Notices and Disclaimers

- Intel technologies may require enabled hardware, software or service activation.

- No product or component can be absolutely secure.

- Your costs and results may vary.

- © Intel Corporation. Intel, the Intel logo, and other Intel marks are trademarks of Intel Corporation or its subsidiaries. Other names and brands may be claimed as the property of others.

About Me

Global Solution Architect

Background in NFV solution stacks

- Kubernetes, OpenStack

Open-source communities

- Maintainer Collectd, CNCF SMP
- Elected member of OPNFV (now Anuket) Technical Steering Committee

IEEE Initiatives

- Future Networks - Edge Services Platform
- Senior Member

ETSI Experiential Network Intelligence

Patents (8 Filed, 1 Granted)

Conferences

- IEEE, ONES, OSS, FOSDEM, Promcon, etc.
- Meetup organizer/contributor

Agenda

- Intro Edge Computing

- Types of Edge Computing

- Intel® Smart Edge Open

- Experience Kits & their use cases

- What can you do?

What is Edge Computing?

- Provide compute power closer to end devices

- Enable low latency communication

- Enables distributed processing of data

Need for Localized Data Centers

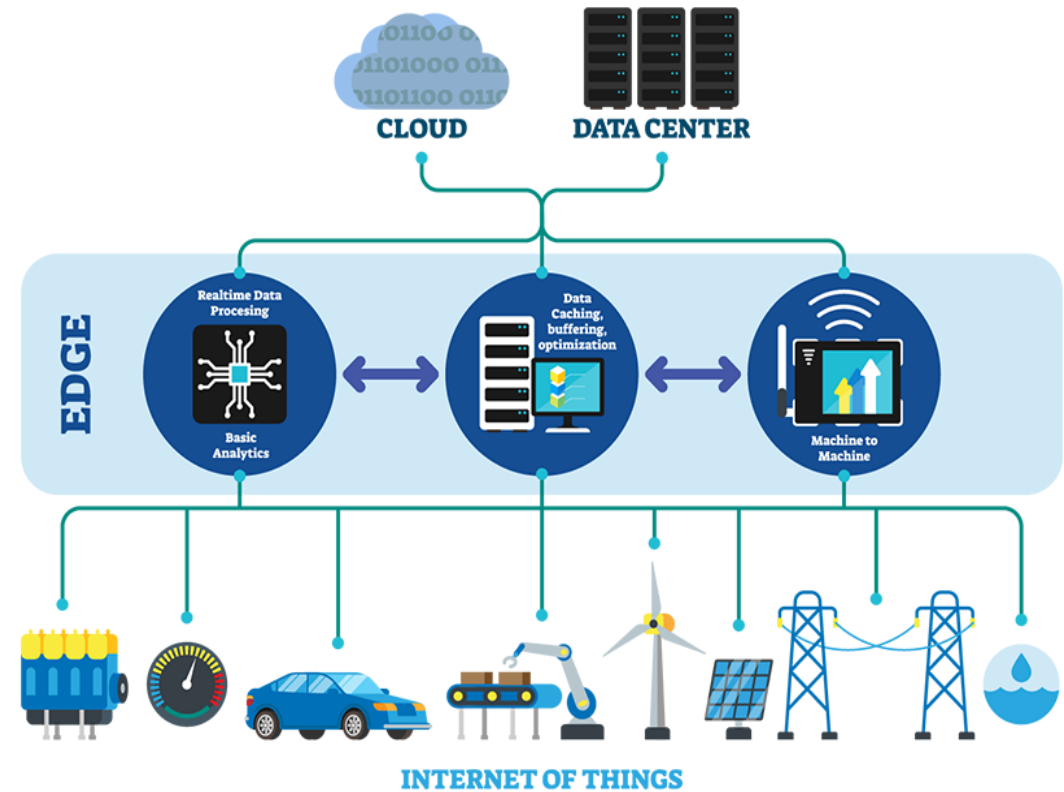Figure Source: https://innovationatwork.ieee.org/real-life-edge-computing-use-cases/

Importance of Edge Computing

Latency & Speed
- Processing close to source reduces RTT
- Enables innovative technological models

Localized Data Processing
- Derive value of data close to source
- Unlocks intelligence with new data

Security & Privacy
- Distributed attack surface
- Sensitive data don't have to travel to cloud

Cost Savings
- Reduced Data Storage requirements
- Reduced cloud footprint

Reliability & Resiliency
- Multiple levels of redundancy ensuring reliability
- Reduces critical point of failure

Scalability
- Scaled across geographically distributed regions

Terminologies around Types of Edge Computing

1. Device Edge

2. Sensor Edge

3. Mobile Edge

4. Far Edge

5. Internet of Things Edge

6. Wireless Access Edge

7. Router Edge

8. Service Provider Edge

9. Branch Edge

10. On Premise Edge

11. Near Edge

12. Network Edge

13. Enterprise Edge

14. Multi-Access Edge Computing

15. Data Center Edge

16. Cloud Edge

17. Cloudlets

18. Infrastructure Edge

intel.

Edge Computing Types by Latency
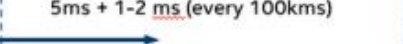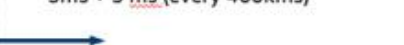
TIERS

ON-PREMISE EDGE		NETWORK EDGE	DC EDGE	PUBLIC CLOUD
INTELLIGENT SENSOR/GW	INTELLIGENT EDGE	NETWORK EDGE	DC EDGE	PUBLIC CLOUD

NETWORK LATENCIES (Wire Round trip)

< 1ms	< 1ms	1-5ms	5ms + 1-2 ms (every 100kms)	5ms + 5 ms (every 400kms)

DEPLOYMENT REQUIREMENTS

Compute Available Power: < 50 W **Form Factor:** Small Box **Thermals:** NEBs **Mgmt.:** Remote	**Compute Available Power:** ~10KW **Form Factor:** Rack(s) **Thermals:** NEBS or Standard DC **Mgmt.:** Remote	**Compute Available Power:** <600 W **Form Factor:** Pizza box **Thermals:** NEBS **Mgmt.:** Remote	**Compute Available Power:** 9KW/rack 1KW sqm **Form Factor:** Rack(s) **Thermals:** NEBS or Standard DC **Mgmt.:** Remote	**Standard Data Center (DC)**

WHERE, WHAT & WHY

Use case	KPI	Use case	KPI	Use case	KPI	Use case	KPI	Use case	KPI
Intelligent Transportation	Data Privacy, Backhaul Traffic Savings, Reliability	AR/VR	Latency. Backhaul Traffic Savings, Network scalability	Intelligent Transportation	Data Privacy, Backhaul Traffic Savings, Reliability, throughput Latency	Intelligent Transportation	Data Privacy	CDN	Backhaul Traffic Savings, Throughput
V2V	Latency	Retail	Data Privacy, Backhaul Traffic Savings, Reliability	V2V	Latency	Video Analytics	Same as Int. Transp.	Storage GW	Same as CDN
Retail	Same as Int. Transp.	RT Streaming Healthcare	Same as AR/VR Access to services	Video Analytics	Same as Int. Transp.	Drone/IoT	Same as Int. Transp.		
Video Analytics	Same as Int. Transp.			Drone/IoT	Same as Int. Transp.	Healthcare	Access to services		
				Rural	Access to services	CDN & Storage	Backhaul traffic Savings Throughput		
						FaaS	Latency		
						AR/VR/MR	Latency		

Figure Source: https://networkbuilders.intel.com/solutionslibrary/composable-architectures-for-a-sustainable-edge

IoT Edge

- Smart devices with ability to communicate with each other

- Ability to make autonomous decisions

- Attributes
  - Mobility
  - Various levels of intelligence
  - Data privacy & secure communication
  - <1ms RTT
  - Connectivity using various wired/wireless protocols

- Adhere to various city/state/country wide regulations
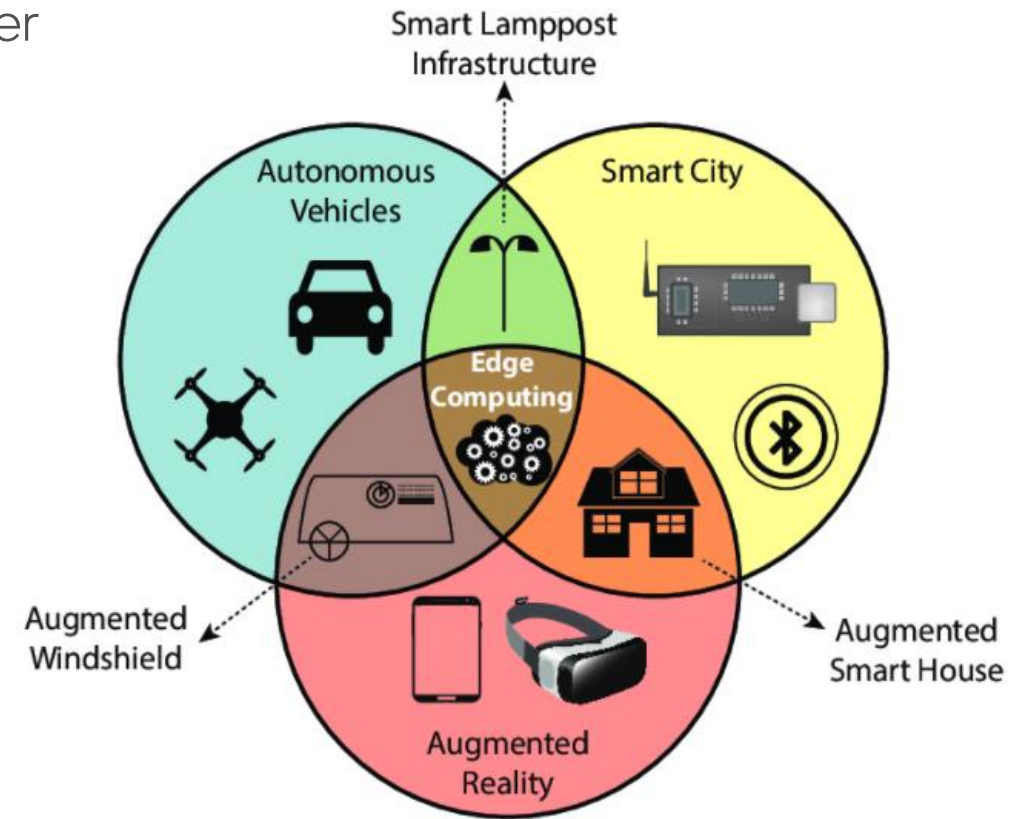
- Enables new revenue models with IT & OT services

Figure Source: https://www.researchgate.net/figure/A-subset-of-use-cases-and-services-enabled-by-IoT-edge-computing_fig4_320729008

On-Premises Edge

- Situated at Customer Premises/Points of Presence

- Close to IoT Devices

- Large enterprises, manufacturing floors, retailers, etc., benefit from On-Prem Edge

- Biz models: Fully owned/operated, subscription-based, pay-per-use, etc.

- Enables connectivity between IoT devices & Cloud

- Attributes:
  - Disaggregated, remote LCM
  - SD-WAN & u-CPE are common forms of deployment
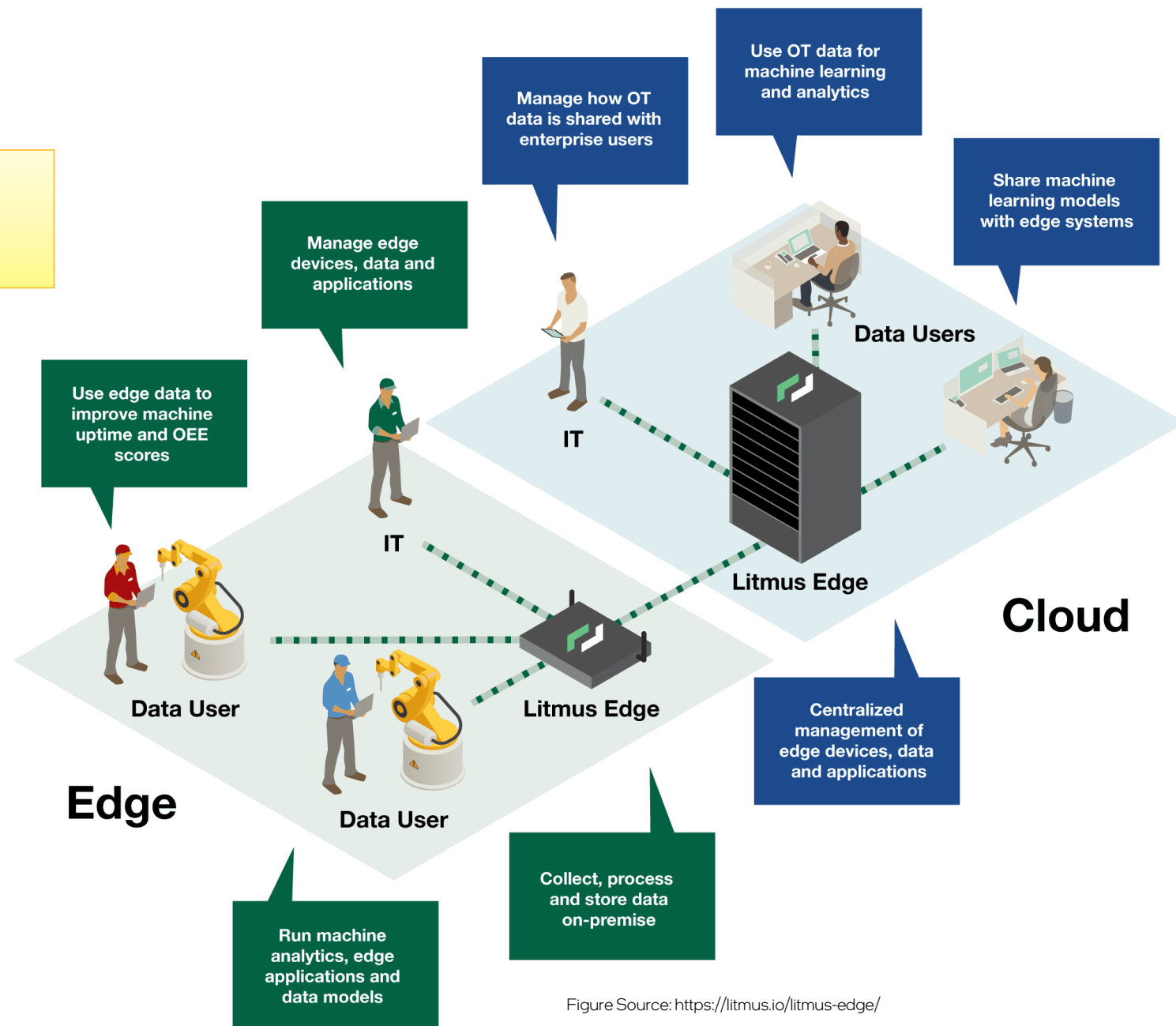 - Unlocks value of data using AI/ML models

Example from Litmus Edge

Figure Source: https://litmus.io/litmus-edge/

Access Edge

Transformation of Radio Access Network (RAN) into Disaggregated & Virtualized Functions	Utilize COTS Servers	Leverage Cloud-Native & DevOps Principles
O-RAN Ecosystem Gaining Traction	Local Breakout (LBO) is an Offloading Solution of Access Network to Save Core Network Load and Reduce the End-to-end Latency.	Examples at Local Breakout: ▪ Game server ▪ Video processing, etc.

NOTE: in practical cases, the edge deployment at S1 interface may come with multiple issues; many deployment options are possible (for more a detailed analysis see IEEE Tech Blog, Part 1 and Part 2)
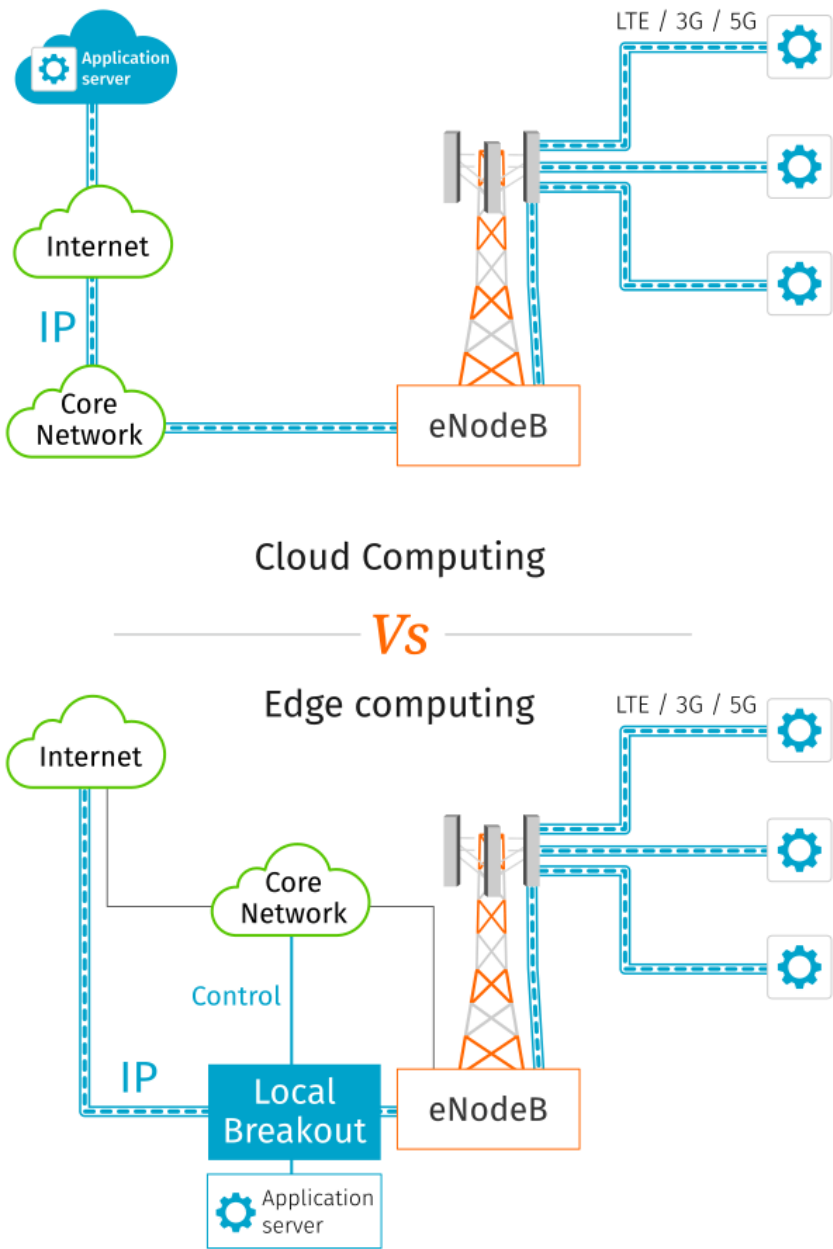
Figure Source: https://yatebts.com/solutions_and_technology/mec-multi-access-edge-computing/

Access Edge

- Attributes:

  - Manage RAN as IaaS or PaaS services

  - Distributed RAN functions: RU, CU, DU, RIC, etc.

  - Leverage AI/ML to form the basis of connection management & data processing

NOTE: in practical cases, the edge deployment at S1 interface may come with multiple issues; many deployment options are possible (for more a detailed analysis see IEEE Tech Blog, Part 1 and Part 2)


Figure Source: https://opennetworking.org/wp-content/uploads/2020/09/Petr-Ledl-Final-Slides.pdf

Network Edge

Figure Source: https://www.networkworld.com/article/3387641/beyond-sd-wan-vmwares-vision-for-the-network-edge.html
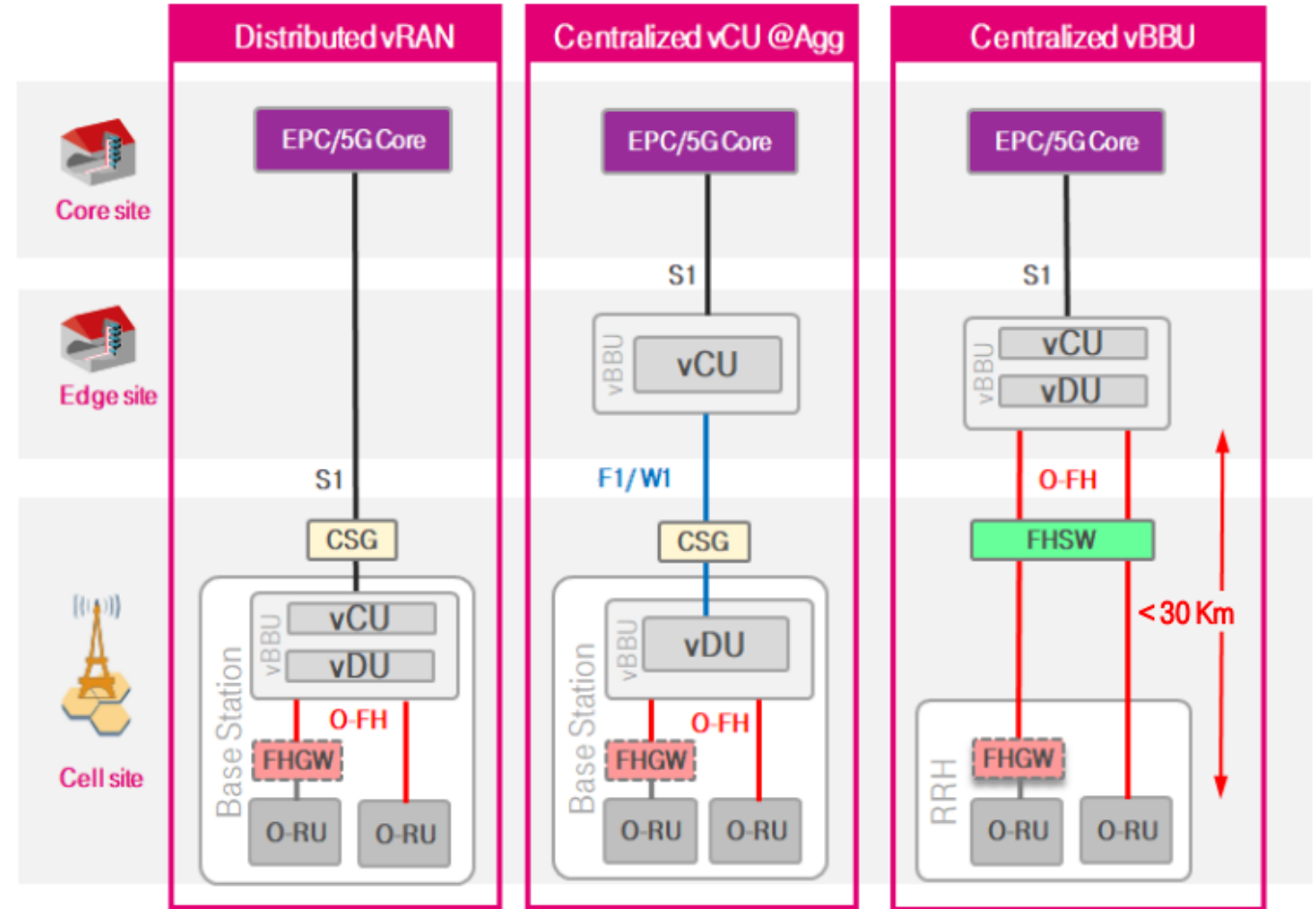
- Data aggregation point across Edge: IoT, On-Prem, Access, etc. before connecting to Data Center

- Distributed across vast set of regions

- Nano Data Centers & Micro Data Centers are emerging infrastructure models

- Next Generation Central Office & Fixed Mobile Convergence are evolving models of deployment

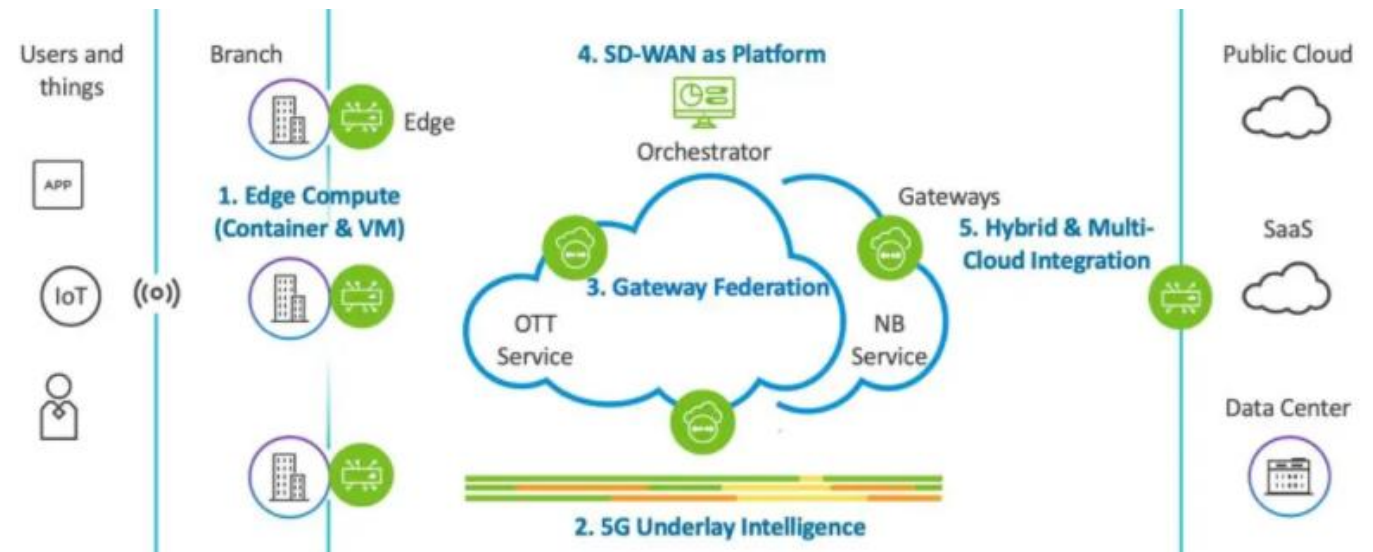# How Does Everything Fit In?

- End-to-End view of IoT to Edge to Cloud Computing
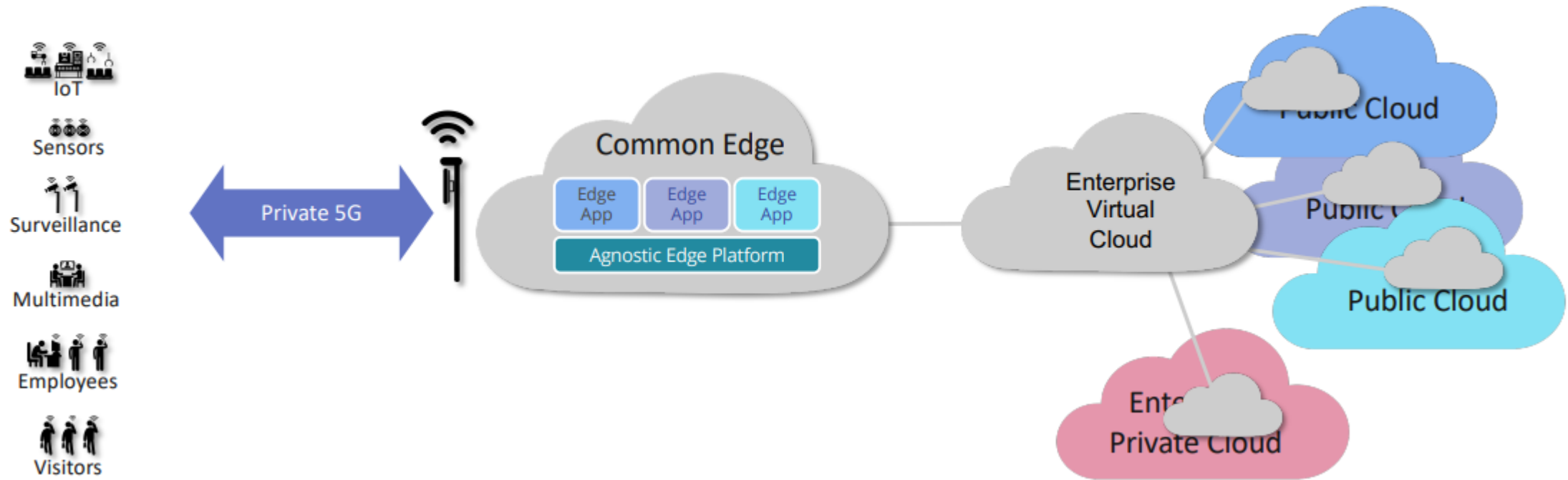
- APIs play Crucial role in End-to-End Connectivity

Figure Source: https://opennetworking.org/wp-content/uploads/2021/09/Enterprise-IoT-5G-Edge-Virtual-Cloud-v12.pdf

Intel® Smart Edge Open

Intel® Smart Edge Open is an edge computing software toolkit that enables **highly optimized and performant edge platforms** to on-board and manage applications and network functions with **cloud-like agility across any type of network**

Modular

Consume as a Whole or as Individual Building Blocks

Microservices Based Architecture

certified kubernetes

Top Use Cases

Access Edge Aggregation Point (Cloud Native RAN + Apps)

Near Edge (5G dUPF + Apps)

uCPE/SD-WAN + Apps

AI/vision inferencing apps with MEC

Media apps with MEC

Smart Edge Building Blocks

Multi-access Networking	Edge Multi-cluster Orchestration	Edge Aware Service Mesh	Confidential Computing	Edge WAN Overlay
Resource Management	Data Plane CNI	Accelerators	Telemetry and Monitoring	Green Edge

Built on an Open Cloud Native Foundation

Kubernetes	Service Mesh	Telemetry	Helm	Operator Framework

Key Features

Optimized for Edge KPIs: throughput. determinism, QoS, latency, jitter, security

Multi-location, Multi-Access, Multi-Cloud

Delivered via use case specific Reference Architectures for ease of consumption and to accelerate TTM

Industry Standards (3GPP, CNCF, ORAN, ETSI)

*Other names and brands may be claimed as the property of others

Components of Intel® Smart Edge Open
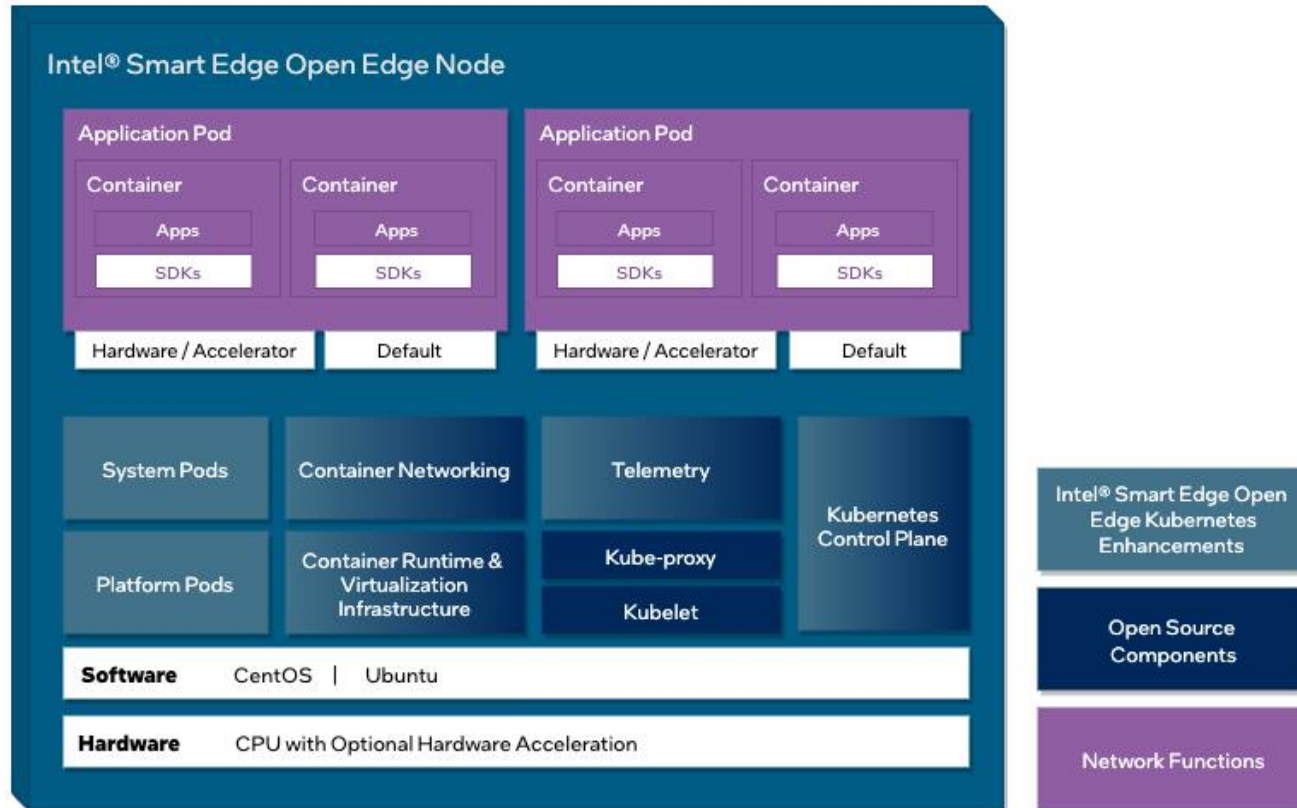
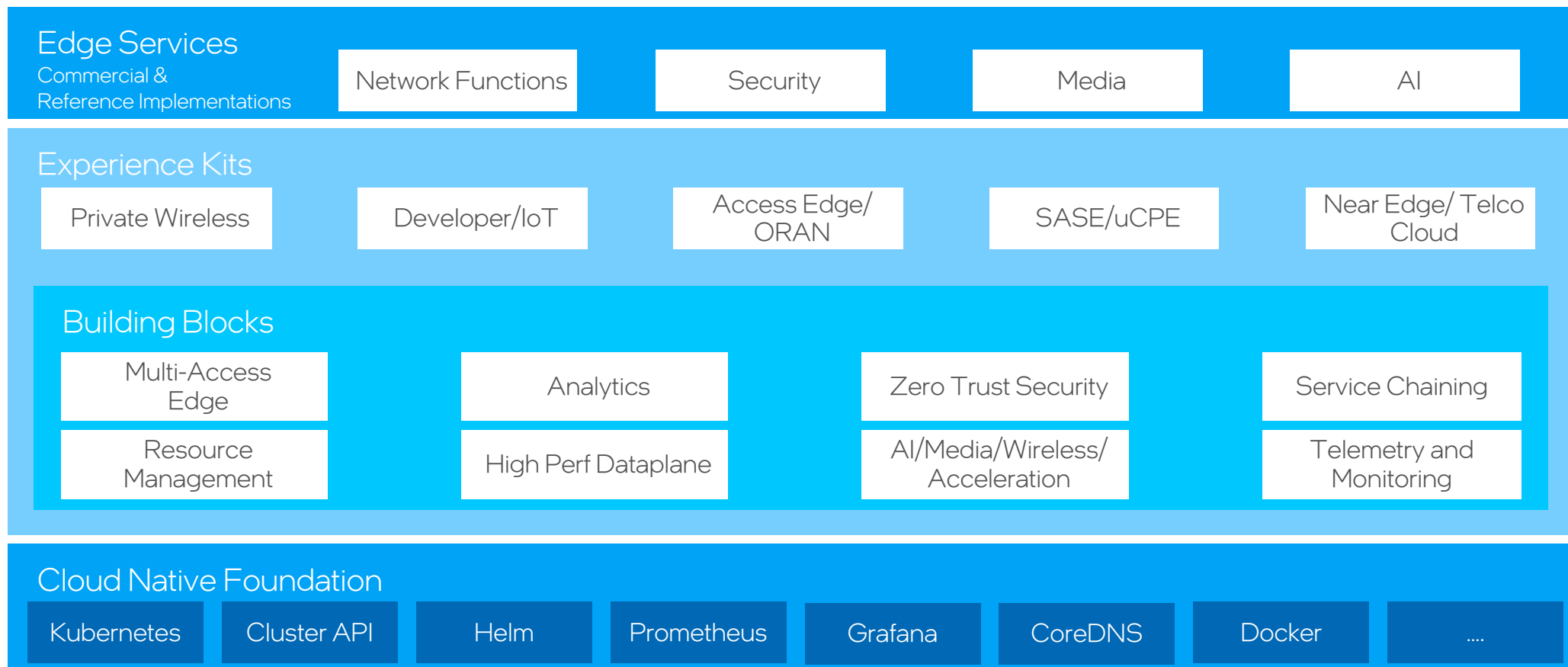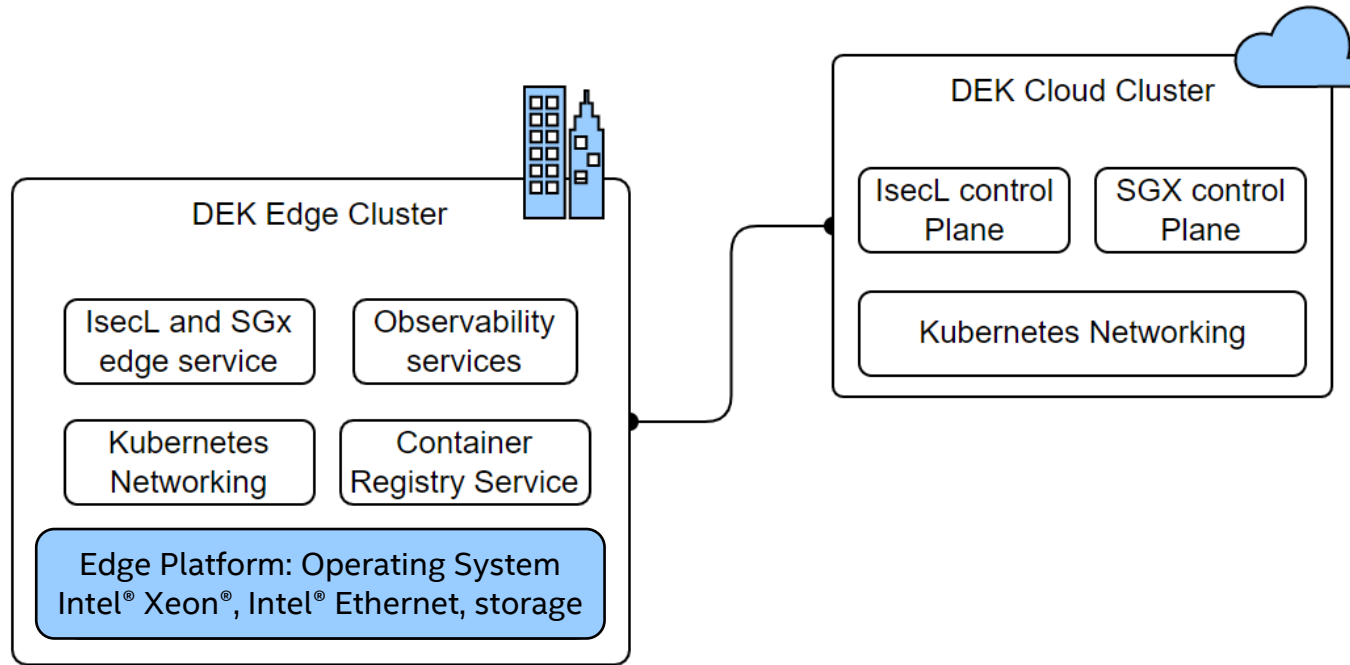- Pre-packaged Kubernetes distribution with customized components for Edge

- Made for open-source collaboration

- On-boards and manages applications with cloud like agility

- Tailored MEC platform for Access, On-prem & Network Edge

Intel® Smart Edge Open Building Blocks

Edge Services
Commercial &
Reference Implementations

| Network Functions | Security | Media | AI |

Experience Kits

| Private Wireless | Developer/IoT | Access Edge/ ORAN | SASE/uCPE | Near Edge/ Telco Cloud |

Building Blocks

| Multi-Access Edge | Analytics | Zero Trust Security | Service Chaining |
| Resource Management | High Perf Dataplane | AI/Media/Wireless/ Acceleration | Telemetry and Monitoring |

Cloud Native Foundation

| Kubernetes | Cluster API | Helm | Prometheus | Grafana | CoreDNS | Docker | .... |

Intel® Smart Edge Open Developer Experience Kit

Figure: Developer Experience Kit

A basic starting point for Edge Computing on Intel® Architecture platforms

Deploys required essentials for services:

- Resource management

- Accelerator support

- Container network interfaces

- Telemetry & monitoring

- Software Development Kits

5G Private Wireless Experience Kit

The Private Wireless Experience Kit provides:

- A single orchestration domain

- Optimizes the edge node to support 5G RAN, Applications, and 5G network functions, such as DU/CU, AMF, SMF, and UPF.

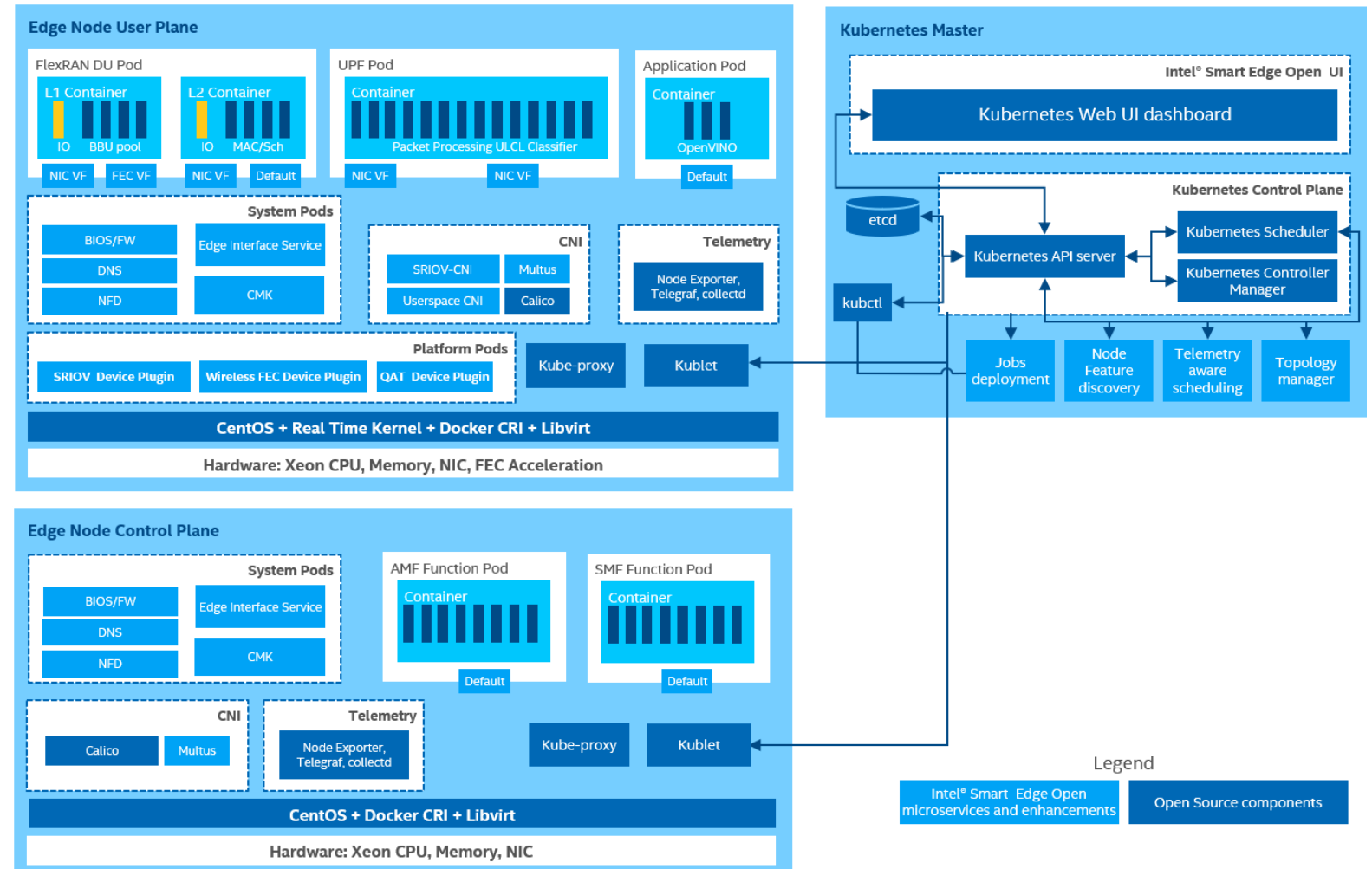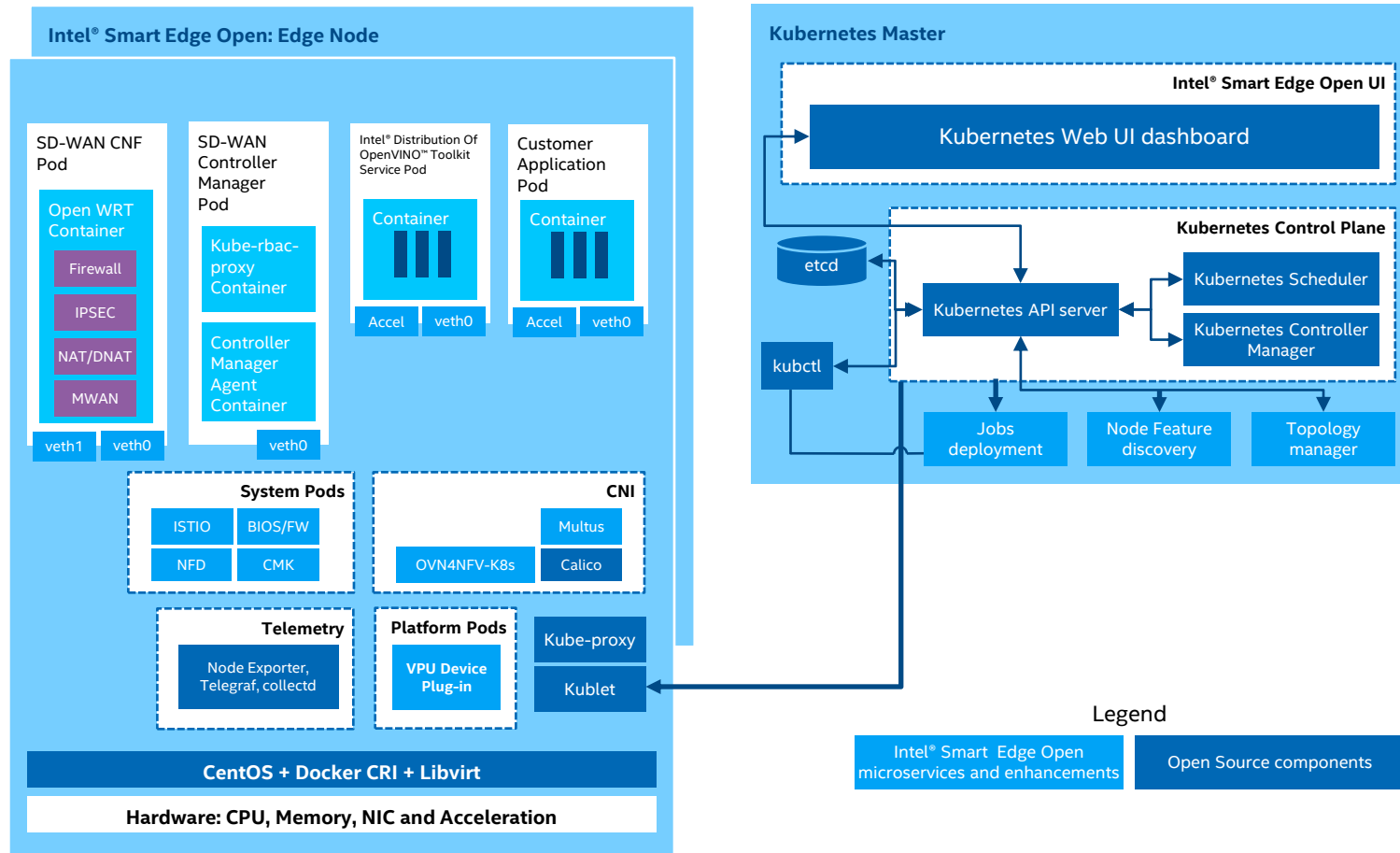Suitable for private 5G deployments – Factories, offices, Hospitals, etc.

Figure: 5G Private Wireless Experience Kit Architecture

Intel® Smart Edge Secure Access Service Edge Experience Kit: Edge Node

The Intel® Smart Edge Open Secure Access Service Edge Experience Kit:

- Provides a recipe for an open-source distributed Edge/POP architecture

- Leverages OpenWRT, CRD Controllers, OpenVINO™ toolkit, etc.

- Suitable for Enterprises, WFH network deployments, SD-WAN & u-CPE implementations

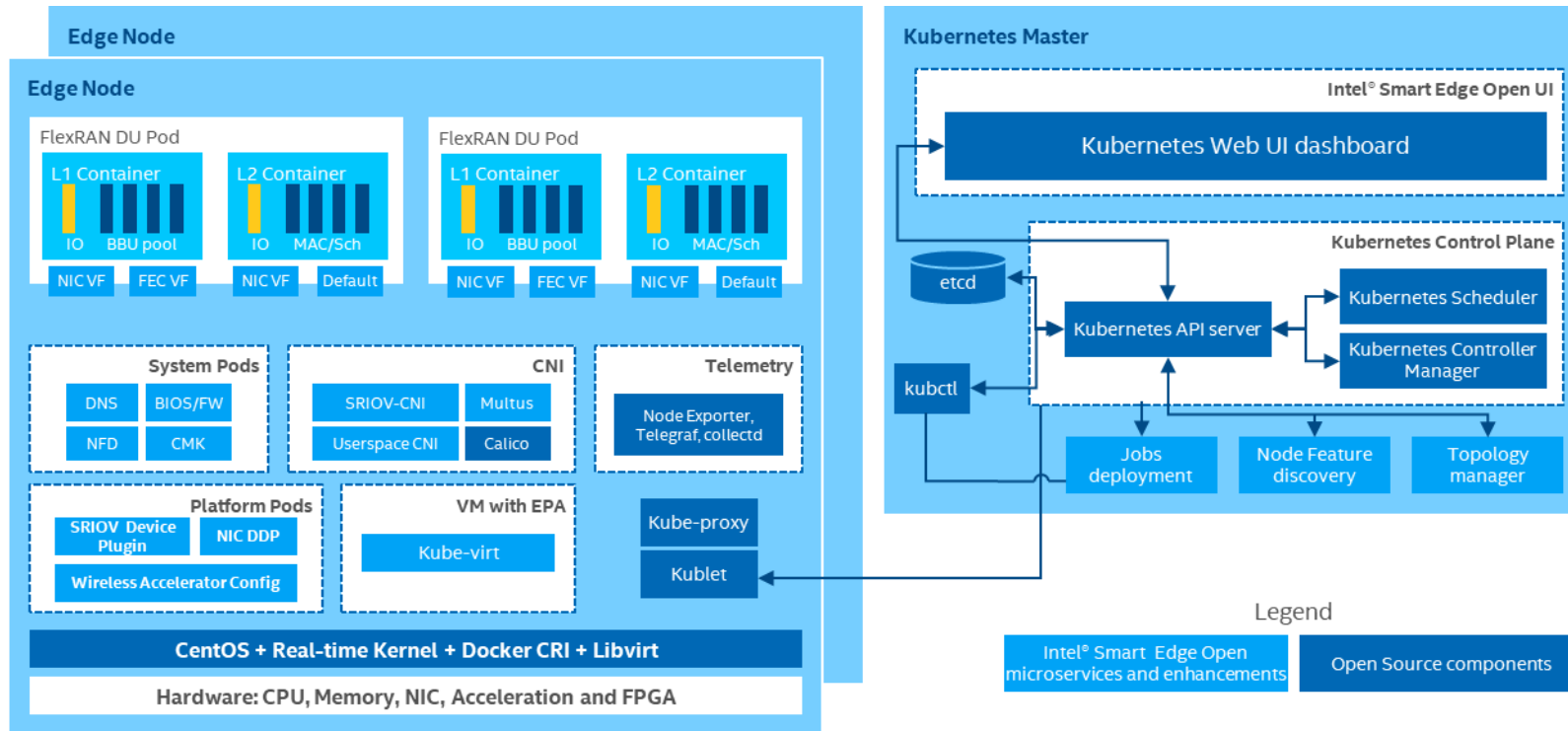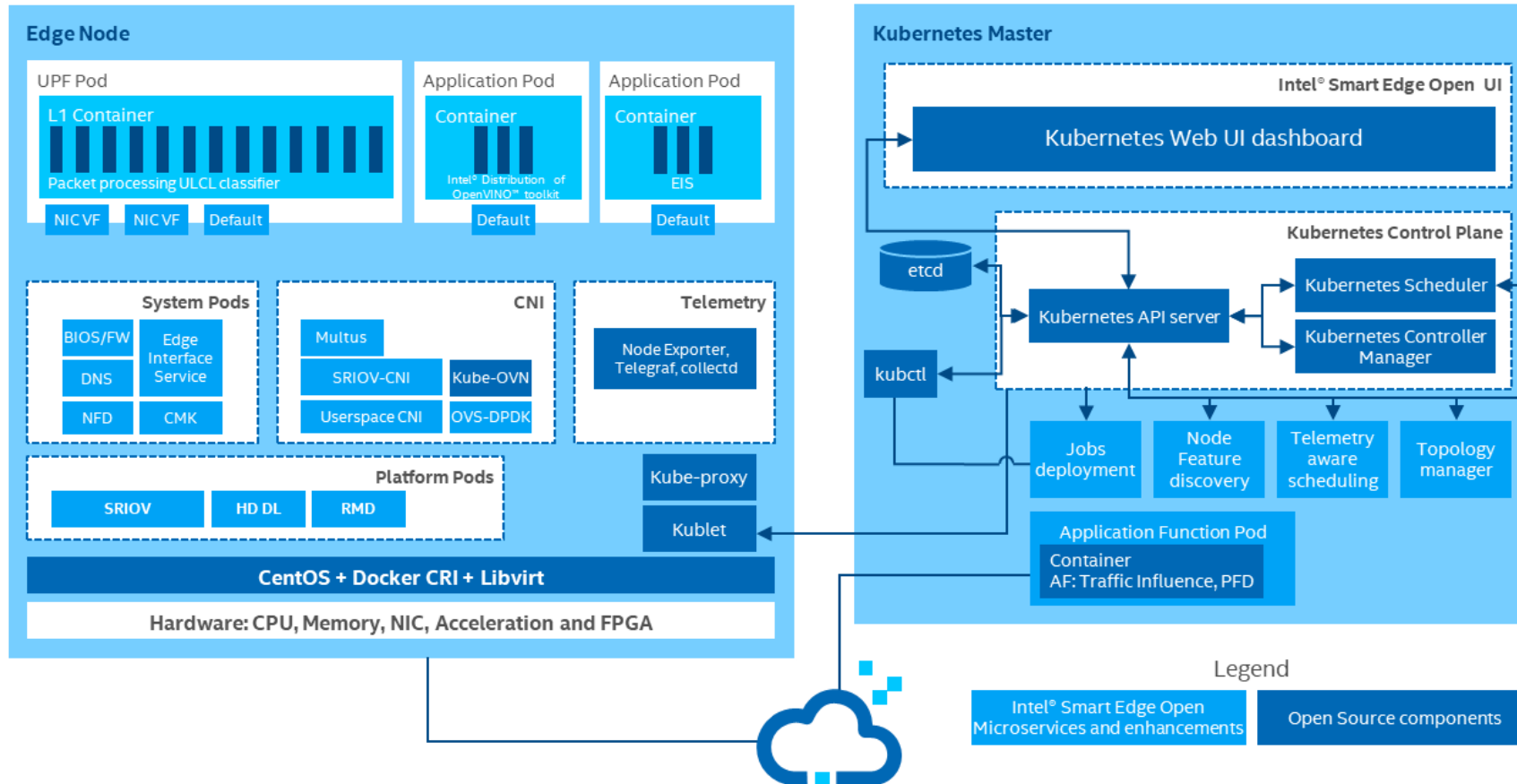# Intel® Smart Edge Open Access Edge Experience Kit

Figure: O-RAN DU Deployment Architecture

- Cloud native reference architecture for O-RAN DU

- Uses Intel® FlexRAN™ as reference for 4G/5G base stations

- Intel® FlexRAN™ offers high-density baseband pooling that could run on a distributed Telco cloud to provide a smart indoor coverage solution and next-generation fronthaul architecture

- Support for determinism (IO, Platform, Acceleration, Orchestration)

Intel® Smart Edge Near Edge Experience Kit

The Intel® Smart Edge Open Near Edge Experience Kit focuses on network edge aggregation points, mini central office.

Presents a scalable solution across the near edge network scaling from a single edge node to a multi cluster deployment services many edge nodes
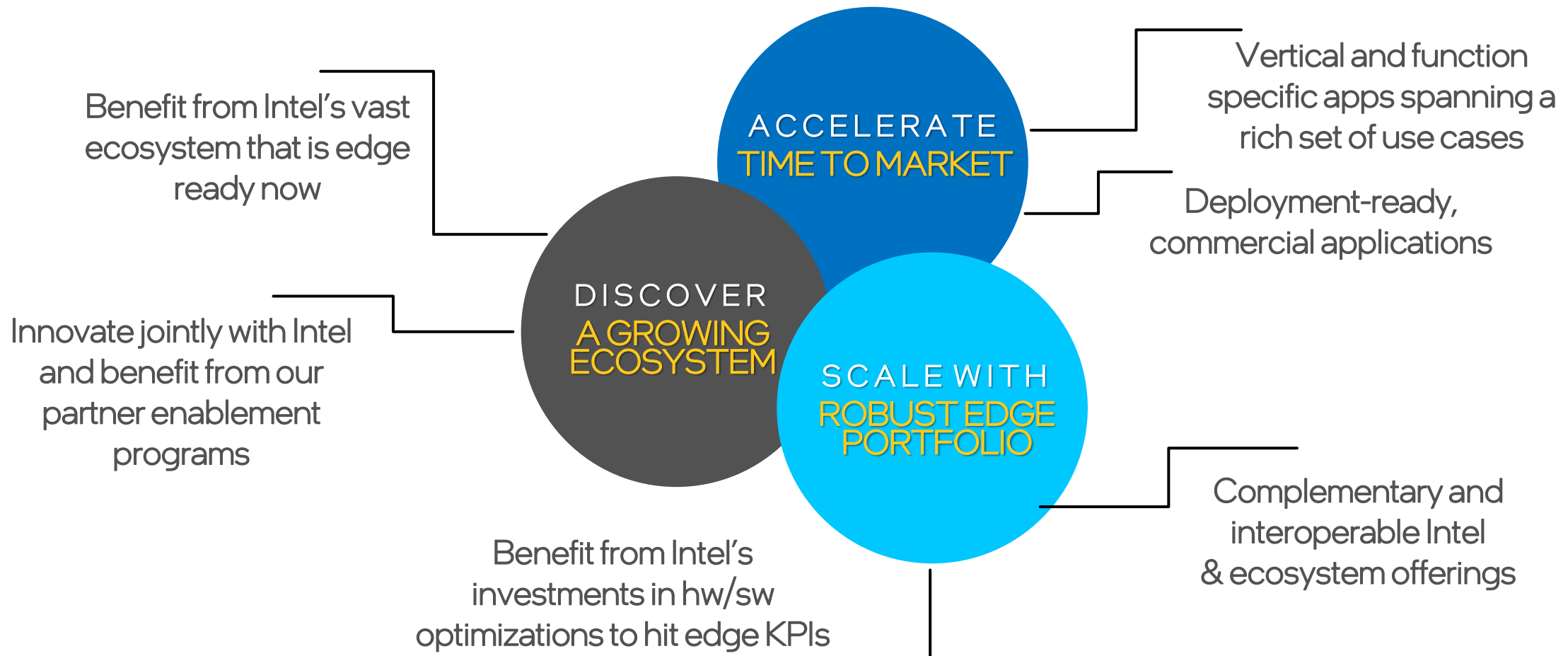
Reference Implementations

- Wireless Network Ready Intelligent Traffic Management

- Wireless Network Ready PCB defect detection

- Telehealth Remote monitoring

- Network Optimization and AI inferencing for Telepathology
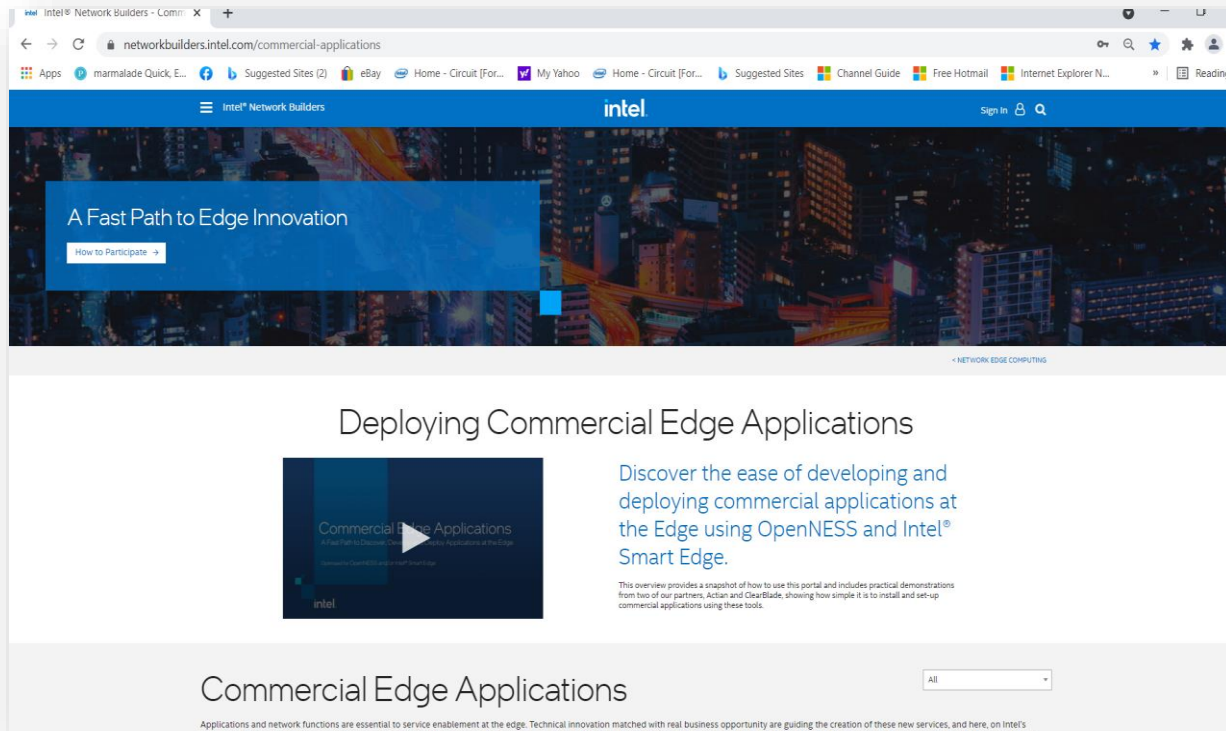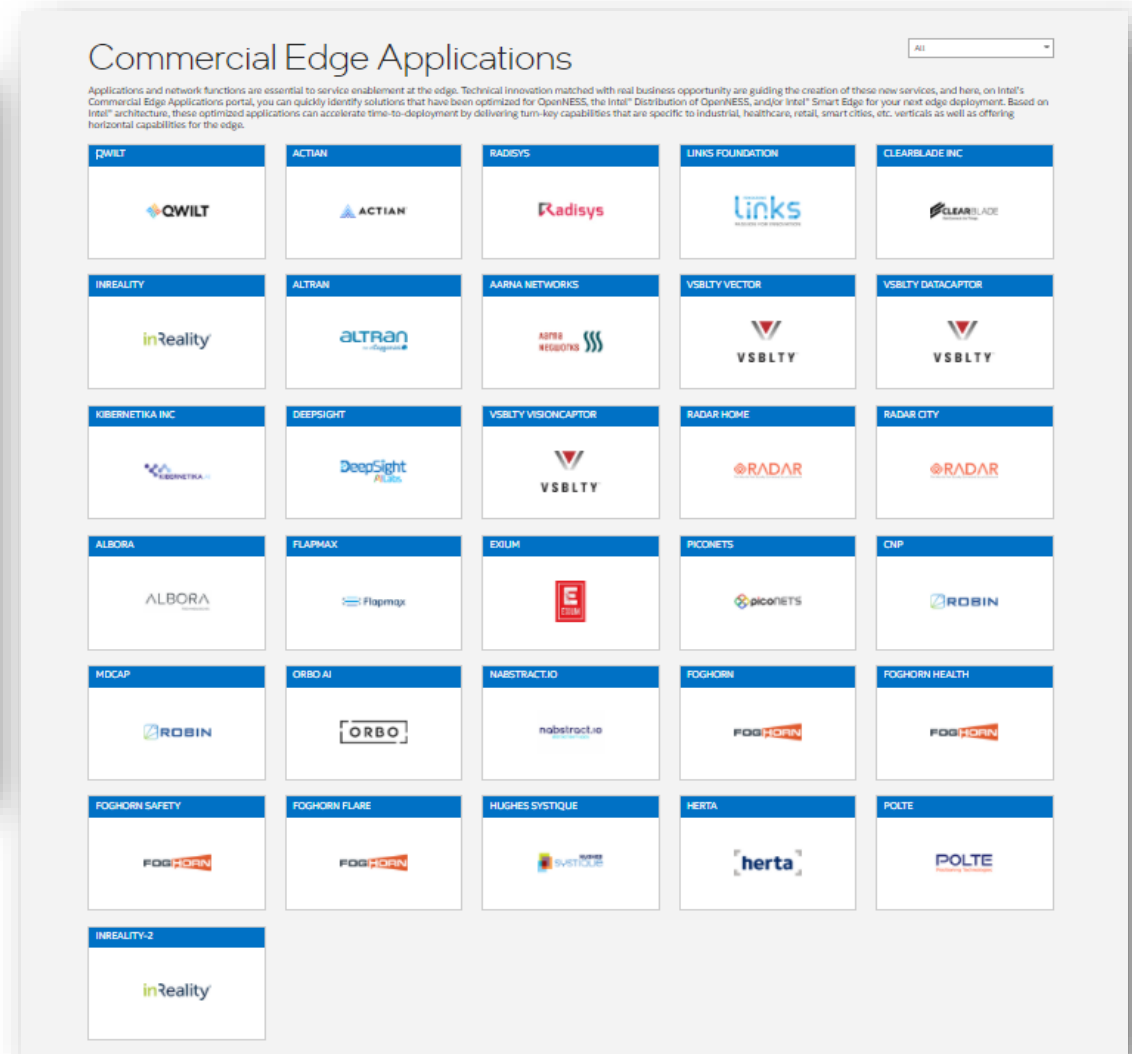
- Smart VR – Live Streaming of Immersive Media

* https://www.intel.com/content/www/us/en/edge-computing/edge-software-hub.html

A Portal for Commercial Edge Apps

A One-Stop Shop for Commercial Edge Applications Optimized for
Intel® Smart Edge Open   &   Intel® Smart Edge

ACCELERATE TIME TO MARKET

DISCOVER A GROWING ECOSYSTEM

SCALE WITH ROBUST EDGE PORTFOLIO

Benefit from Intel's vast ecosystem that is edge ready now

Innovate jointly with Intel and benefit from our partner enablement programs

Vertical and function specific apps spanning a rich set of use cases

Deployment-ready, commercial applications

Complementary and interoperable Intel & ecosystem offerings

Benefit from Intel's investments in hw/sw optimizations to hit edge KPIs

Commercial Apps Portal

https://networkbuilders.intel.com/commercial-applications

What Can You Do?

- What are your use cases?

- Try out Intel® Smart Edge Open Platform

- Expand on existing use cases

- Participation in Standards, Industry Consortia, Open-source software

- Open Collaboration

Questions?

Sunku Ranganath, Solutions Architect
sunku.ranganath@intel.com