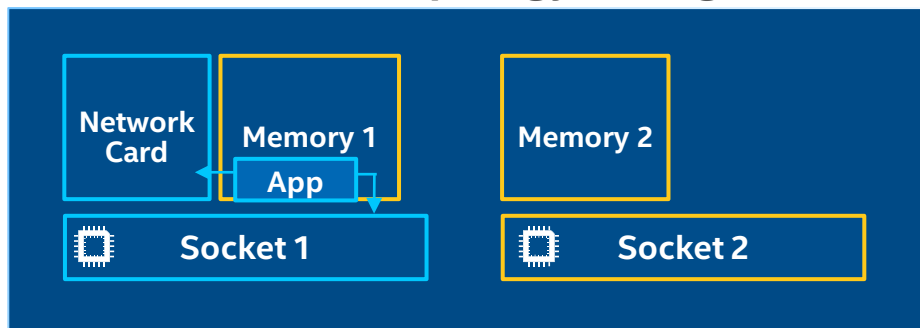
资源分配不理想，导致性能下降

编排器具有NUMA意识，可以优化性能敏感边缘应用程序的部署

Node without Topology Manager

Not NUMA Aware

Application may be deployed to the wrong socket leading to performance degradation

Node with Topology Manager

NUMA Aware

Application always deployed on the socket with the desired resources for deterministic & reliable performance

NUMA: 非一致内存访问

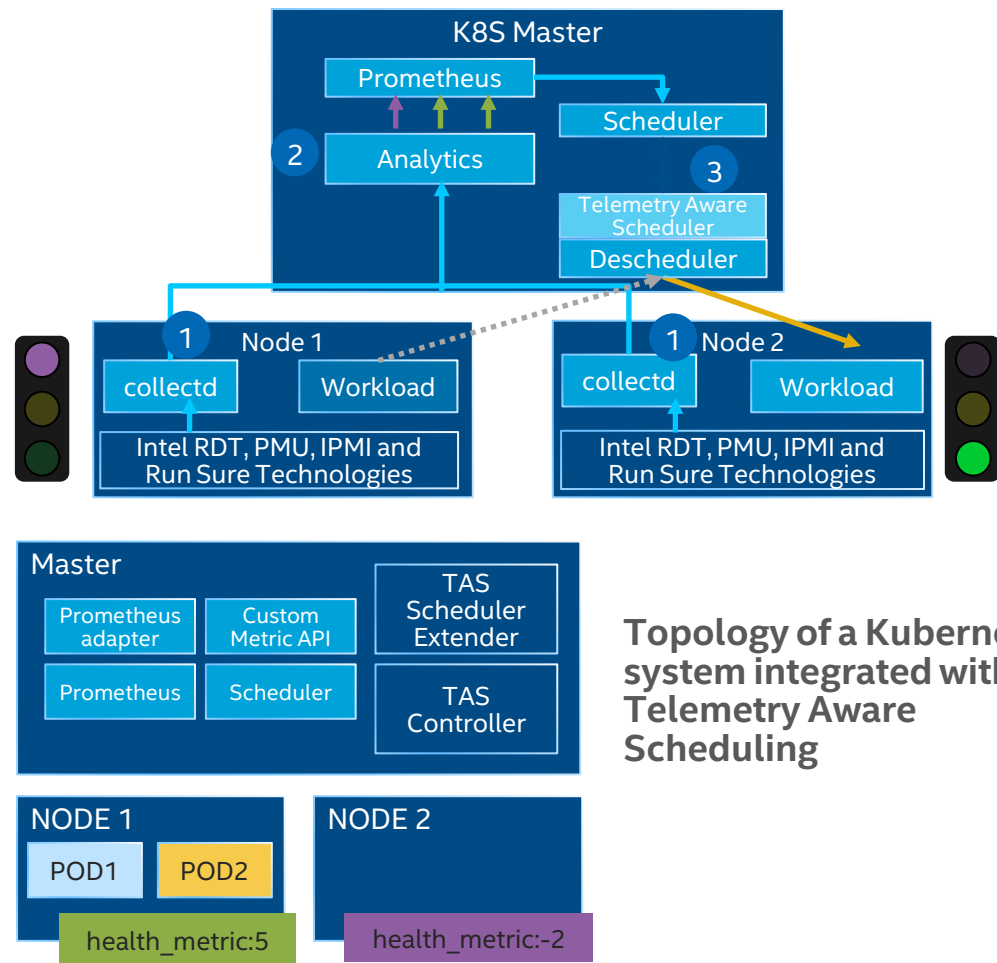# OpenNESS微服务: Telemetry Aware Scheduler

TAS是EPA组件的一部分：

主要功能：

1. TAS收集整个平台telemetry数据给Master

2. master主机能够监视各个节点的性能，并动态部署/迁移工作负载以获得最佳性能

3. 示例：位于地点A的CDN为一个服务提供商支持高收入的流媒体应用以及语音应用。

   - Loc A由于本地紧急情况而导致语音应用程序过载。

   - 使用来自TAS的Telemetry，K8s Master可以观察到位置A的瓶颈并确定位置B能够增加工作量。

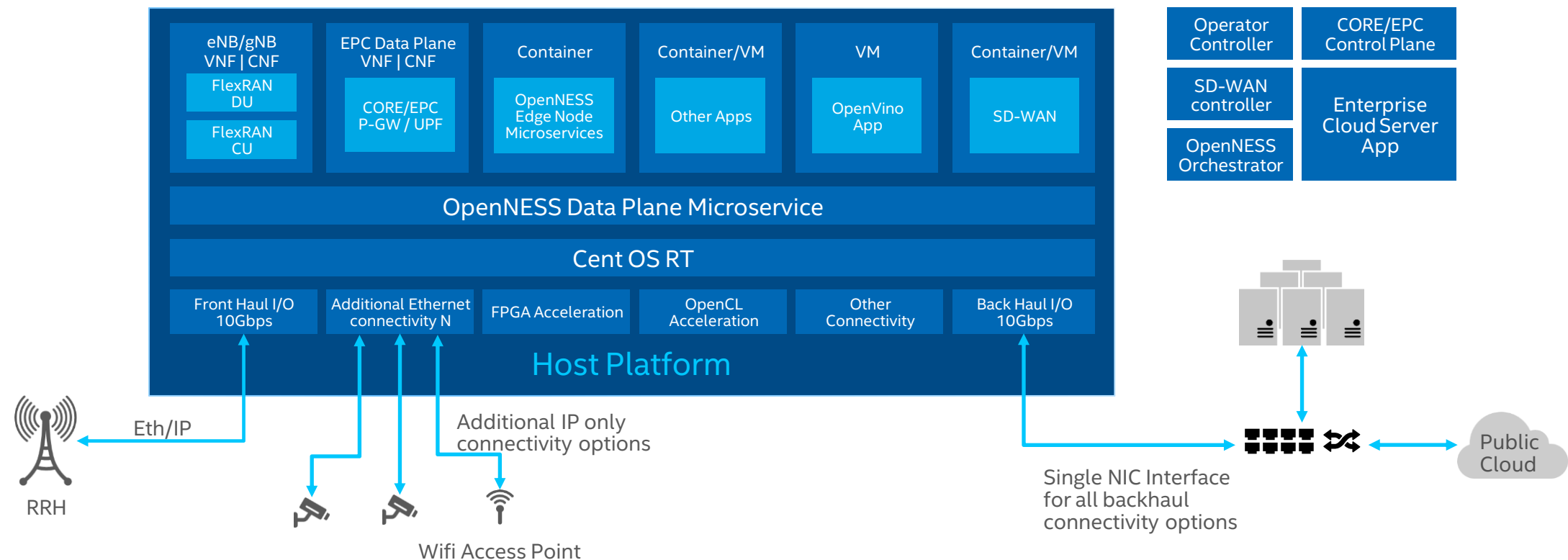   - 服务提供商快速无缝地将流媒体应用程序移动到Loc B，而对客户体验的影响最小。

其他方案：
缺少这种telemetry集成，就无法获取识别瓶颈和适合动态卸载的节点信息的实时数据

通过边缘节点telemetry指标，使服务提供商能够实施基于规则的工作负载布置，以实现业务最佳性能和弹性部署。

Topology of a Kubernetes system integrated with Telemetry Aware Scheduling

All-in-One的一体化参考解决方案

Workloads: RAN, CUPs/UPF, IOT, SD-WAN, Edge Services

基于现场边缘CERA的垂直行业解决方案

基于CERA平台，为垂直行业定义个性化平台

垂直行业

智慧工业
Networking, AI, edge services, industrial insights & private wireless
- Fault Detection Apps
- Predictive Maintenance Apps
- Edge Insights Software

智慧交通
Networking, AI, edge services & private wireless
- Traffic Monitoring Apps
- Pedestrian Detection Apps
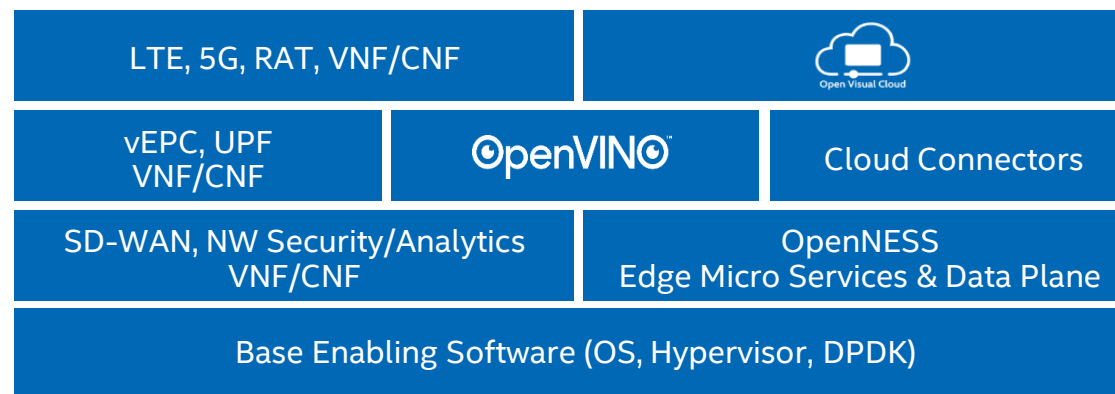- Near Miss/Collision Detection Apps

零售, CDN, DSS
Networking, AI, edge services, visual cloud & private wireless
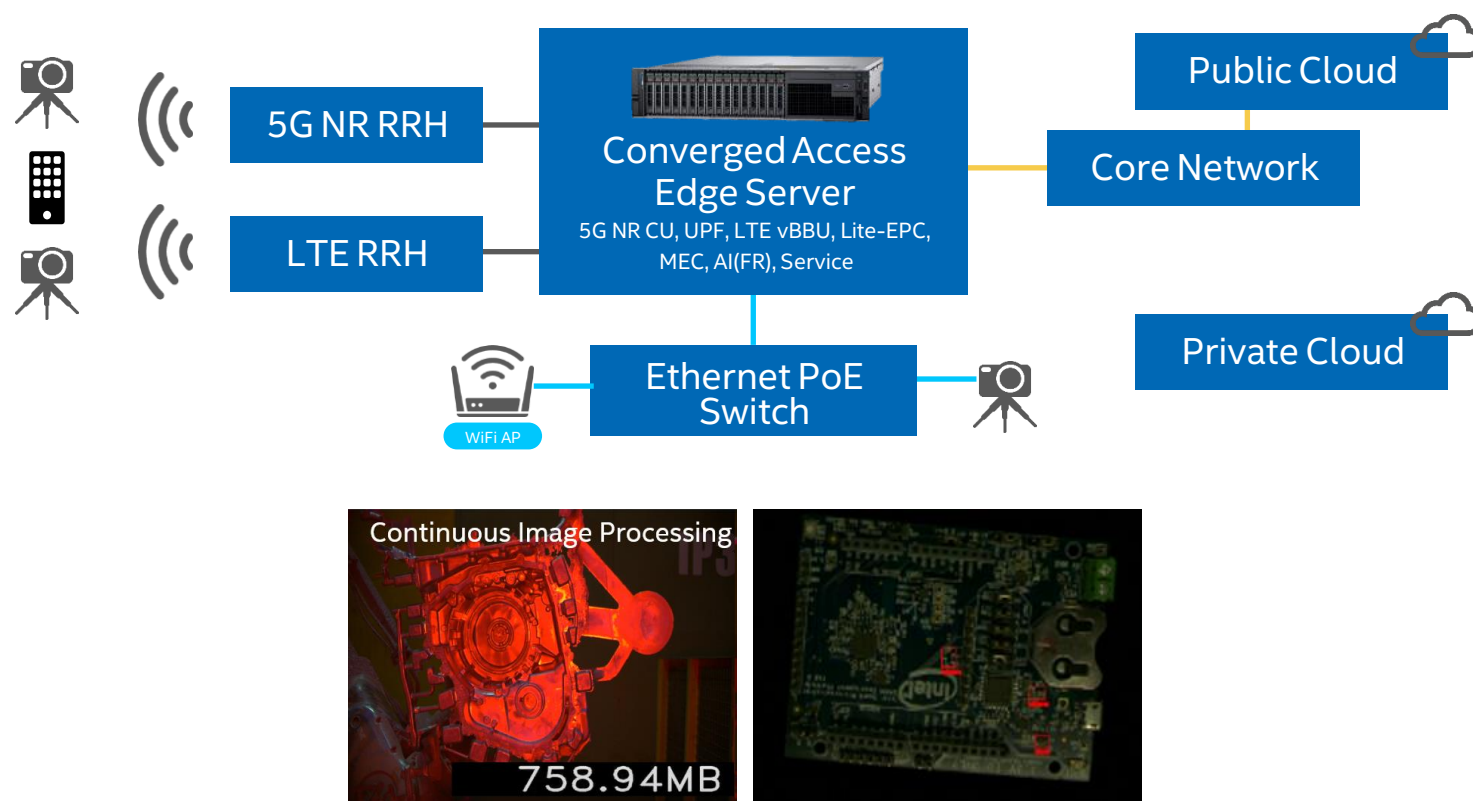- Customer Hotspot Apps
- POS Apps
- Traffic Flow Analysis Apps

CERA On-Premise

NETWORKING, AI, MEDIA AND EDGE SERVICES
(Intel® Xeon® D & Intel® Xeon® Scalable Platforms)

intel XEON inside

LTE, 5G, RAT, VNF/CNF

Open Visual Cloud

vEPC, UPF VNF/CNF | OpenVINO | Cloud Connectors

SD-WAN, NW Security/Analytics VNF/CNF | OpenNESS Edge Micro Services & Data Plane

Base Enabling Software (OS, Hypervisor, DPDK)

intel XEON PLATINUM inside

现场边缘应用案例 – 工业场景

5G NR RRH

LTE RRH

WiFi AP

Converged Access Edge Server

5G NR CU, UPF, LTE vBBU, Lite-EPC, MEC, AI(FR), Service

Ethernet PoE Switch

Public Cloud

Core Network

Private Cloud

Continuous Image Processing

758.94MB

What is the use case?

Video Analytics and 5G enabled AGV use cases for the factory floor.

Business value that CERA drives:

Friendly, simple, easy to use and maintain, run IT/OT Apps and services. Increase operational efficiency and factory floor insight with AI.
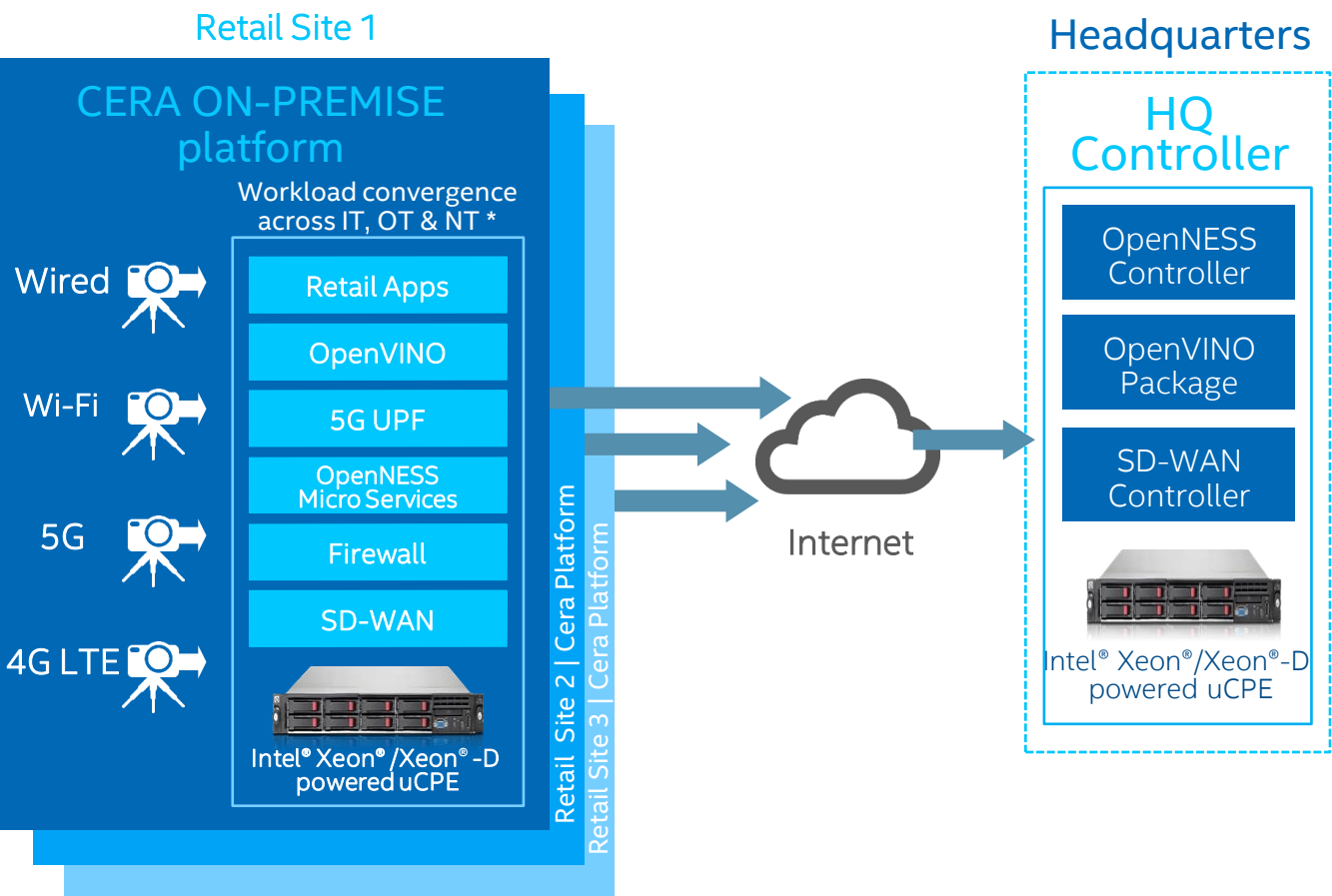
CERA architecture benefits:

Cloud native CERA architecture supporting convergence of 5G CU/DU, 5G UPF, OpenNESS, OpenVINO on Intel Xeon based platform.

How did Intel help the ecosystem?

Intel is working closely with Foxconn in developing 4G and 5G private wireless and MEC solutions based on CERA. Solution is in trial now.

现场边缘应用案例－零售场景

| Digital Advertising | Personalized Shopping | Inventory Management | POS Detection | Customer Behavior Analysis |

Retail Site 1

CERA ON-PREMISE platform

Workload convergence across IT, OT & NT *

Wired

Wi-Fi

5G

4G LTE

- Retail Apps
- OpenVINO
- 5G UPF
- OpenNESS Micro Services
- Firewall
- SD-WAN

Intel® Xeon®/Xeon® -D powered uCPE

Retail Site 2 | Cera Platform

Retail Site 3 | Cera Platform

Internet

Headquarters

HQ Controller

- OpenNESS Controller
- OpenVINO Package
- SD-WAN Controller

Intel® Xeon®/Xeon®-D powered uCPE

What is the use case?

Smart branch networking solution combined with artificial intelligence (AI) to drive advanced smart check out and facial recognition applications.

Business value that CERA drives

Build up a stable, easy to scale IT. Friendly, simple, easy to use and maintain IT systems that do not require dedicated IT team in each shop.
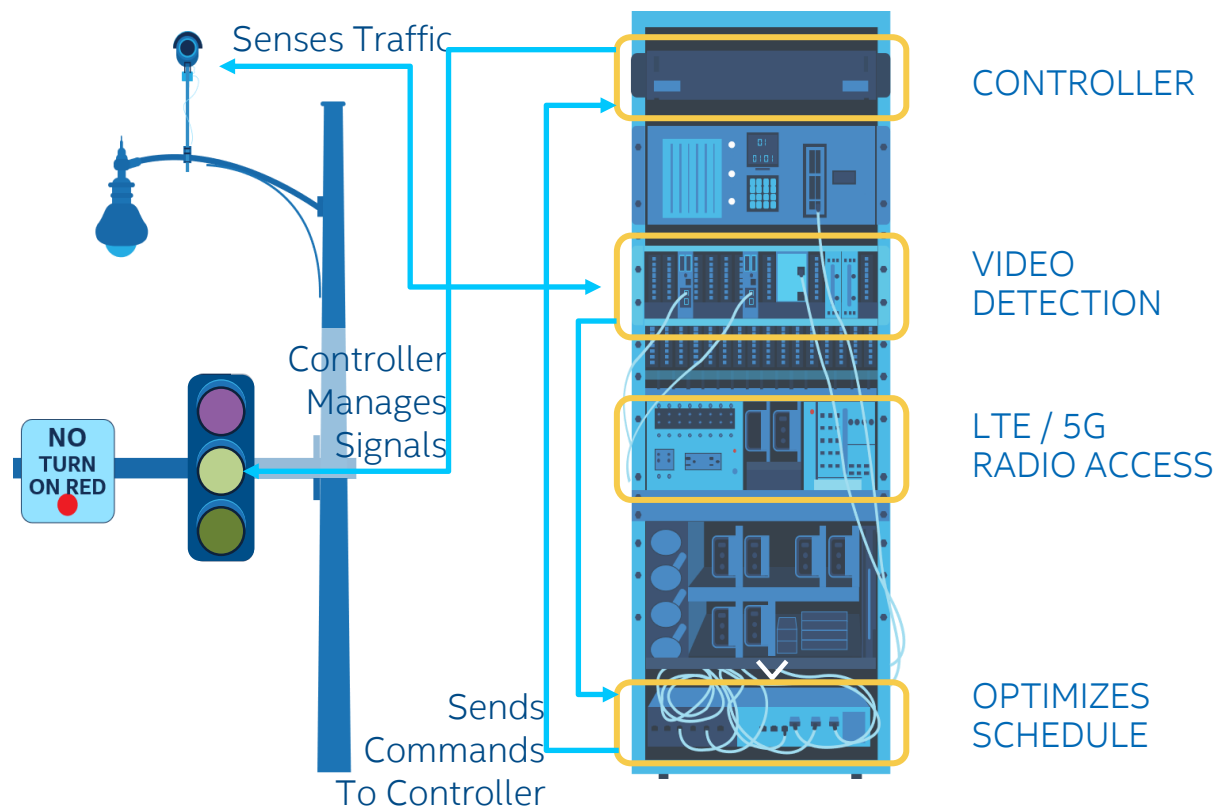
CERA architecture benefits:

Cloud native CERA architecture supporting convergence of 5G UPF, OpenNESS, OpenVINO, SD-WAN on Intel Xeon based platform.

How did Intel help the ecosystem?

QNAP and Intel closely collaborated in developing the uCPE platform for Retail Office. Solution has completed trial and RFP Ready Kit (RRK) created via Intel's market scale program is available now.

现场边缘应用案例 — 智慧城市/路边站

Senses Traffic

CONTROLLER

VIDEO DETECTION

Controller Manages Signals

NO TURN ON RED

LTE / 5G RADIO ACCESS

OPTIMIZES SCHEDULE

Sends Commands To Controller

Adaptive traffic control is the future of mobility
Smart Intersections leverages AI, Edge Compute, Networking to improve city mobility

What is the use case?

Smart Traffic Management & Advanced Roadside Infrastructure.

Business value that CERA drives:

In order to support the growing traffic and urban mobility needs, traffic management is leveraging AI to optimize the lights and traffic flow. This workload convergence hence with better TCO, less complex edge nodes, and ability to scale the solutions based on demand.

CERA architecture benefits:

Moving from individual/purpose built boxes into a foundational edge compute node that can service various functions: traffic controller, tolling, video analytics, V2X, sensor fusion, MEC, 5G etc..

How did Intel help the ecosystem?

Intel is enabling ITS Traffic Management OEM partners leveraging outdoor edge solutions from SuperMicro and other Intel ODM partners for converging WLs (video analytics/V2X/MEC focus).