November 2021

# Smart Edge Open Features and 5G E2E solution

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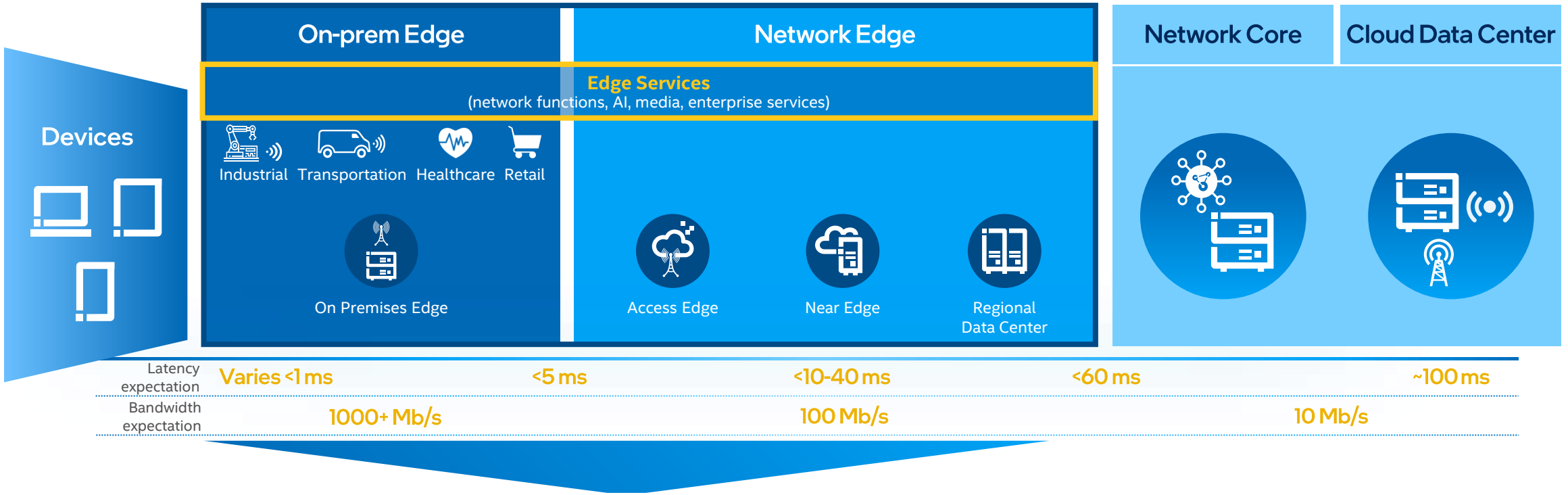
# Delivering Cloud Native Platforms for the Edge




## Lower TCO with a consistent cloud native platform approach across edge locations

- Applications and Services
- Middleware
- Resource and service orchestration
- Operating system
- Edge hardware platform

## Key challenges to overcome

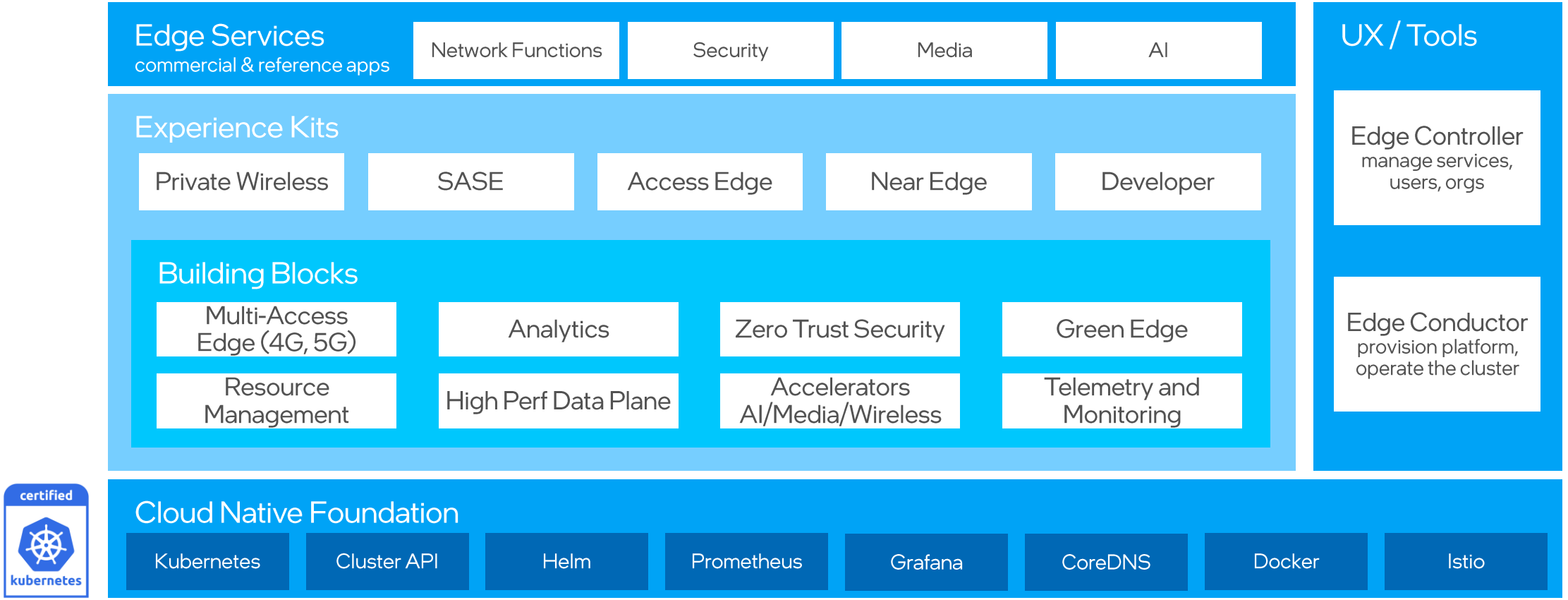
- Deliver platform consistency & scalability across diverse edge location requirements
- Optimize cloud native frameworks to meet stringent edge KPIs and network complexity
- Leverage a broad ecosystem and evolving standards for edge computing

# Smart Edge Solutions: Optimized for Edge Computing

Edge native software to build use case optimized edge platforms

Hyperlocal, hyperconverged, distributed edge locations

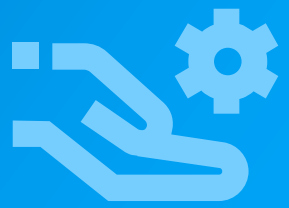
Open and commercial options



# Value Proposition

## Easy to Use

- Cloud native and microservices based implementation
- Kubernetes certified
- Hand-picked CNCF projects integrated for easy edge computing
- Optimized for Intel platforms and built-in support for latest features



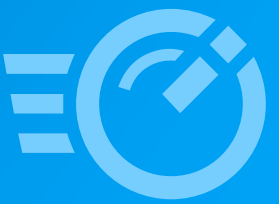
## Reference Solutions

Highly-tuned edge experience kits ready-to-use on validated platforms

- Developer Experience Kit with reference implementations
- Enterprise Edge: Private Wireless and Secure Access Service Edge
- Telco Edge: Access Edge (ORAN) and Near Edge (dUPF)

## Optimized 4G/5G Networking

- Standards aligned: 3GPP, ETSI MEC, ORAN, GSMA, OPG, and WiFi
- Support for commercial CNFs (4G/5Gcore and RAN)
- High performance data plane options, eBPF, and SRIOV for low latency & high throughput



# Deeper Dive into Intel® Smart Edge OpenExperience Kits

# Experience Kits Defined

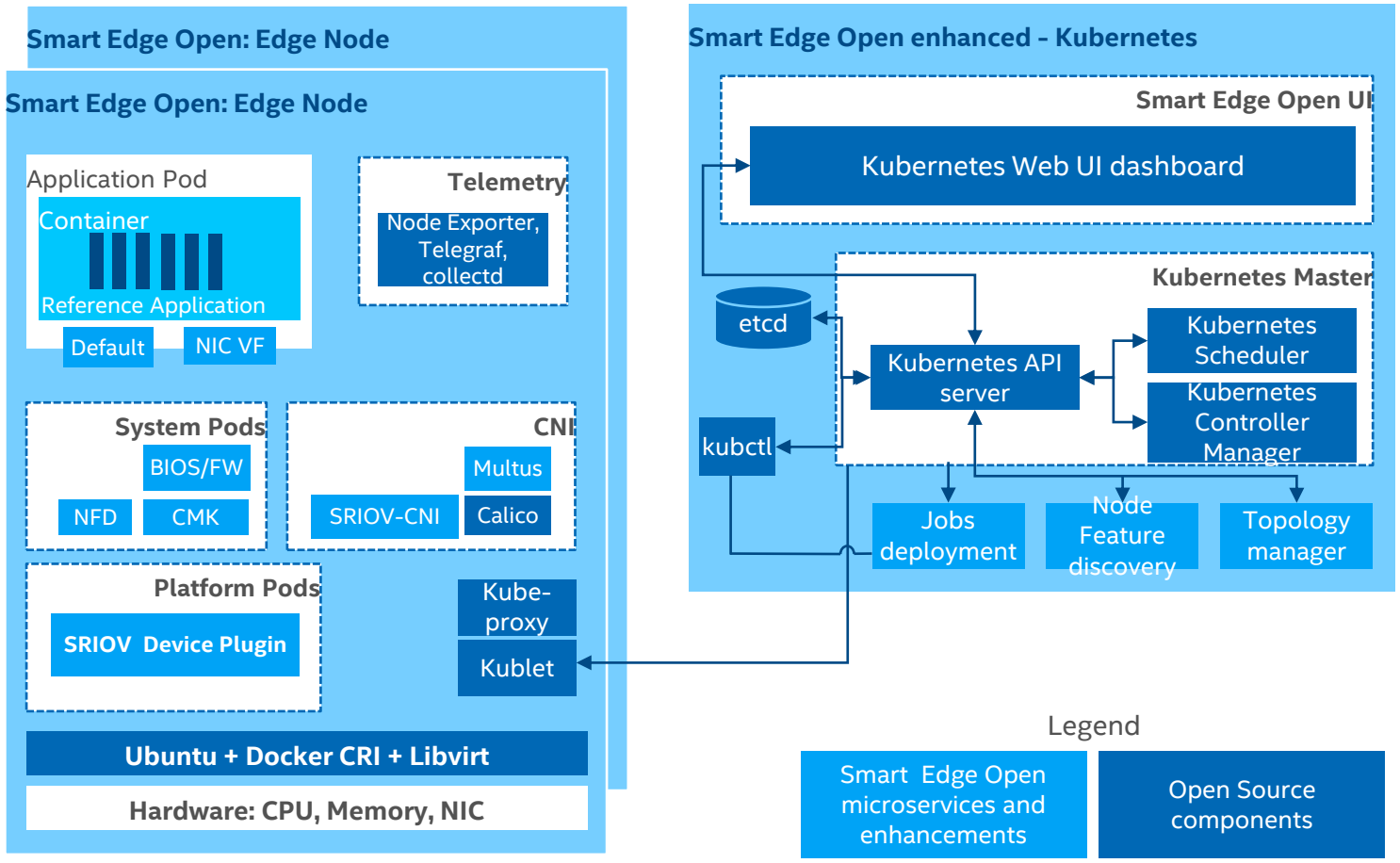
Opinionated edge software stacks built on open cloud-native technologies, designed to host a specific set of edge services on dedicated hardware platforms or hyperscaler instances, and for specific edge locations

Composed of a set of building blocks from the open community or from Intel, that are carefully selected, IA optimized and integrated with modern tools to be able to address the target edge services

A starting point for edge builders to create their own performant and optimized edge platforms, significantly reducing their development time and cost

Edge builders can adopt kits in their entirety or as specific building blocks

# DEK: Developer Experience Kit




The **Developer Experience Kit** (DEK) lets you easily install and instantiate an Intel® Smart Edge Open edge cluster. Once the cluster has been installed, you can onboard edge applications and run reference implementations – example end-to-end solutions built on Intel® Smart Edge Open – to get familiar with operating a stand-alone edge node or to start creating your own solution.

**Validated Platform:**

- Dell PowerEdge R750 server
- 2 Intel® Xeon® Gold 6338N Processors: 2.2G, 32C/64T
- 128 GB RDIMM, 3200MT/s
- Intel E810-XXV Dual Port 10/25GbE SFP28 NIC
- Ubuntu 20.04 LTS Operating System

# Getting Started with SE-O DEK

Provision the operating system and Developer Experience Kit on a target system by 4 steps. After completing these instructions, you will have created a single edge node cluster capable of hosting edge applications.

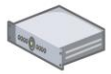
## Step 1

### Meet Requirements

**Provisioning System**

**Memory:** At least 4GB RAM
**Hard drive:** At least 30GB
**USB** flash drive
A recent **Linux distribution** such as Ubuntu 20.04, Centos 7.9 or RHEL 8.
**Docker**
**Python 3.6 or later**, with the PyYAML module installed
**Internet access**

**Target System**



**CPU:** 3rd Generation Intel® Xeon® Gold 6338N Processor
**Memory:** 8 * 32GB DIMM
**Hard drives:** 2 SATA SSDs, one for booting and a second for data caching
**Sockets:** 2 CPU-populated sockets
**Network adapters:** 2 Intel® Ethernet Network Adapters E810-XXVDA2
**Operating system:** Provisioning process will install Ubuntu 20.04

**GitHub Account**
**Git**

## Step 2

### Clone & Run

**Clone** the Developer Experience Kit from github.com/smart-edge-open

CLI

> **Run** provisioning script

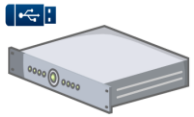
> **Build** provisioning script

> **Run** provisioning

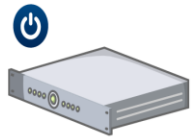
## Step 3

### Flash & Install

**Flash** installation image



Insert drive into a USB port & **run**



**Reboot** & log into system

## Step 4

### Verify Installation

CLI

- `in progress` - deployment is in progress
- `deployed` - deployment was successful - cluster is ready
- `failed` - error occurred during the deployment

**Check status** of installation



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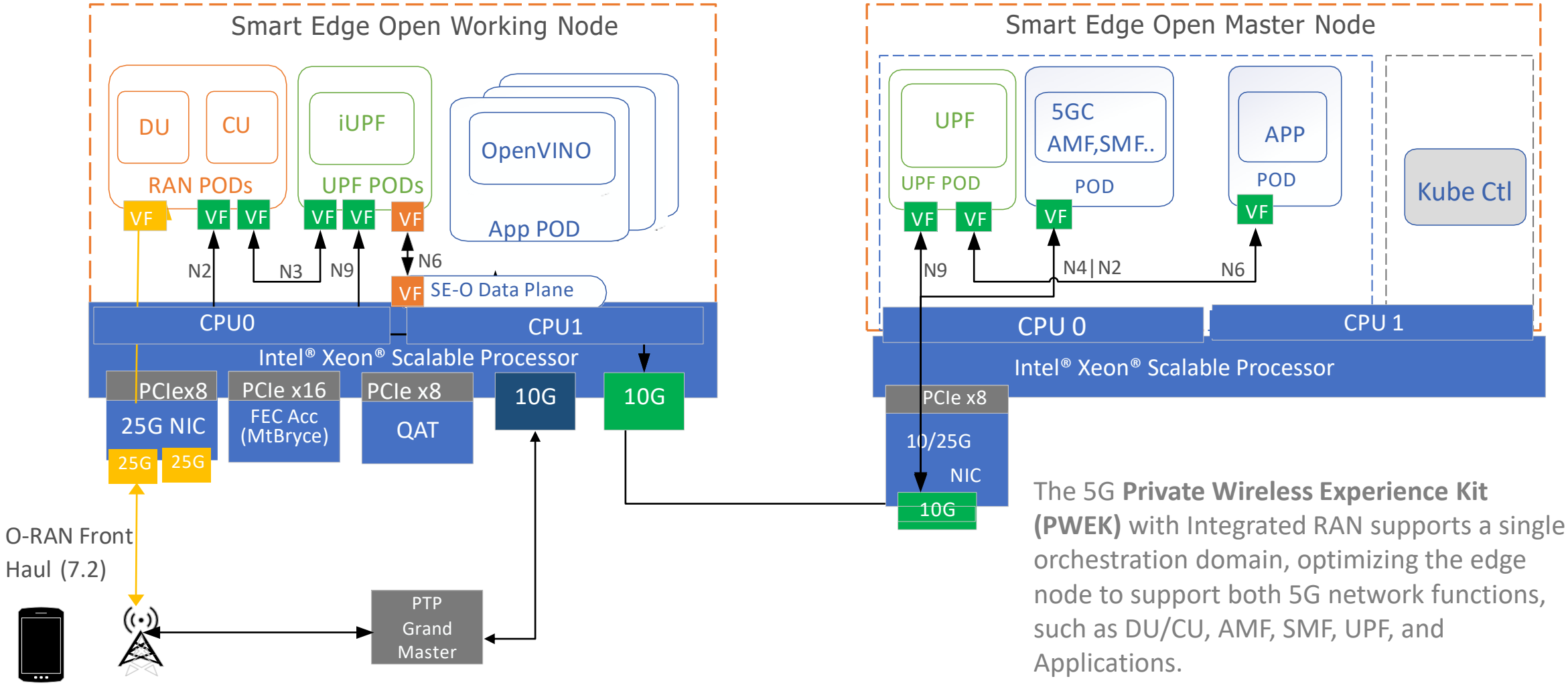
# PWEK: Private Wireless Experience Kit




The 5G **Private Wireless Experience Kit (PWEK)** with Integrated RAN supports a single orchestration domain, optimizing the edge node to support both 5G network functions, such as DU/CU, AMF, SMF, UPF, and Applications.

# PWEK: DEVICE BOM LIST

RRU

Ground Master for GPS


## Inside Shielding Box

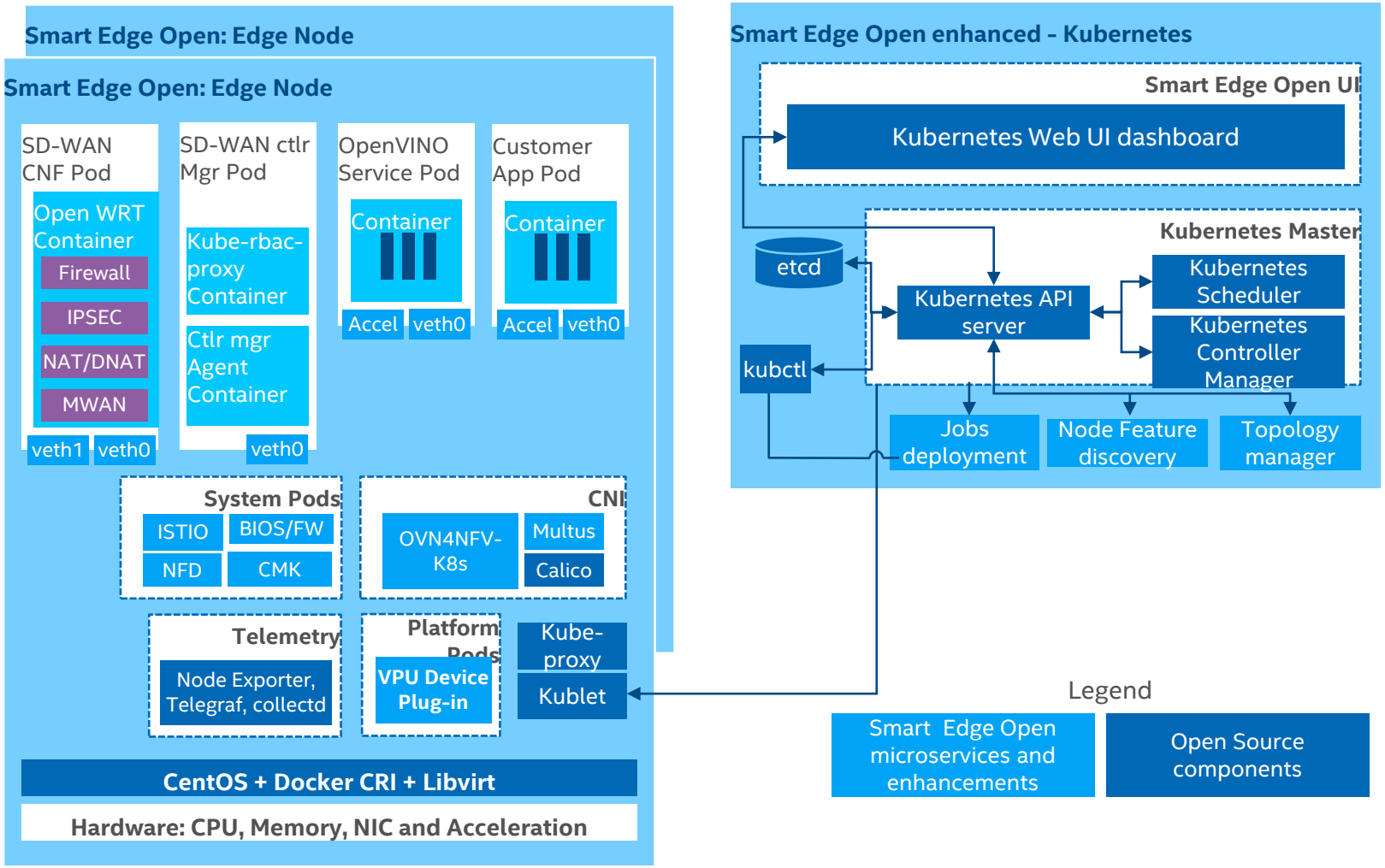
Outside


Inside

## K8S Controller & 5G Control Plane
(ICX Coyote Pass Server)


## K8S Working Node with UPF and RAN(CU, DU)
(ICX Coyote Pass Server with ACC100 and QAT card)

# SEK: SASE Experience Kit




The **Secure Access Service Edge Experience Kit (SEK)** provides a recipe for distributed Edge/POP architecture

**Validated Platform:**

- Intel Xeon D-2154NT, 8C @ 1.9GHz, 16GB DDR4 2400MHz, Intel NIC X722 10GbE SFP+, HDDL accelerator
- CentOS 7.9 Operating System

# Deeper Dive into (select) Smart Edge Open Building Blocks

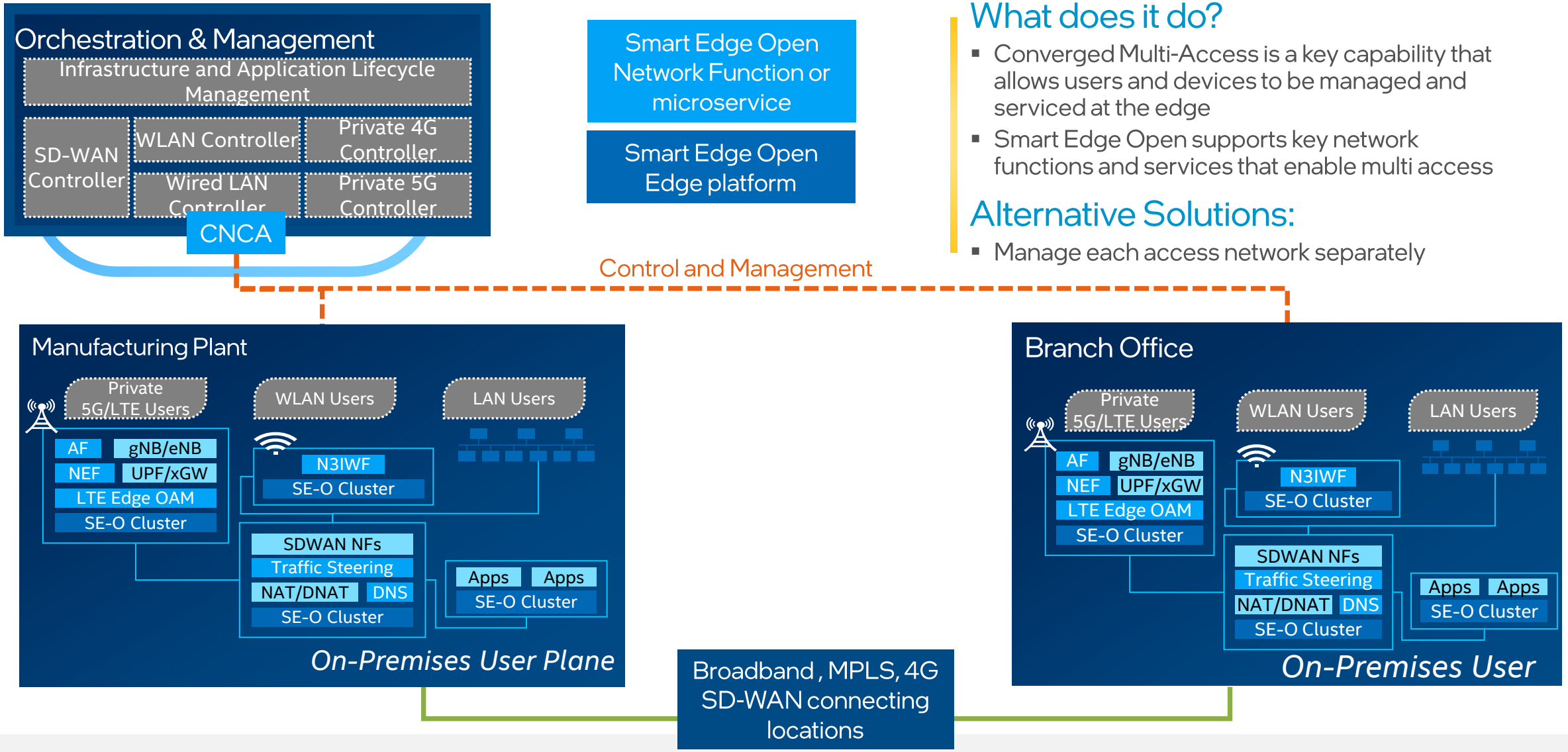
# Core Building Blocks

| | |
|---|---|
| Kubernetes Foundation | A CNCF certified cloud native and microservices architecture |
| Standards Aligned | 3GPP, ETSI MEC, GSMA, OPG, and ORAN |
| Multi-Access Networking | 3GPP Network function microservices enabling deployment of edge cloud in a 4G/5G network |
| Edge WAN Overlay | Secure WAN Overlay implementation providing abstraction of multiple edge & cloud provider networks as a uniform network, traffic sanitization, and SD-WAN |
| Security | Platform attestation, integrity, trusted execution, secure device onboarding, and data confidentiality whether data is at rest, in-motion, or in-use |
| Platform Provisioning | Automated installation of operating system and software stack on bare-metal or virtual machines using Intel Edge Software Provisioning software |

| | |
|---|---|
| Resource Management | K8s extensions for Node Feature Discovery, NUMA awareness, Core Pinning, Resource Management Daemon, Topology Management |
| Data plane CNI | High performance data planes and CNIs for various edge use cases: Calico, eBPF, SRIOV |
| Accelerators | Kubernetes device plugins for FPGA, FEC, DDP, and GPU* |
| Kubernetes Operators | Kubernetes extensions that automate management and lifecycle of applications or accelerators and their components |
| Telemetry and Monitoring | Platform and application telemetry leveraging industry standard frameworks |
| Inferencing and AI | Direct support for OpenVINO, OVC, and Edge Insights for Industrial based on CPU compute or with acceleration |

*Coming soon as part of future enhancements

# Multi-Access Networking



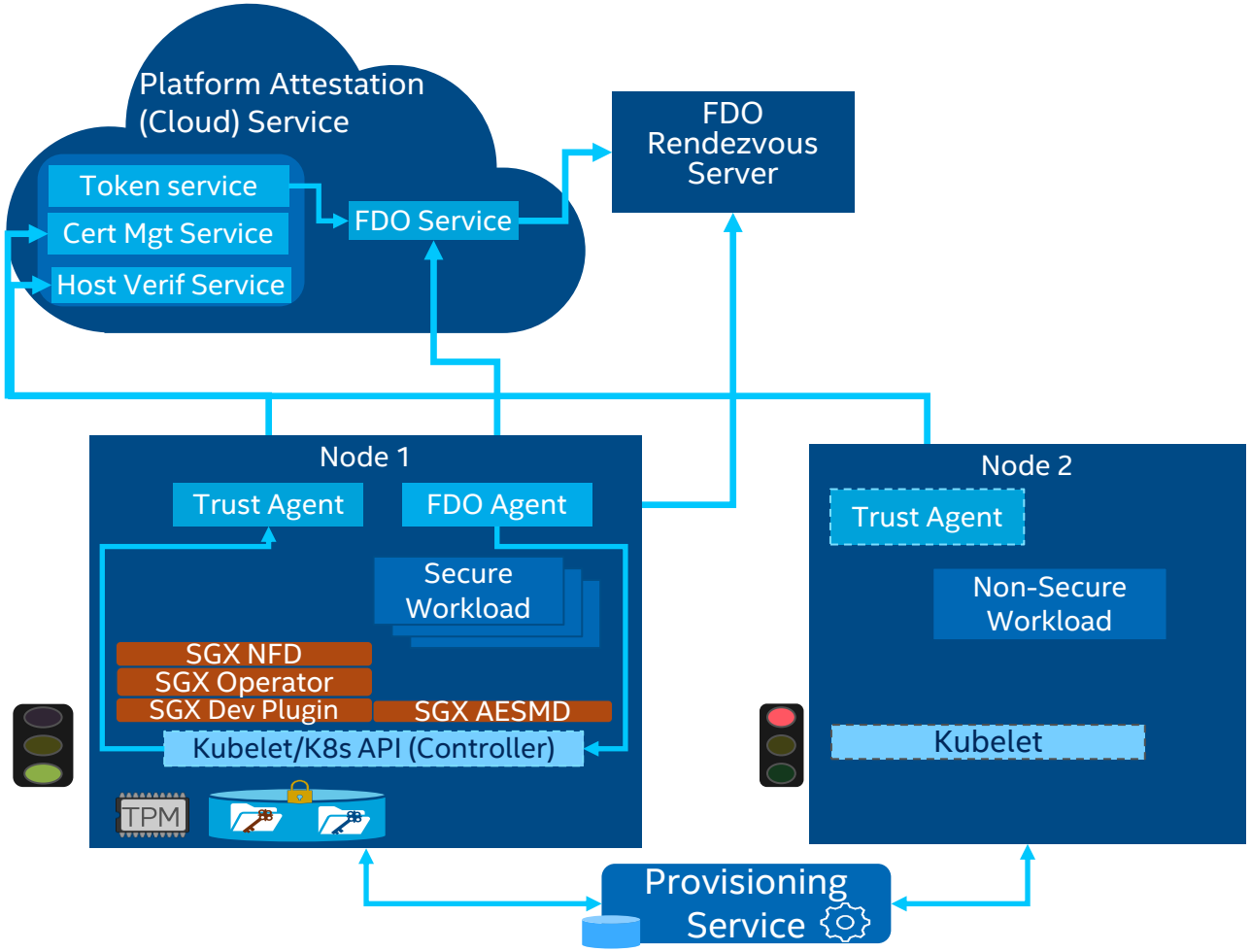

## What does it do?

- Converged Multi-Access is a key capability that allows users and devices to be managed and serviced at the edge
- Smart Edge Open supports key network functions and services that enable multi access

## Alternative Solutions:

- Manage each access network separately

# Zero Trust Security Architecture




## Key Features

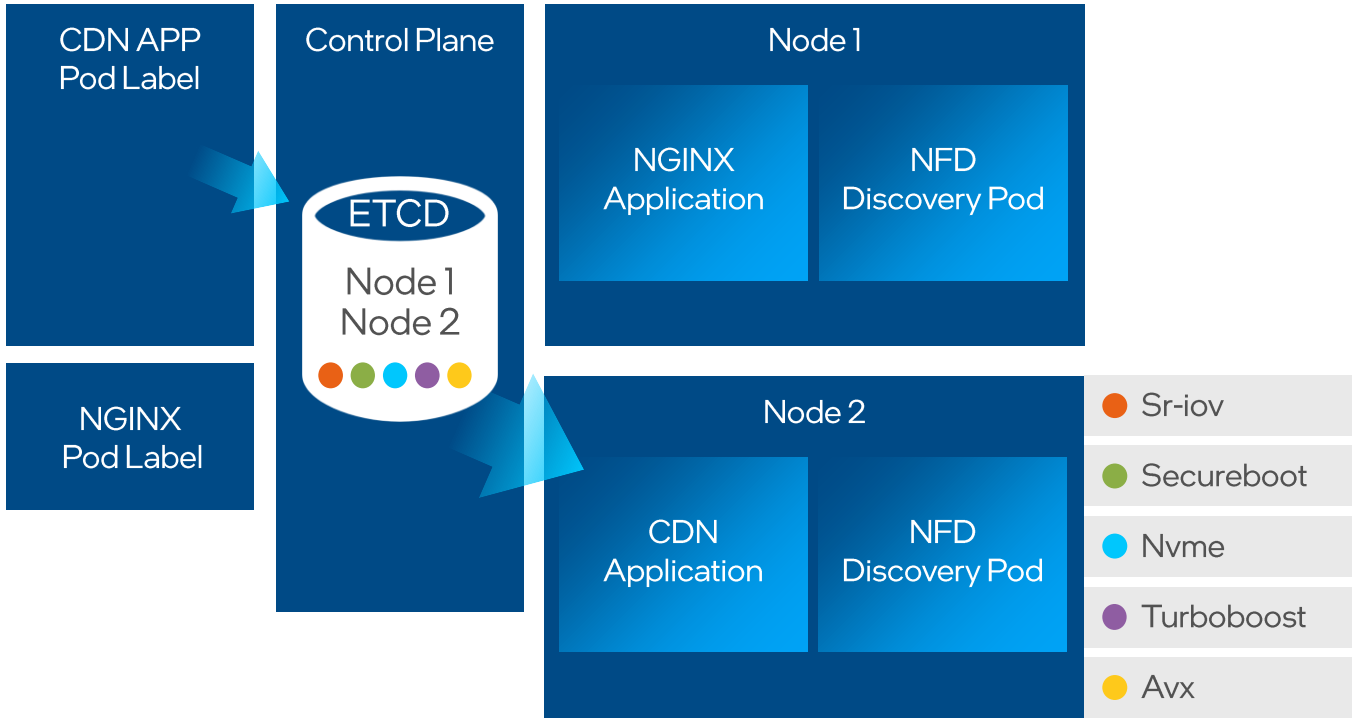
- Secure On-Boarding and provisioning
- Platform integrity verification and attestation at boot time (using ISecL)
- Data at rest protection with LUKS full disk encryption (AES-NI accelerated)
- Secure Key Management and Caching
- SGX attestation framework and workload isolation

## Usage

- Drop ship server to field for deployment, where it comes up, gets authenticated, provisioned and registered as a secure node.
- Tenant provisions transport keys for secure use in case of connecting traffic stream.
- Tenant provisions a secure workload to run on the same trusted node.

**Enables HW root-of-trust based security of dense multi-tenant edge platforms, to protect data at rest, in use and in motion, using zero-trust principles, posturing and policies.**

# Resource Management (Node Feature Discovery)




## What does it do?

- Advertises edge node capabilities to the orchestrator
- Enables the orchestrator to deploy the applications to the edge node with optimum capabilities that best meet edge KPIs

## Alternative Solutions:

Without NFD, application is deployed with degraded performance

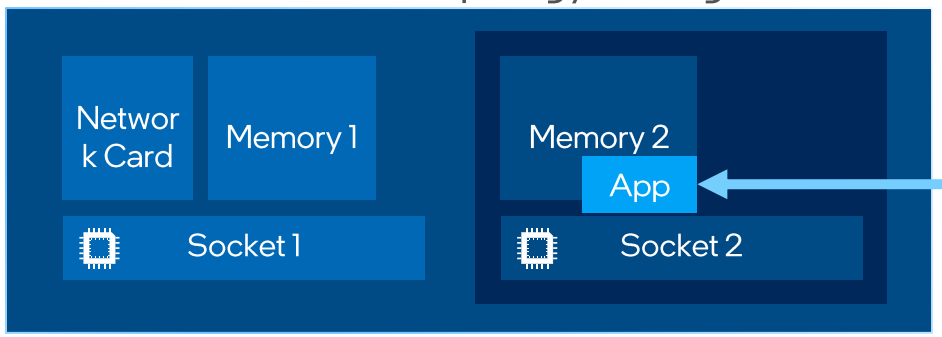
Implement a custom solution for the deployment

Unique HW Capability Examples: FPGA, Security, Performance, ...

**Exposes node specific HW capabilities to the orchestrator to enable intelligent placement of workloads for optimized application performance and manageability**

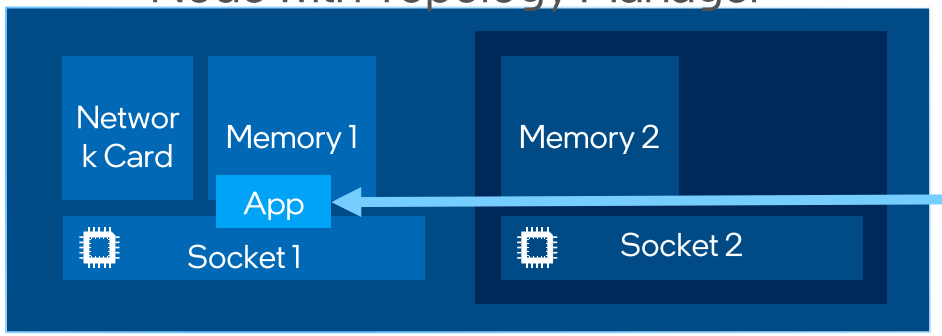
# Resource Management (Topology Manager)

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

## What does it do?

For un-balanced NUMA nodes with network card attached to only one socket:

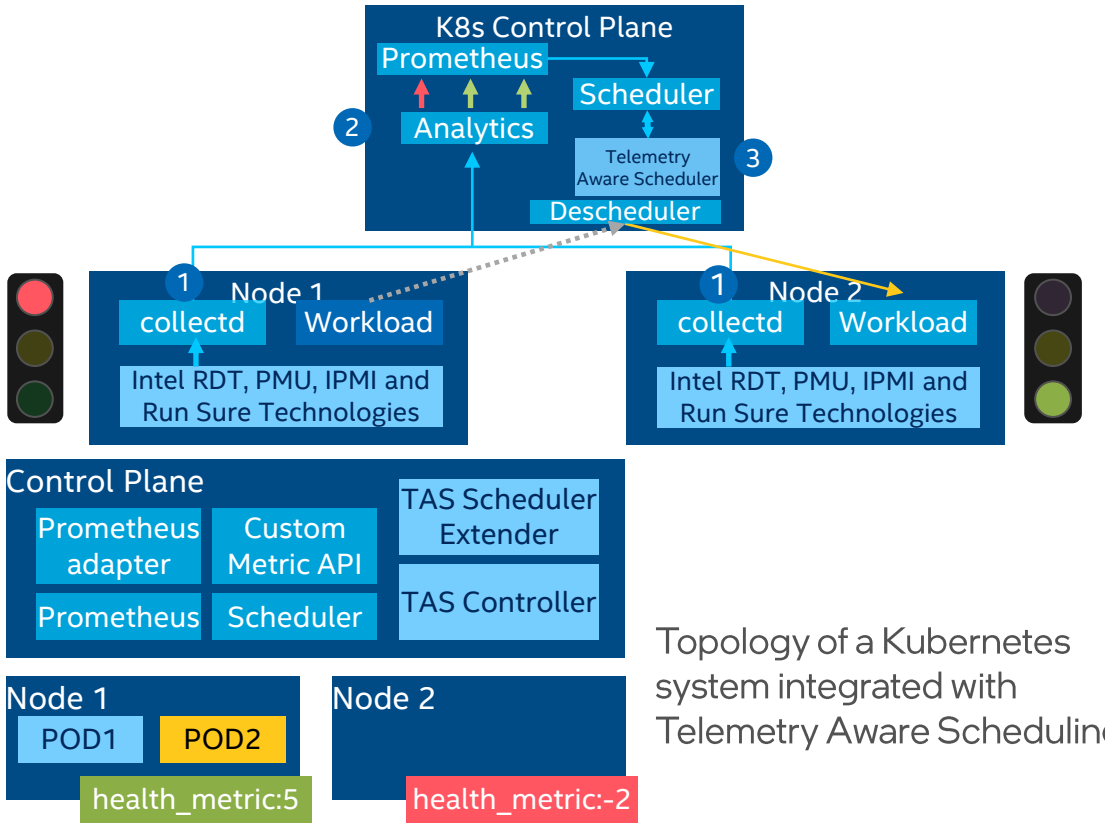
- TM microservice exposes which socket is attached to the network card
- Enables the orchestrator to properly deploy performance sensitive edge applications (throughput, latency)

## Alternative Solutions:

Suboptimal allocation of resources resulting in degraded performance

**Makes the orchestrator NUMA Aware, enabling optimum deployment of performance sensitive edge applications**

# Telemetry Aware Scheduler




Topology of a Kubernetes system integrated with Telemetry Aware Scheduling

## What does it do?

- TAS collects and exposes platform telemetry from collected and other sources to the Control Plane
- Control Plane able to monitor performance of respective nodes and dynamically place/migrate workloads for optimum performance

Example:

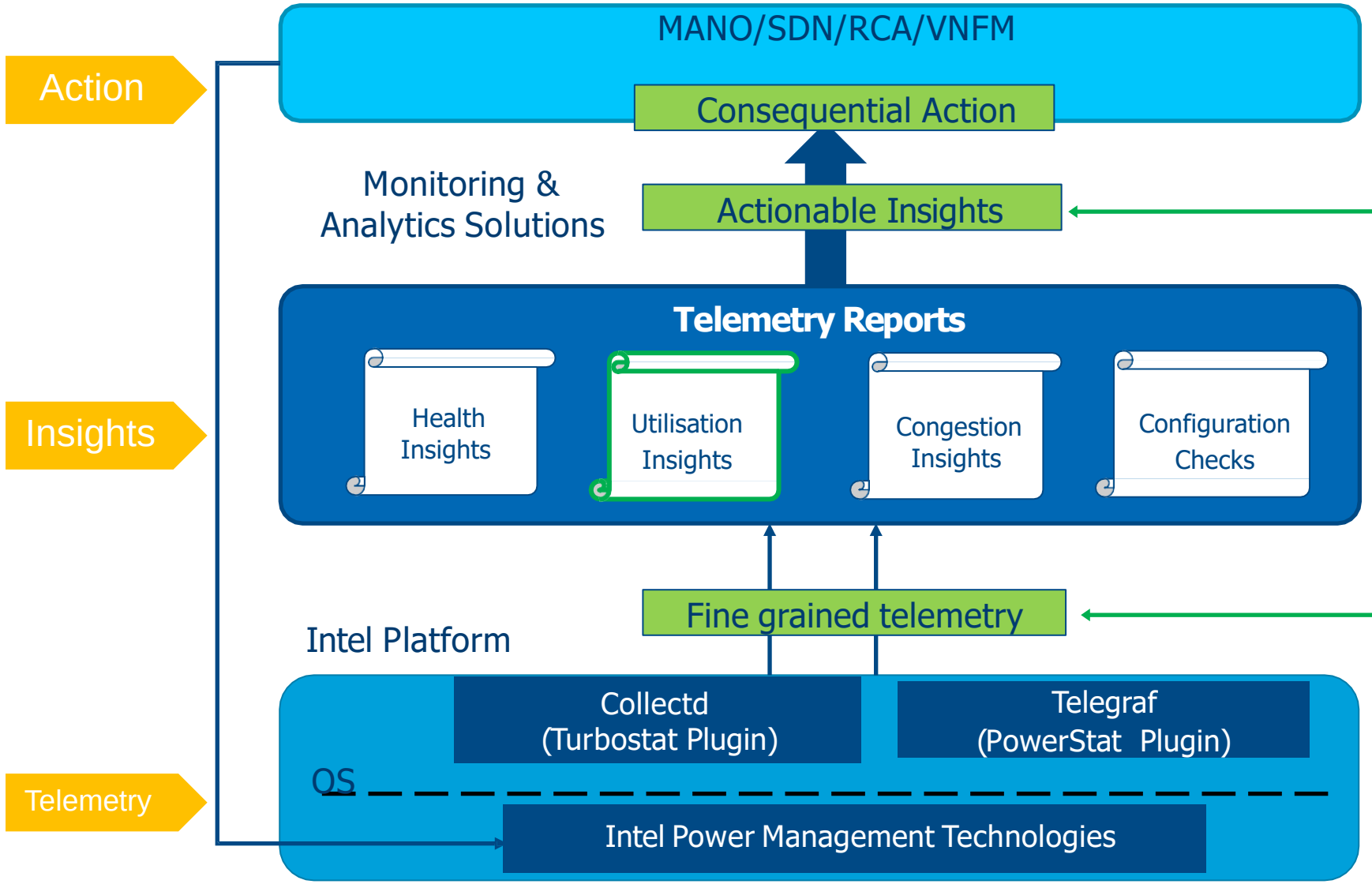
- CDN in Loc A with streaming app and voice app.
- Loc A experiences voice app overloads due to local emergency.
- TAS the K8s Control Plane observes bottleneck at Loc A and identifies Loc B that is capable of added workload.
- Quickly and seamlessly moves the streaming app to Loc B with minimal impact to customer experience

## Alternative Solutions:

Absent this level of telemetry integration there is no way to get real time data needed to identify bottleneck and suitable node for dynamic offload

**Exposes edge node telemetry metrics enabling service providers to implement rule-based workload placement for optimum performance and resilience**

# Power-Aware Telemetry



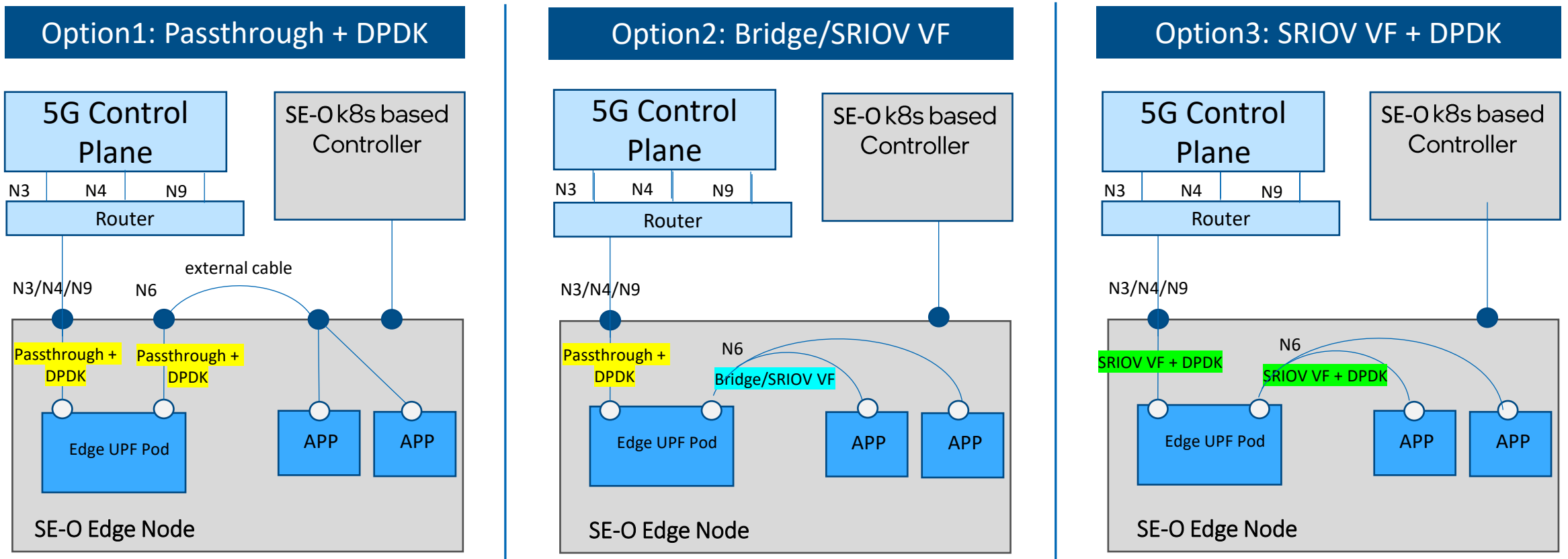

Example derived metrics:

- Power to TDP Ratio
- Power Headroom
- Watts per CPU
- Platform Watts
- Busy/Idle Cores
- C-State residency over time

- Package Current Power Consumption
- PSU Input Power(Wall Power)
- CPU Frequency
- Package Thermal Design Power
- Package DRAM Power Consumption
- C-State residency

# 5G E2E Solution

# Edge UPF CNF Deployment Solutions with Multi-CNI




UPF Pod with Multi-CNI to support N3/N4/N6/N9 interface.
DPDK/Passthrough and SR-IOV VF provide different performance and flexibility.

# Native CPU Manager to pin isolated CPU

CPU Manager policy: (--cpu-manager-policy = none, **static**)

Topology Management: (none, best-effort, restricted, **single-numa-node**)

Reserve Compute Resources for System Daemons: (--system-reserved, --system-reserved-cgroup, **--reserved-cpu**)

kubelet

Grub cmdline: (**isolcpus, irqaffinity….**)

Grub

QoS classes: (**Guaranteed**, Burstable, BestEffort)

Pod

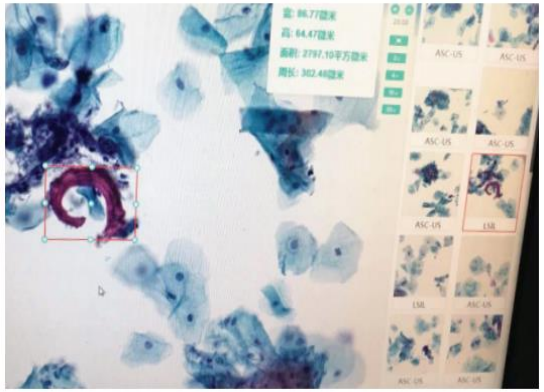
Xeon Feature: (**SST-BF, SST-TF**)

CPU

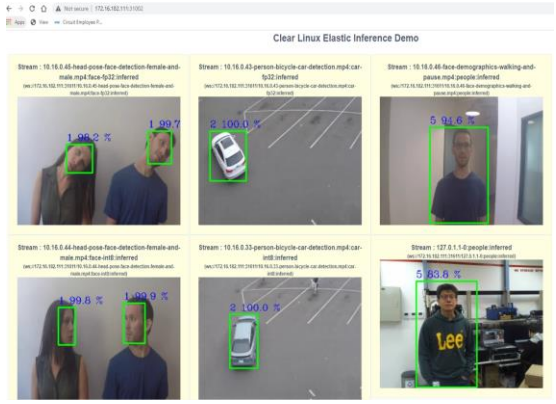
# Edge Applications Integrated on the Testbed

## EII Smart Fabric Factory

## Cancer Diagnosis

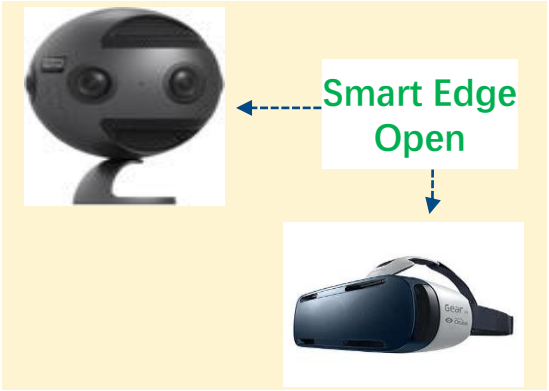


## Object Recognition



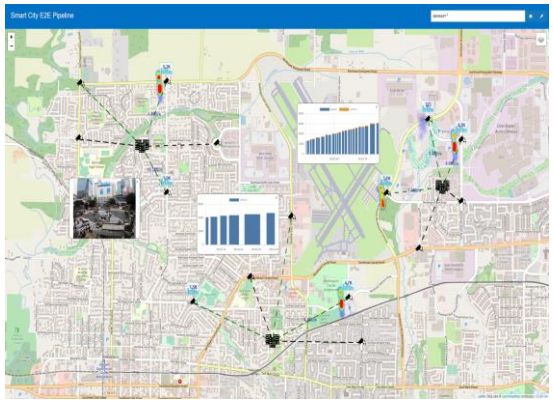

## WebRTC For Smart Office


## IM360




## Robot

## Smart City



## Education

# Commercial Apps Portal

Commercial Applications pre-integrated with Smart Edge Open available via Intel Network Builders
https://networkbuilders.intel.com/commercial-applications

| | | | | |
|---|---|---|---|---|
| QWILT | ACTIAN | RADISYS | LINKS FOUNDATION | CLEARBLADE INC |
| INREALITY | ALTRAN | AARNA NETWORKS | VSBLTY VECTOR | VSBLTY DATACAPTOR |
| KIBERNETIKA INC | DEEPSIGHT | VSBLTY VISIONCAPTOR | RADAR HOME | RADAR CITY |

# Smart Edge Open

Accelerating Service
Innovation at the Edge