The New Open ”Edge”

IOT+Telecom+Cloud+Enterprise

Presenter: Tina Tsou – Enterprise Architect, Arm. TSC Co-Chair, Akraino

Topics

1. LF Edge formation announcement
2. Why Edge, killer apps & defining the Edge
3. LF Edge Summary
4. Backup
   - Details of LF Edge Projects

LF Edge, Unifying Open Source Edge
IOT, Telco, Cloud, Enterprise

The Linux Foundation Launches New LF Edge to Establish a Unified Open Source Framework for the Edge

More than 60 global founding members across enterprise, IoT, telecom and cloud collaborate on open source framework for edge computing and future of IoT

SAN FRANCISCO, January 24, 2019 – The Linux Foundation, the nonprofit organization enabling mass innovation through open source, today announced the launch of LF Edge, an umbrella organization to establish an open, interoperable framework for edge computing independent of hardware, silicon, cloud, or operating system. LF Edge is initially comprised of five projects that will support emerging edge applications in the area of non-traditional video and connected things that require lower latency, faster processing and mobility.

LF Edge includes **Akaino Edge Stack, EdgeX Foundry, and Open Glossary of Edge Computing,** formerly stand-alone projects at The Linux Foundation and new projects **EVE (Edge Virtualization Engine), Home Edge.**

Jan 2019

LF Edge Momentum continues with Project EVE seed code, project demonstrations at IOT World and new members

- *IOT OnPrem Edge Virtualization Engine seed code contributed by Zedada to LF Edge*
- *Four new members join existing community of 70+ LF Edge organizations*
- *LF Edge on Display at IoT World, with Akraino Edge Stack, EdgeX Foundry and Project EVE demonstrations*

SANTA CLARA, Calif. – IoT World – May 14, 2019 – LF Edge, an umbrella organization within the Linux Foundation that aims to establish an open, interoperable framework for edge computing independent of hardware, silicon, cloud, or operating system, today announced continued project momentum. Project Edge Virtualization Engine (EVE) receives initial seed code from LF Edge founding member ZEDEDA, as the community showcases a range of edge/IoT application demonstrations, from connected cars to wind turbines, on-site at IoT World.

Additionally, LF Edge welcomes new Associate and Liaison member organizations Industrial Internet Consortium (IIC), the LIONS Center at the Pennsylvania State University, OTAinfo, and University of New Hampshire's Interoperability Lab (UNH-IOL).

May 2019

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LF EDGE

Why Edge and Defining the Edge

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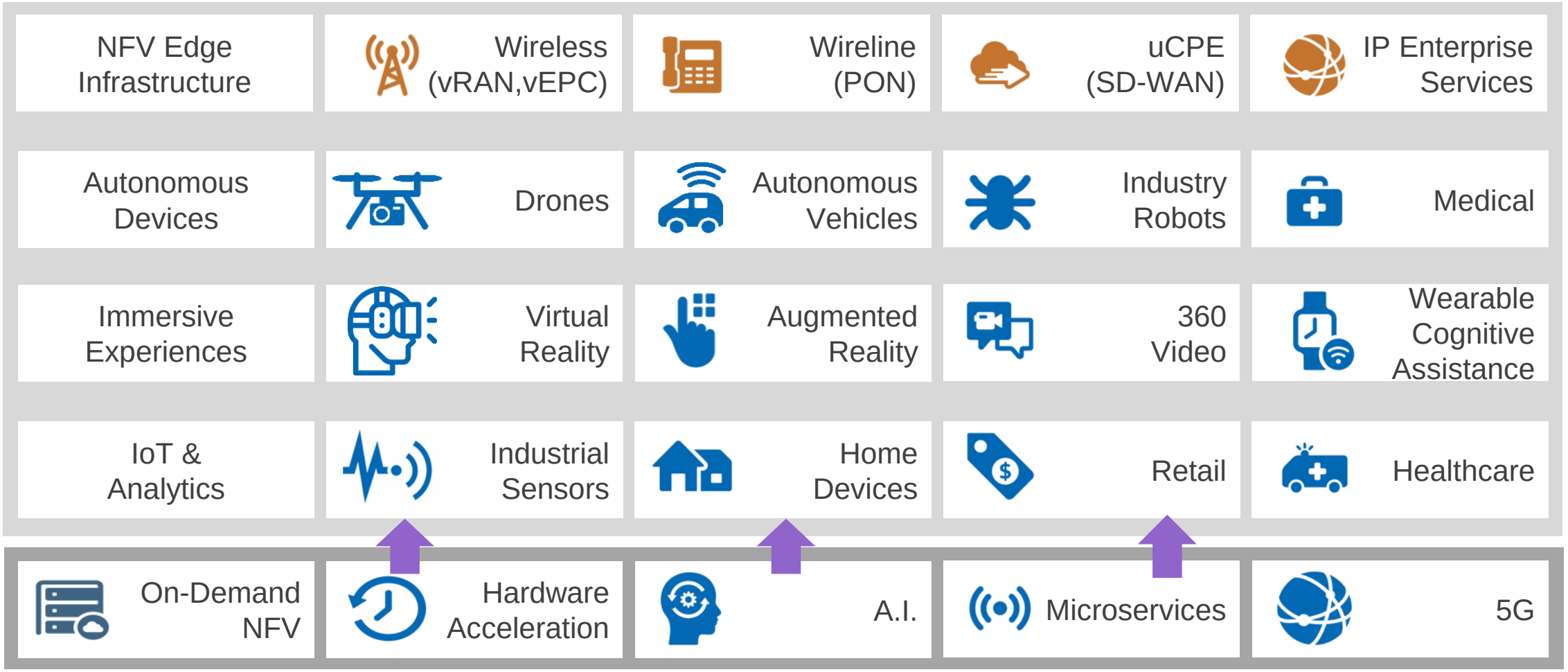
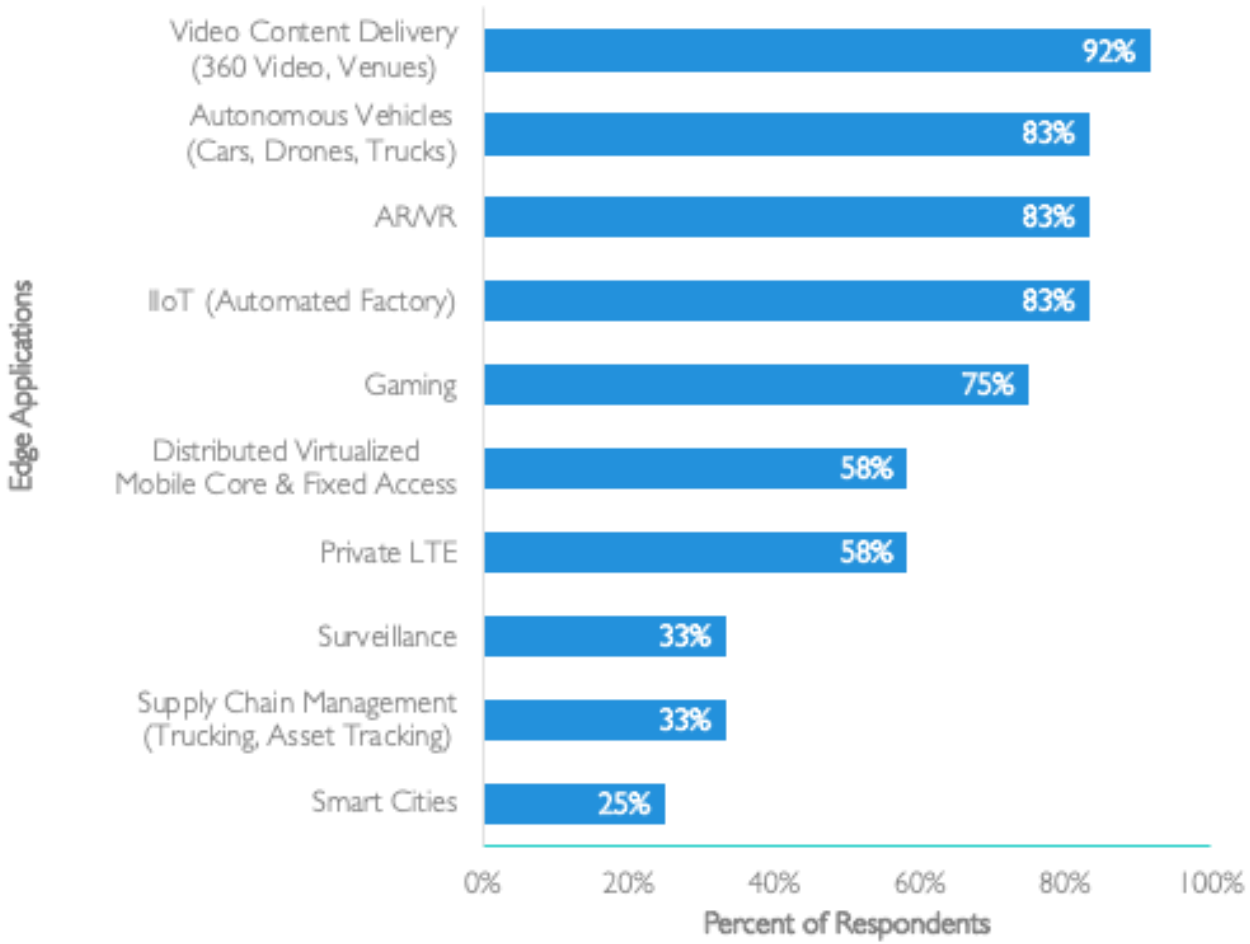
Emerging Edge Applications & Convergence of Technologies

are demanding & fueling lower latency + accelerated processing



Edge Killer Apps: Non-traditional video + Connected things that move

Q: What are the top 5 (or more) edge services?



- Many metro IX locations within 20ms of parts of populations…
- Telcos have advantage of COs, cell sites, cell backhaul aggregation, fixed backhaul, street cabinets, etc. much closer to users
- Edge enhanced apps include many elements: natural language, facial recognition, immersive experience, swarming
- Big (too much) bandwidth top driver
- Our categories are a grouping of several applications; can be user delivered

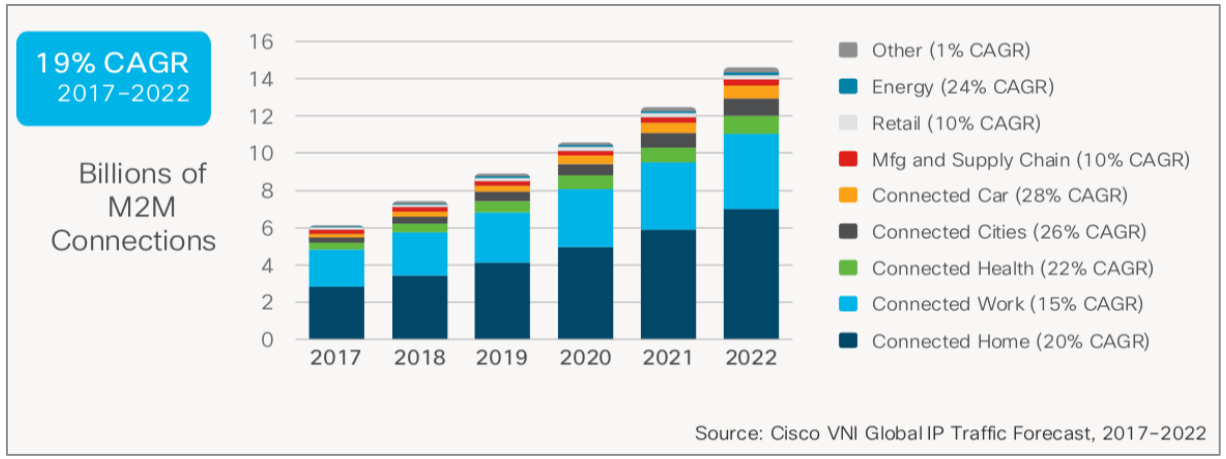
Source: IHS Markit. *NFV Strategies: Global Service Provider Survey*, June 2017*; Respondents control 61% of global telecom capex*

Market Opportunity for LF Edge

Industrial, Enterprise and Consumer use cases in complex environments spanning multiple edges and domains.

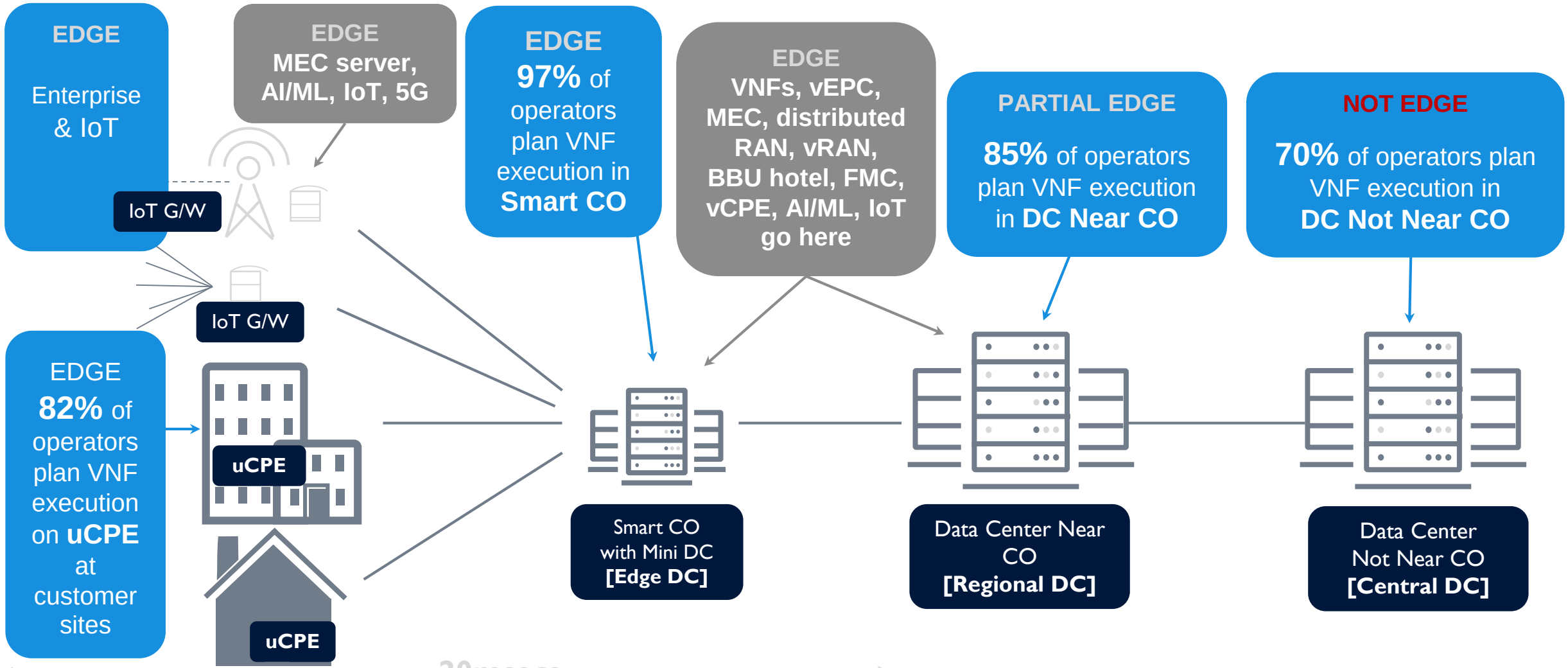
Examples:

- **Industrial Manufacturing**
- **Energy (Oil & Gas, Utilities)**
- **Commerce**
- **Homes (including B2B2C use cases)**
- **Automotive**
- **Fleet/Transportation**
- Logistics
- Building Automation
- Cities and Government
- Healthcare



Where are the edges?

Distributed cloud, edge compute, AI/ML, IoT, 5G, VNFs/NFV, FMC



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Source: IHS Markit. *NFV Strategies: Global Service Provider Survey*, June 2017; *Respondents control 61% of global telecom capex*

Introducing LF Edge

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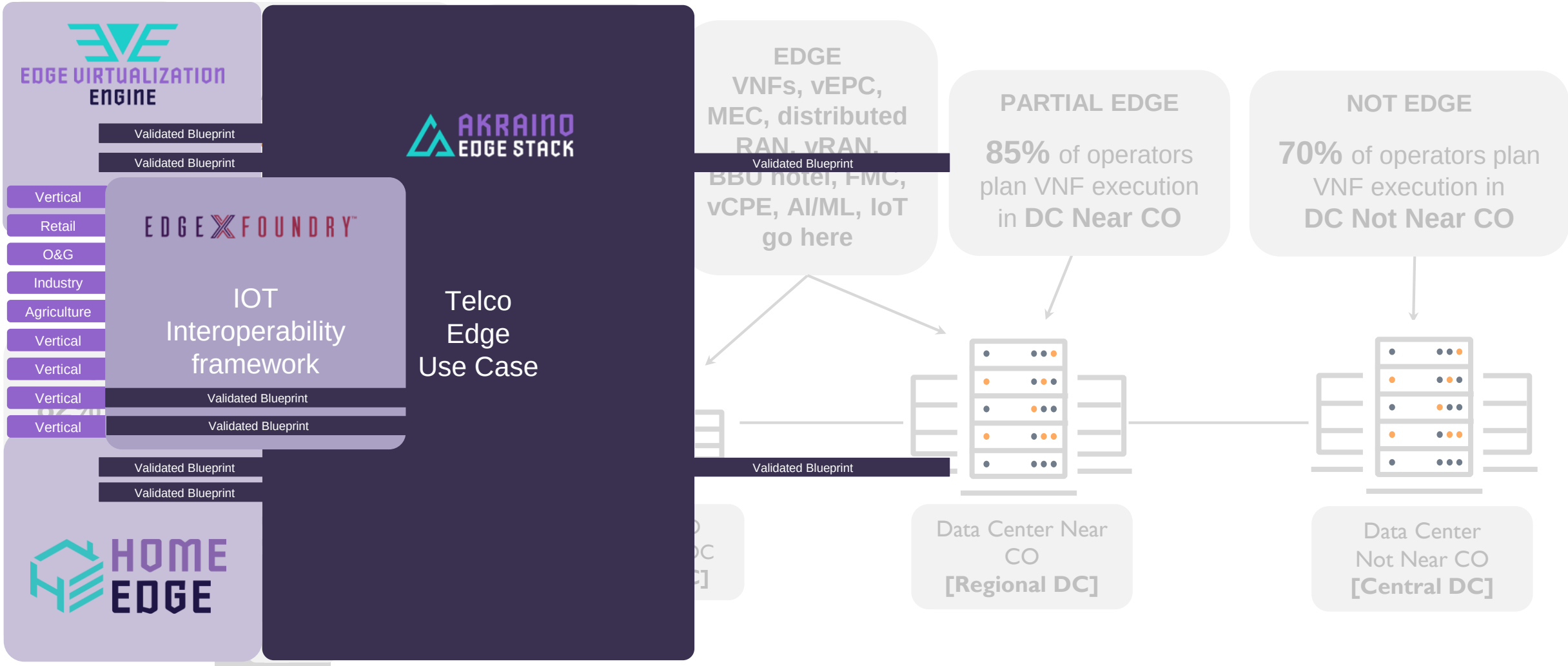
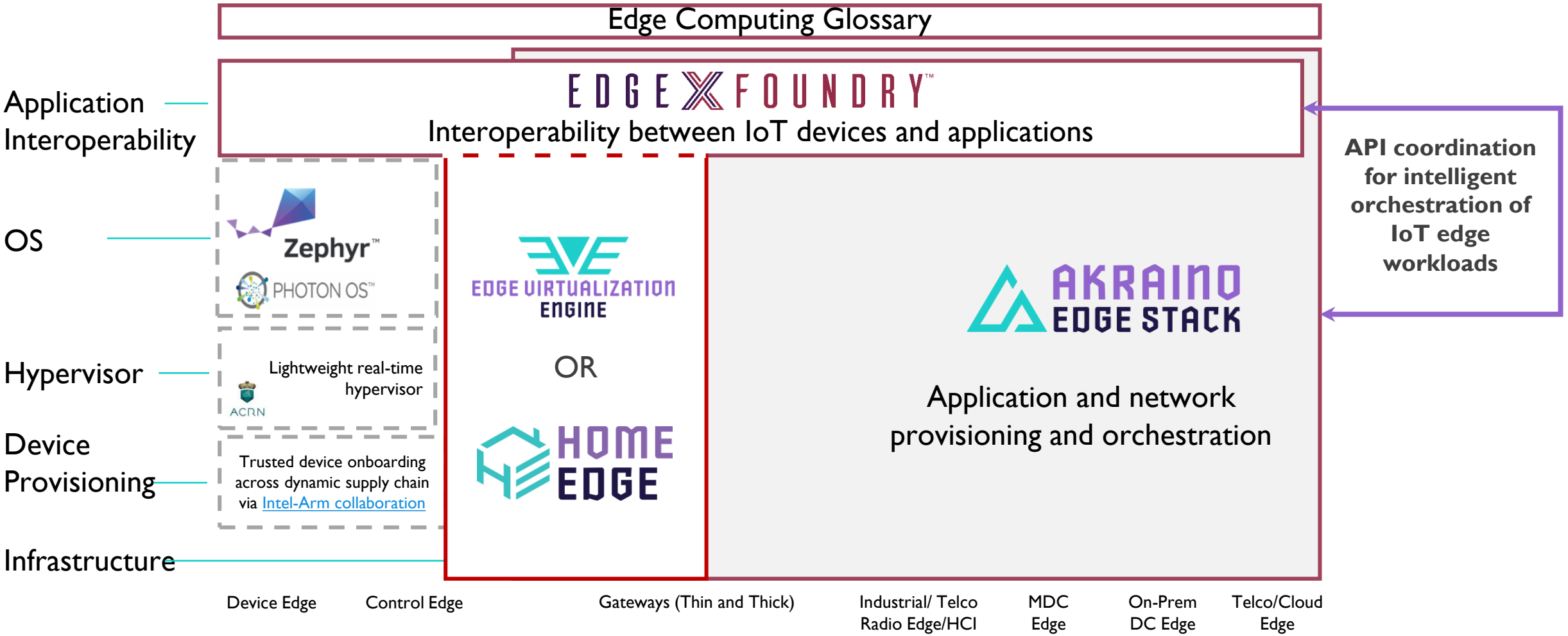
LF Anchor projects for Edge

Akraino and EdgeX Foundry are complementary open source projects addressing Telecom, Enterprise and IOT edge



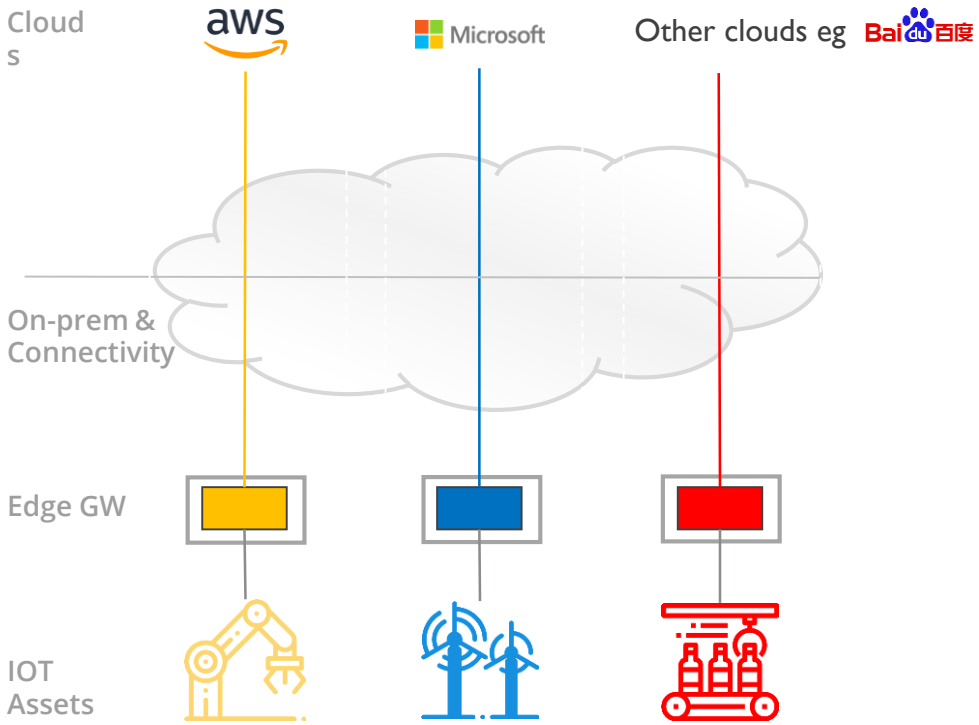
Scope of LF Edge



Open Source LF Edge

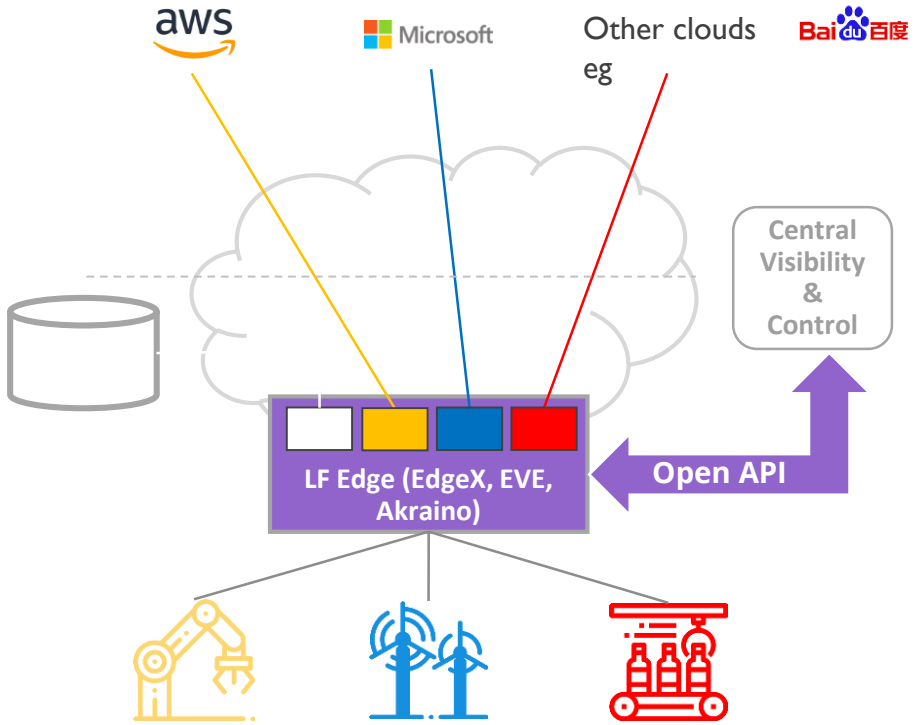
IIoT Today

Vertical data silos & platform lock-in
Data/edge sovereignty & control issues
Hardware-defined & unmanaged edge



IIoT with LF Edge

Open IoT data architecture, no lock-in
Data & edge belong to the enterprise
Software-defined & ubiquitous edge



LF Edge – New umbrella for Edge Projects

Drivers

- Complementary and aligned vision on multiple LF projects
- Fuels faster adoption and deployment
- Edge market is fragmented and creating a larger entity provides leadership

Projects

AKRAINO EDGE STACK

EDGE X FOUNDRY™

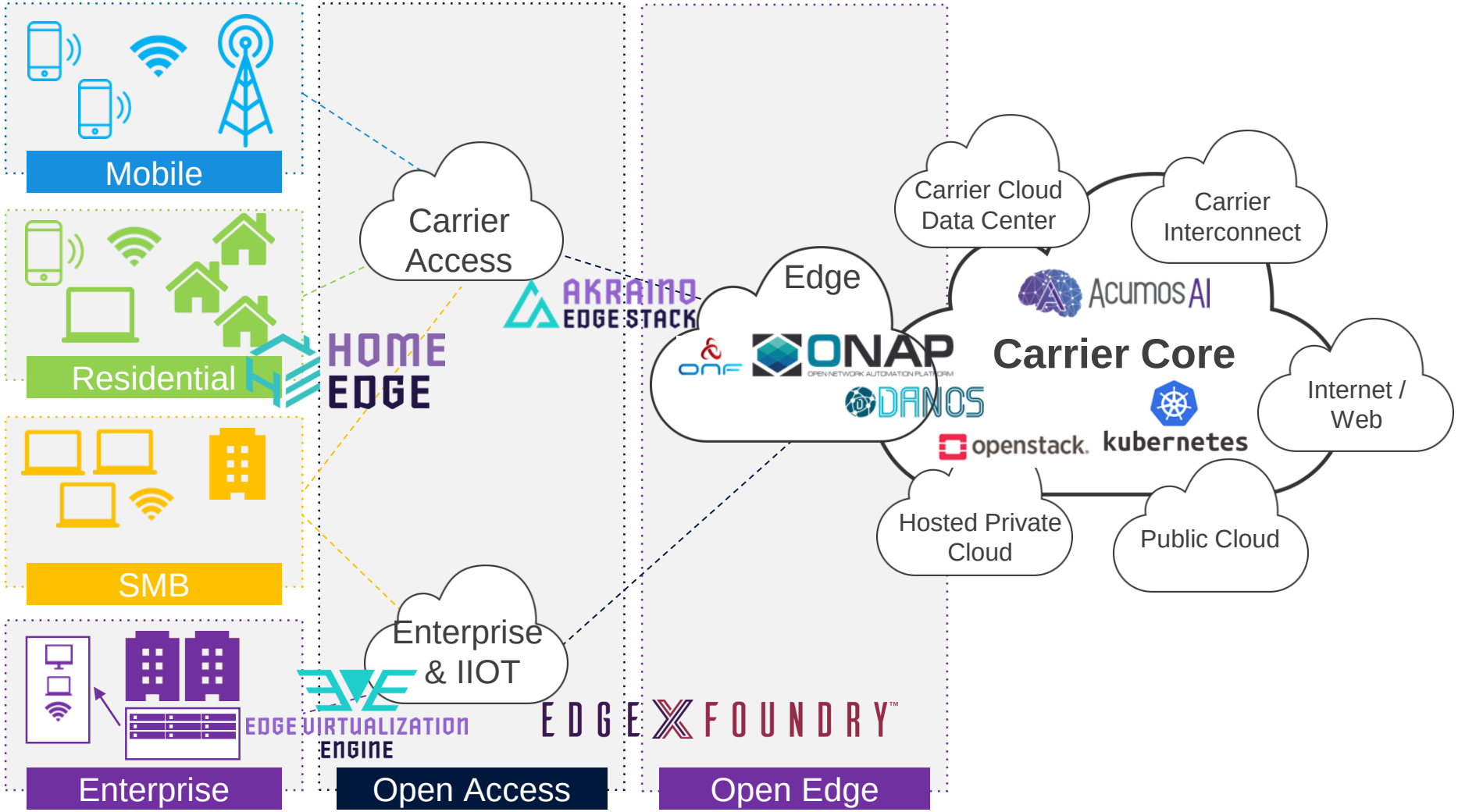
EDGE VIRTUALIZATION ENGINE

OPEN GLOSSARY OF EDGE COMPUTING

HOME EDGE

Bringing It All Together – LF Open Source Edge

With Complementary Standards, Ref Arch and Ref Implementations



Standards & Orgs for Edge

ETSI ISG MEC
World Class Standards

openEDGEcomputing

AECC
AUTOMOTIVE EDGE COMPUTING CONSORTIUM

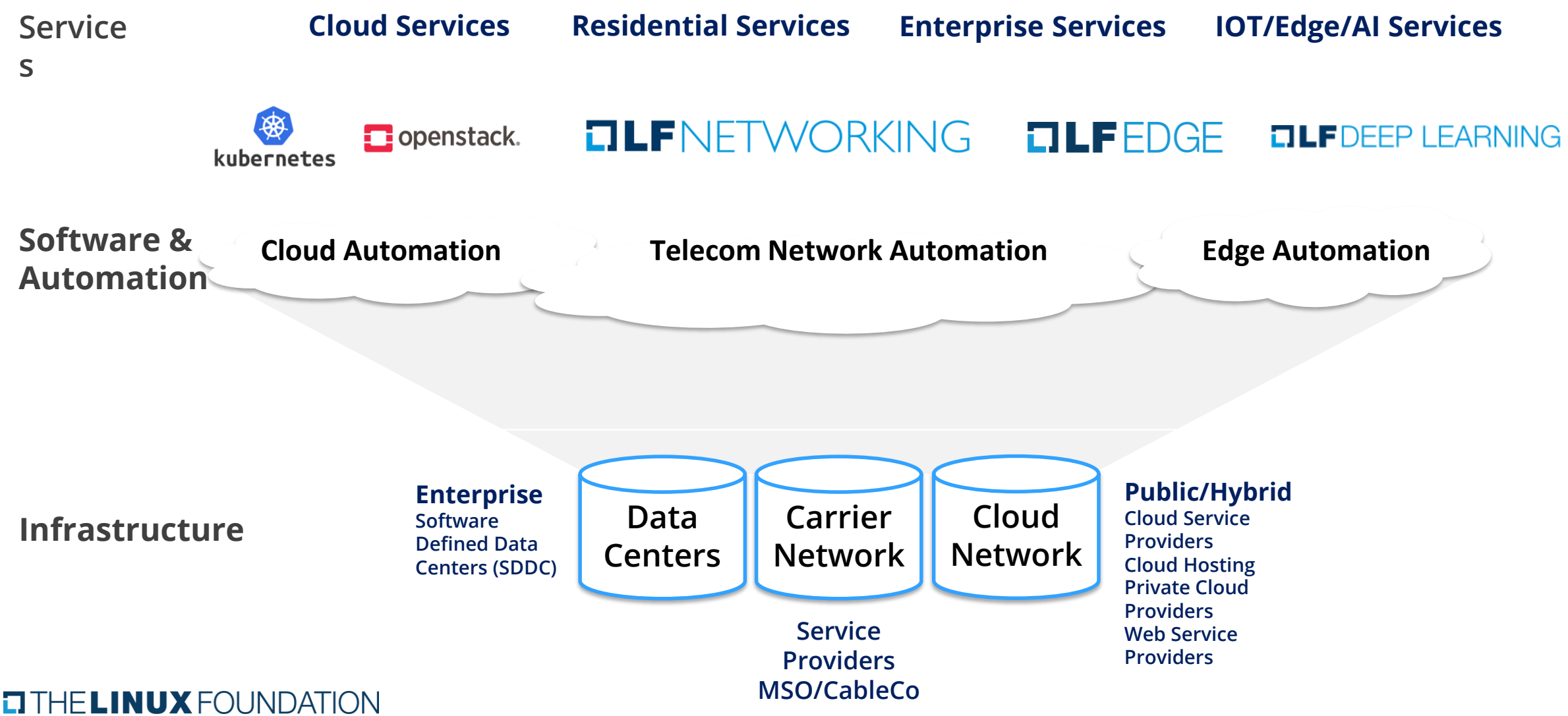
IoT Alliances & Consortiums

OpenFog

industrial internet CONSORTIUM

Other Edge Activities

Automating Cloud, Network & IOT/Edge Services



Premier Members

General Members

Associate Members and Liaisons

LF Edge: Key Takeaways

1. Harmonizing Open Source Edge Communities across IOT, Enterprise, Cloud & Telecom
2. Keeping LF Edge Open & Interoperable with
   - Hardware, Silicon, Cloud, OS, Protocol independence
   - Bringing the best of telecom, cloud and enterprise – location, latency & mobility
   - In collaboration with Consortiums/SDO (IIC, AECC, OEC, ETSI)
3. Hosted by the Linux Foundation similar to other Open Source Communities like CNCF (Kubernetes), LF Networking (ONAP) and many more.

Projects

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Project Introduction: Akraino Edge Stack

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Akraino Edge Stack Overview

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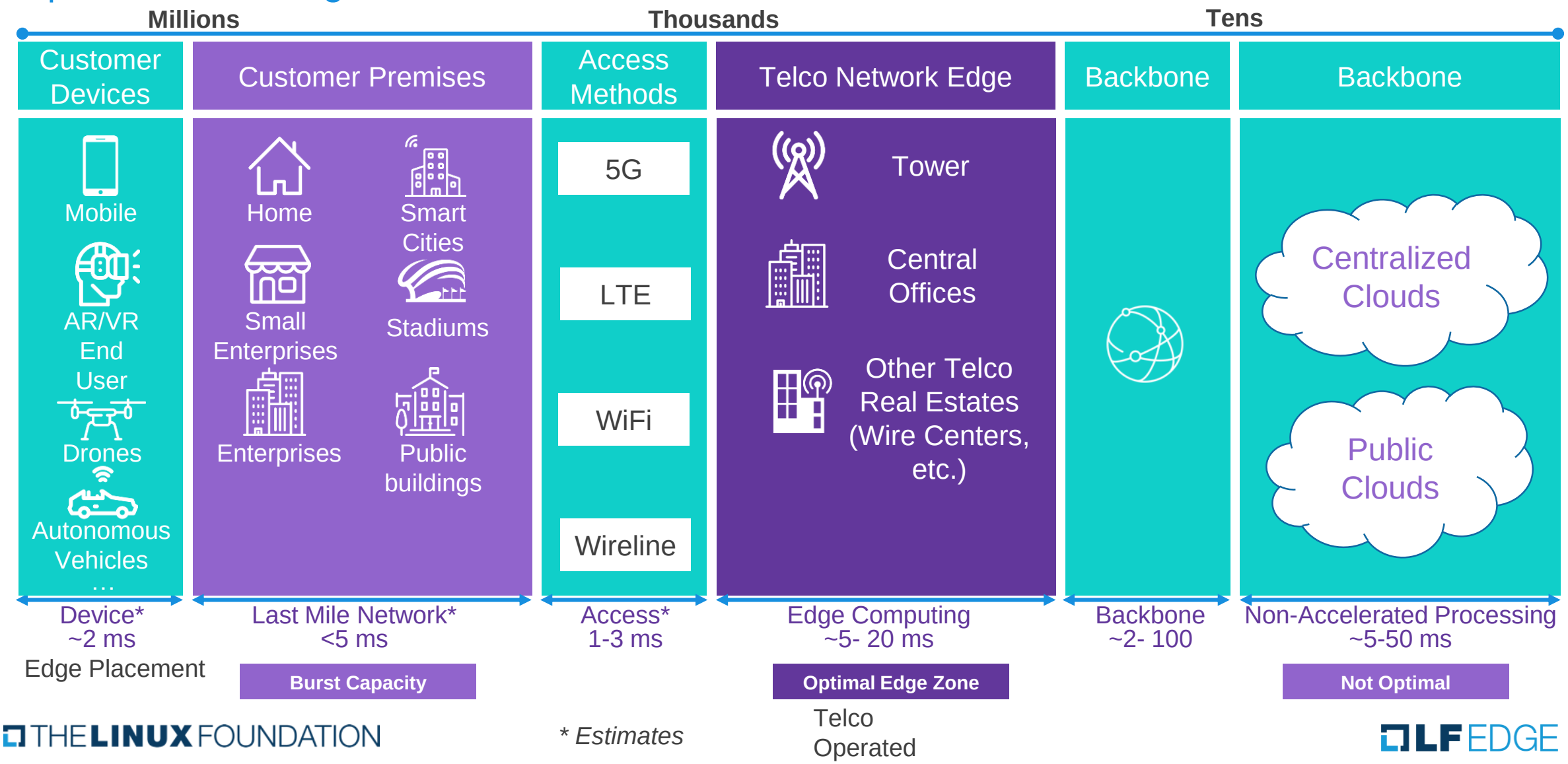
Use Case 1: Operator's Owned Network Edge

Optimal Zone For Edge Placement

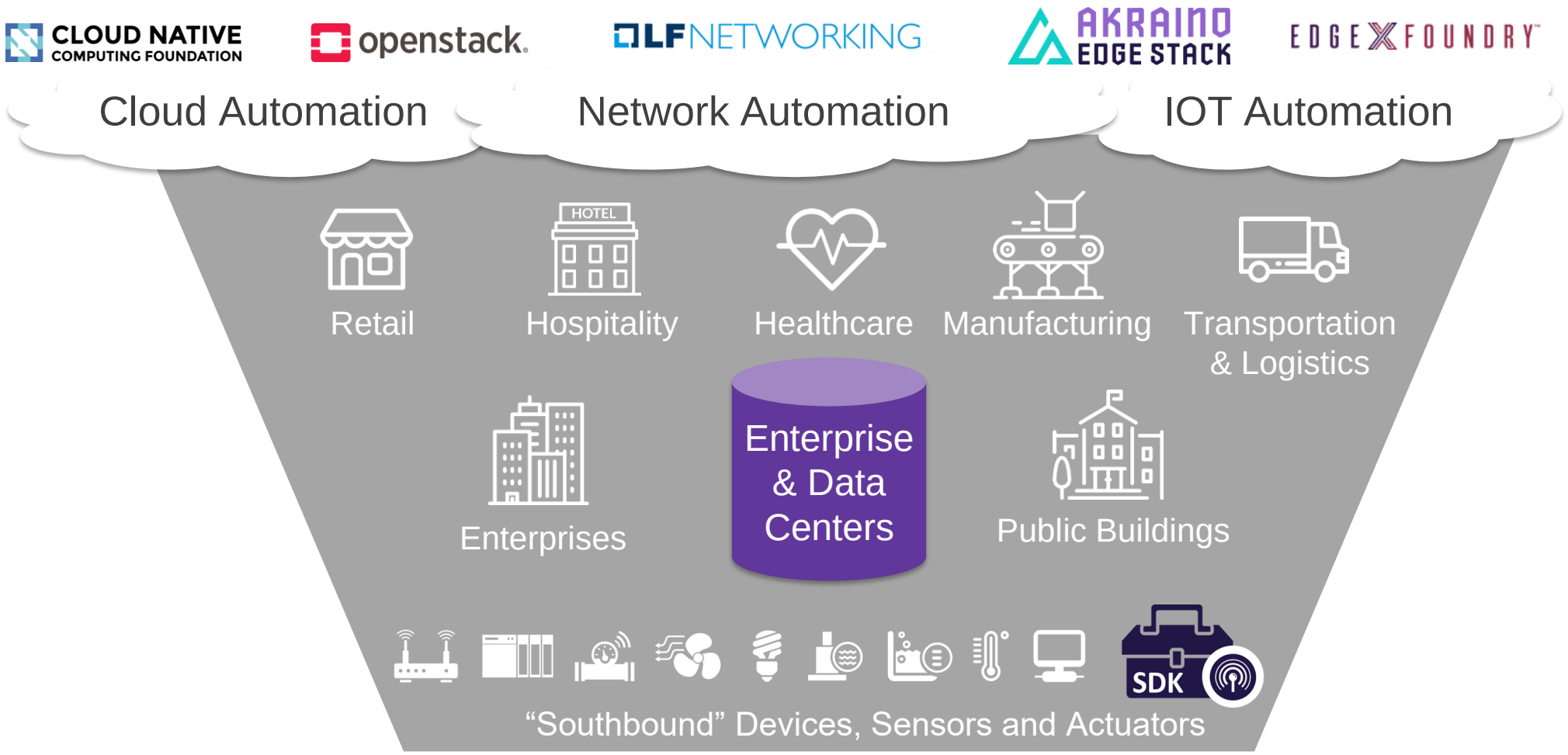


* *Estimates*

Telco Operated

Use Case 2: IOT Driving the New Edge for Enterprise

Retail, Transportation, Healthcare…



Akraino Executive Summary

AKRAINO EDGE STACK

Zero Touch
Edge Cloud
Automation

Akraino is an Edge project targeted to

› Address Telco, Enterprise and Industrial IoT use cases

Mission:

1. Create end to end configuration for a particular Edge Use case which is complete, tested and production deployable meeting the use case characteristics {Integration Projects - Blueprints}

2. Develop projects to support such end to end configuration. Leverage upstream community work as much as possible to avoid duplication. {Feature Projects}

3. Work with broader edge communities to standardize edge APIs {Upstream Open Source Community Coordination - For example, Socialization, so community tools and Blueprints can interoperate. This work can be a combination of an upstream collaboration and development within the Akraino community [i.e. a feature project]}

1. Encourage Vendors and other communities to validate Edge applications and VNFs on top of Akraino blueprints {Validation Project - ensures the working of a Blueprint}

Akraino Release 1

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Akraino R1: Unifying the Edge

NEWS

Akraino Edge Stack Issues Premier Release, Sets Framework to Enable 5G, IoT Edge Application Ecosystem

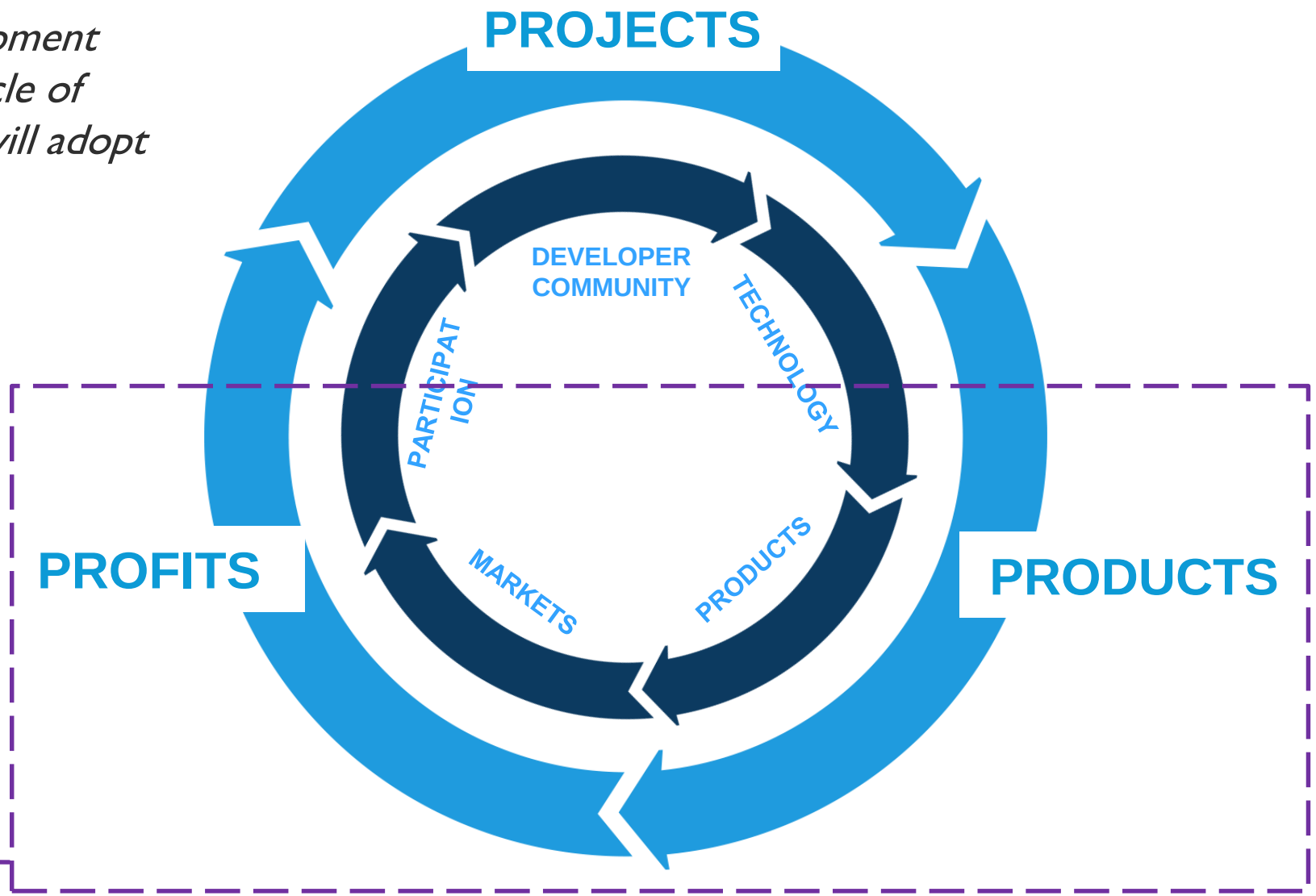
- *Inaugural release unifies multiple sectors of the edge across disciplines, including IoT, Enterprise, Telecom, and Cloud*
- *Delivers tested and validated deployment-ready blueprints*
- *Creates framework for defining and standardizing APIs across stacks, via upstream/downstream collaboration*

SAN FRANCISCO – **June 6, 2019** – LF Edge, an umbrella organization within the Linux Foundation that aims to establish an open, interoperable framework for edge computing independent of hardware, silicon, cloud, or operating system, today announced the availability of Akraino Edge Stack Release 1 ("Akraino R1"). Created via broad community collaboration, Akraino's premiere release unlocks the power of intelligent edge with deployable, self-certified blueprints for a diverse set of edge use cases.

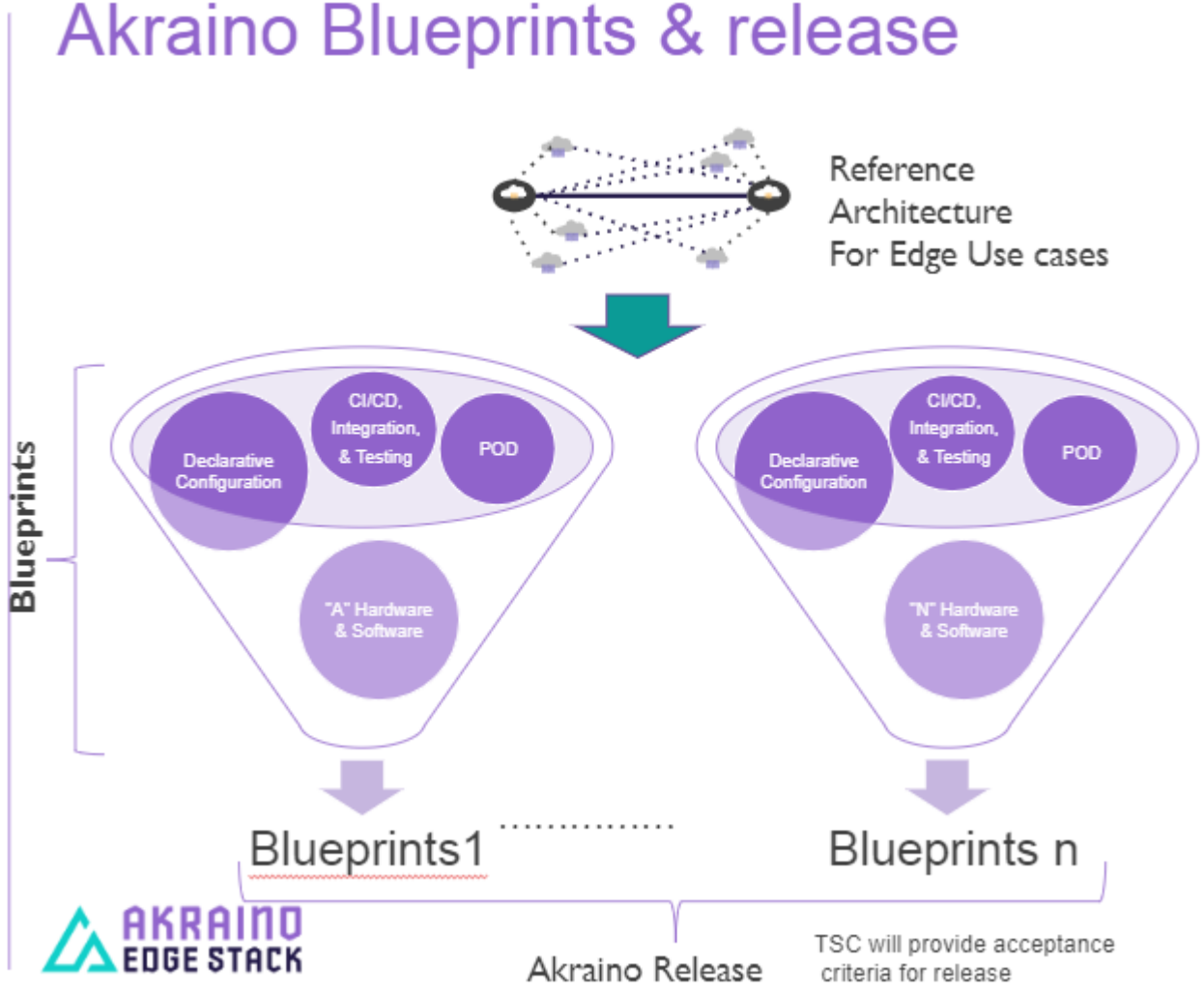
Role of Akraino Blueprints in Open Source Lifecycle

Successful Open Source Development depends on the complete life cycle of projects, products that market will adopt and deploy

- Akraino's blueprint model enables rapid transition from projects to PoC/deployment, cutting down integration time significantly.
- Blueprints augment Open Source Projects to address & accelerate Interoperability, Packaging, and Testing under Open and neutral governance.



Akraino R1: Tested & Validated Blueprints



- 11+ Blueprint families, 20 Blueprints under development
- Community-tested & validated on real hardware, Akraino Labs by members and community.

Blueprints - approved & tested declarative configuration based on use cases, set of hardware, POD & software

Reference Architecture - defines Akraino building blocks

Declarative Configuration - hides lower layer complexity to user

CI/CD, Integration & Testing Tools - drive product quality

Tested & Validated
Deployment-Ready Blueprints Details

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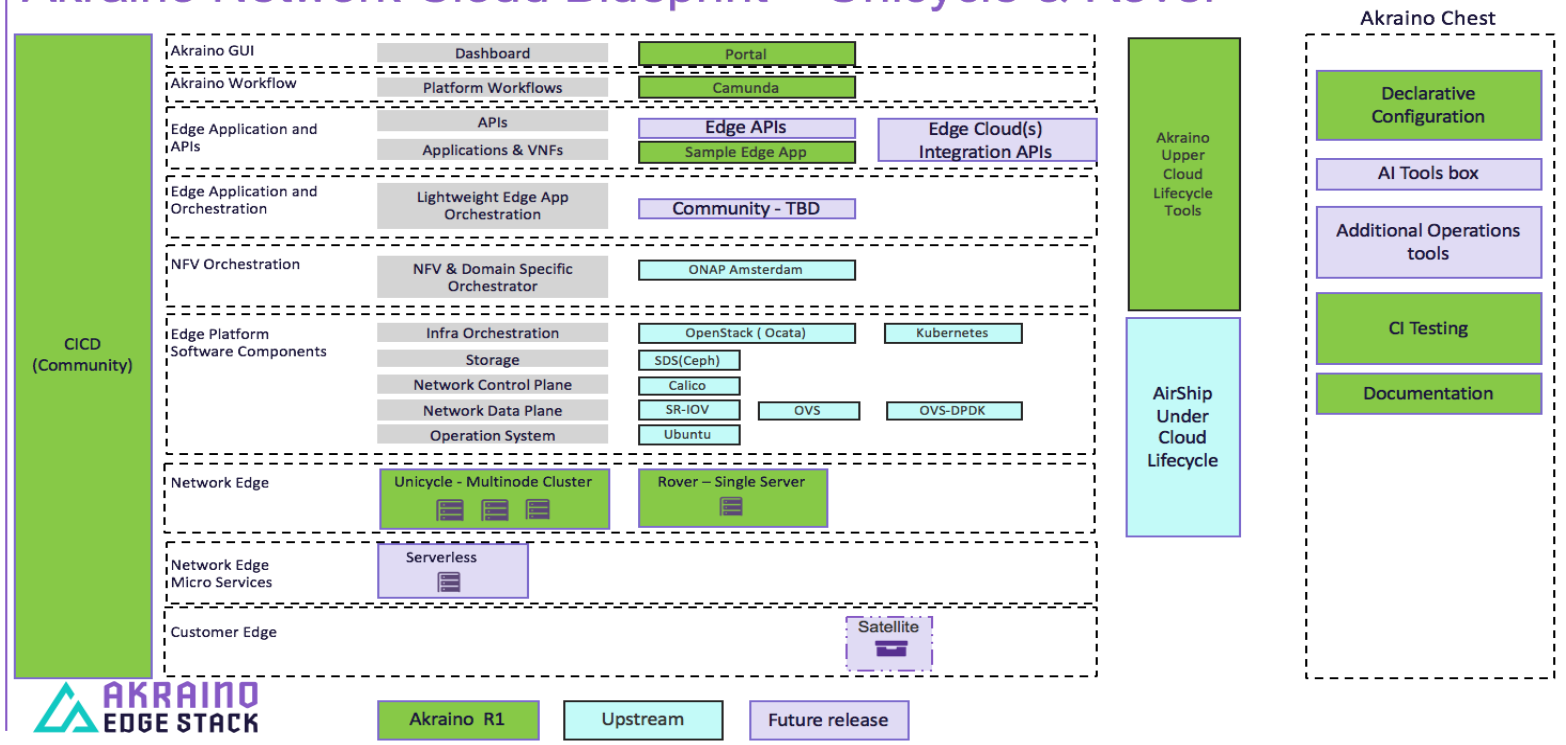
Akraino R1 Blueprints Details

Blueprint Family	Blueprint	Primary Use Case	Industry Target	Blueprint Summary
Network Cloud (NC)	Unicycle with SR-IOV	Telco Edge use cases (Multi Server). Multiple applications	Telco, Enterprise	NC blueprint family enables hardware configuration and automated deployment of telco grade multiple edge sites from a remote regional controller.
	Rover	Telco Edge use cases (Single Server). Multiple applications	Telco, Enterprise	
	Unicycle with OVS-DPDK	Telco Edge use cases (Multi Server). Multiple applications	Telco, Enterprise	
Telco Appliance	**Radio Edge Cloud (REC)**	Appliance for Radio Access Network (RAN), RAN Intelligent Controller and Near realtime Edge MEC Appliance	Telco 5G, Enterprise	Appliance tuned to support the O-RAN Alliance and O-RAN Software Community's Radio Access Network Intelligent Controller (RIC)
Integrated Edge Cloud (IEC)	Type 1 (small Edge)	Telco or enterprise application deployment on Arm servers	Telco, IOT and Enterprise	IEC enables the new functionalities and deployment model on the network edge. It supports ARM processors and architecture.
	Type 2 (Medium Edge)	Telco or enterprise application deployment on Arm servers	Telco, IOT and Enterprise	
StarlingX	**Far Edge Distributed Cloud**	Enterprise edge and Far edge. Multiple applications	Enterprise & IOT	Addresses edge and Far edge use cases at high density locations such as malls, airports and sports stadiums to support value added services at these events and locations.
Kubernetes- Native Infrastructure for Edge	**Provider Access Edge**	vRAN and MEC (AR/VR, Machine learning, etc.,)	Enterprise & Telco	Blueprints in the Kubernetes-Native Infrastructure for Edge family leverage the best-practices and tools from the Kubernetes community to declaratively and consistently manage edge computing stacks from the infrastructure up to the workloads.
Edge Lightweight and IOT blueprint (ELIOT)	IOT Gateway	IOT	IOT & Enterprise	ELIOT targets on making the edge node a lightweight software stack which can be deployed on limited hardware capacity.
	uCPE	uCPE	Enterprise & Telco	

Akraino R1 Blueprint: Network Cloud Family

Network Cloud Blueprints: Unicycle Rover + Unicycle SR-IOV

Akraino Network Cloud Blueprint – Unicycle & Rover



Purpose/Features

- Telco & Enterprise use cases like 5G and beyond
- Enables hardware configuration and fully automated deployment of multiple edge sites from a remote Regional Controller (vNF Workloads)
- Supports Unicycle with SR-IOV

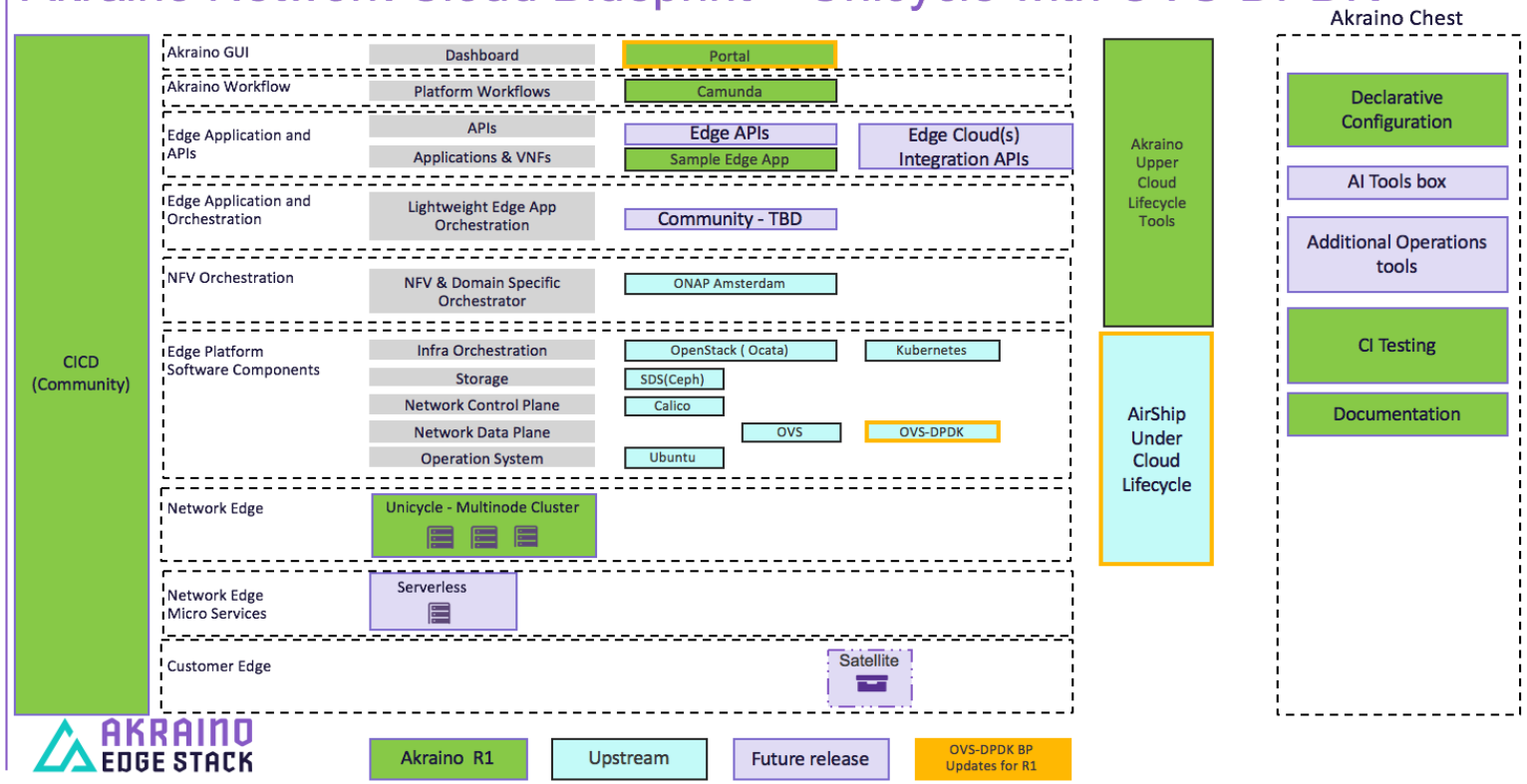
6/4/19

Target Industry : Telco, Enterprise

Akraino R1 Blueprint: Network Cloud Family

Network Cloud Blueprints: Unicycle OVS-DPDK

Akraino Network Cloud Blueprint – Unicycle with OVS-DPDK



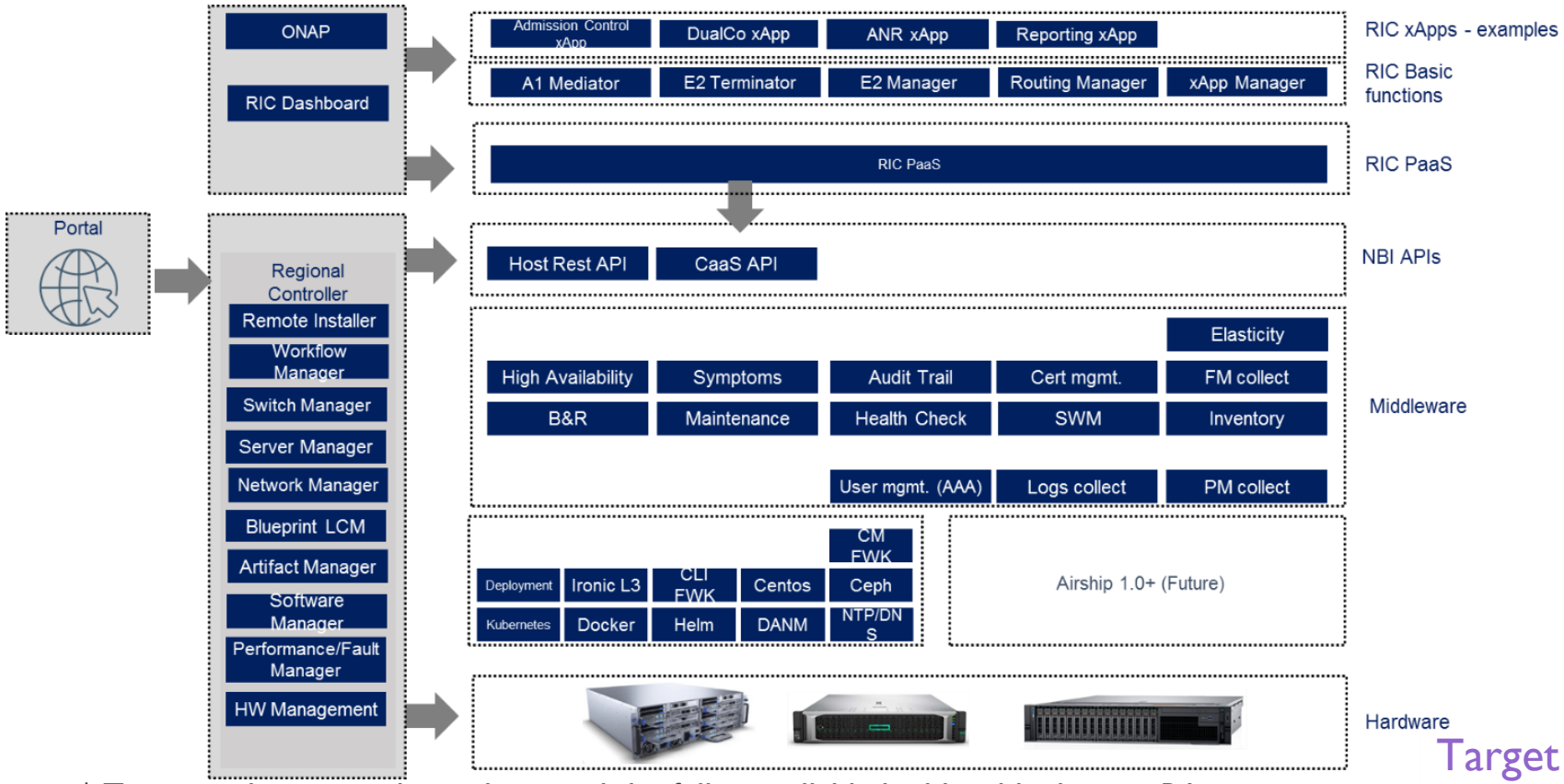
Purpose/Features

- Telco & Enterprise use cases like 5G and beyond
- Enables hardware configuration and fully automated deployment of multiple edge sites from a remote Regional Controller (vNF Workloads)
- Support for OVS-DPDK in Airship, Portal (GUI)

Target Industry : Telco, Enterprise

Akraino R1 Blueprint: Radio Edge Cloud

Radio Edge Cloud for 5G use cases



* Target architecture shown here and the fully installable building blocks is in R1

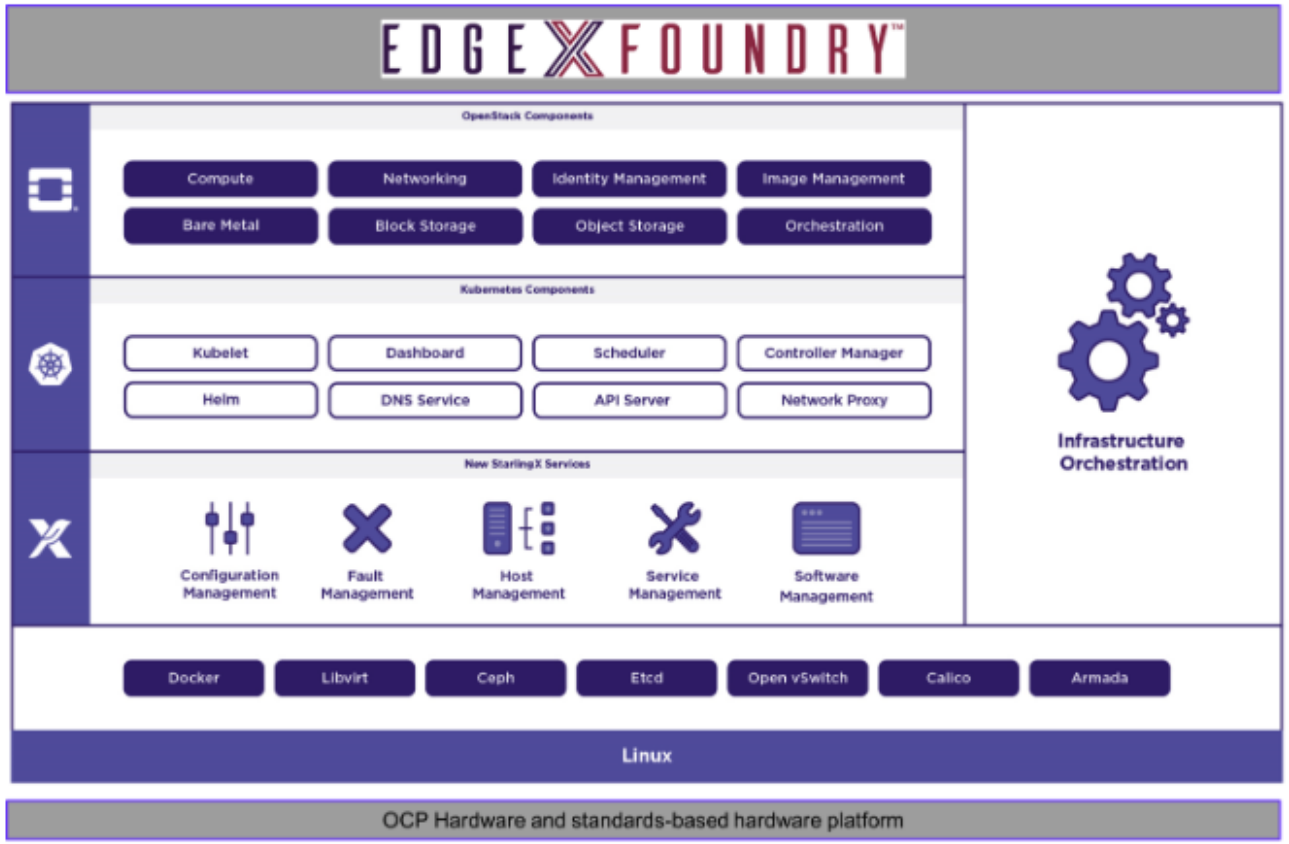
Purpose/Features

- Telco- grade edge cloud platform for near-real time container workloads.
- Integrated with open-source RAN Intelligent Controller (RIC) – helps deploy customized, tailored apps with Zero touch
- Automated CD pipeline testing the full software stack

Target Industry: Telco 5G, Enterprise

Akraino R1 Blueprint: Far Edge Cloud

StarlingX Far Edge Cloud



Purpose/Features

- Addresses Industrial Edge Use cases at high density locations such as malls, airports and sports stadiums to support value added services at these events and locations.
- Based on StarlingX hosted in OpenStack Foundation (upstream collaboration)
- Supports VMs and Containers.

Target Industry: Enterprise, IoT

Akraino R1 Blueprint: IOT & Remote Edge

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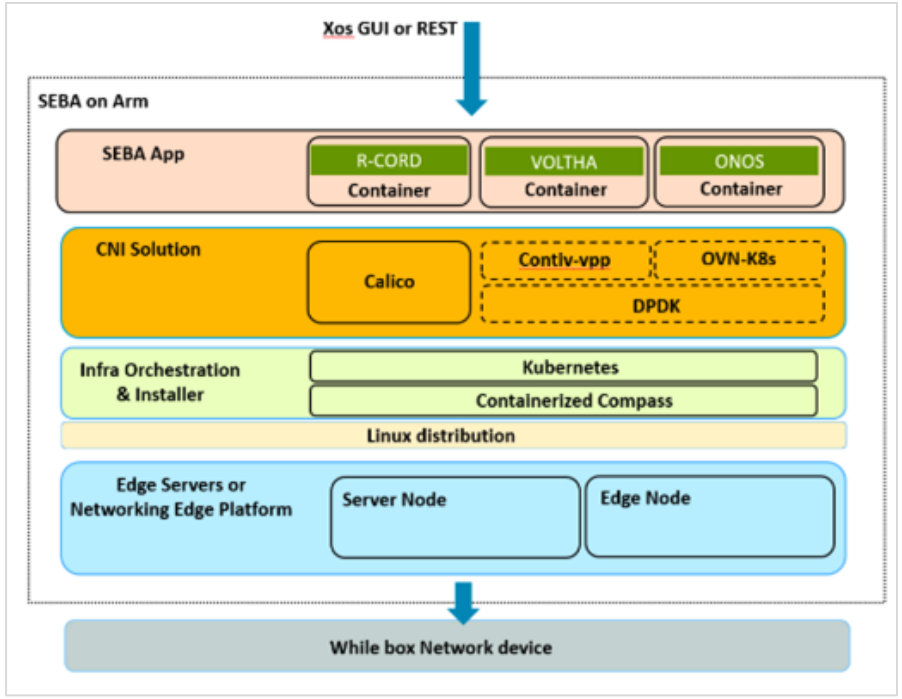
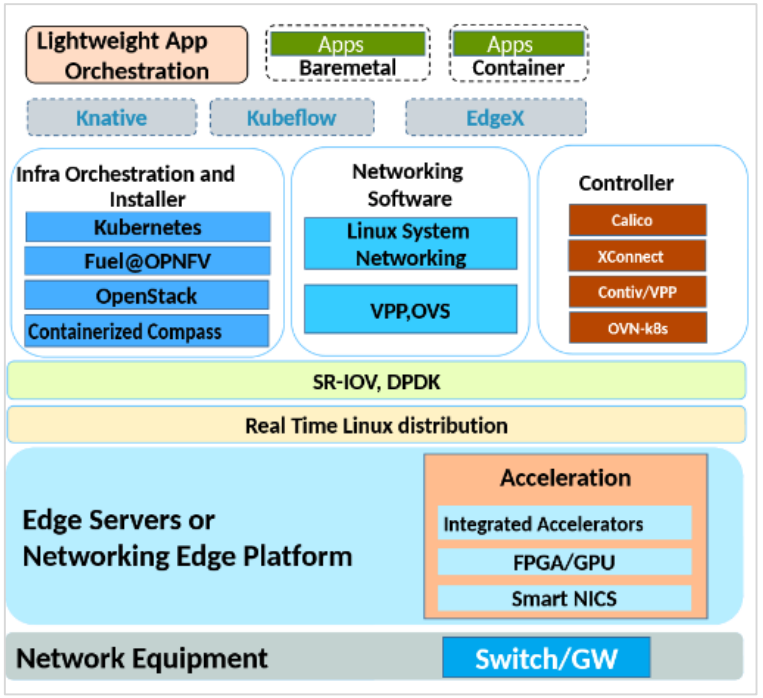
Integrated Edge Cloud



Type 1



Type 2

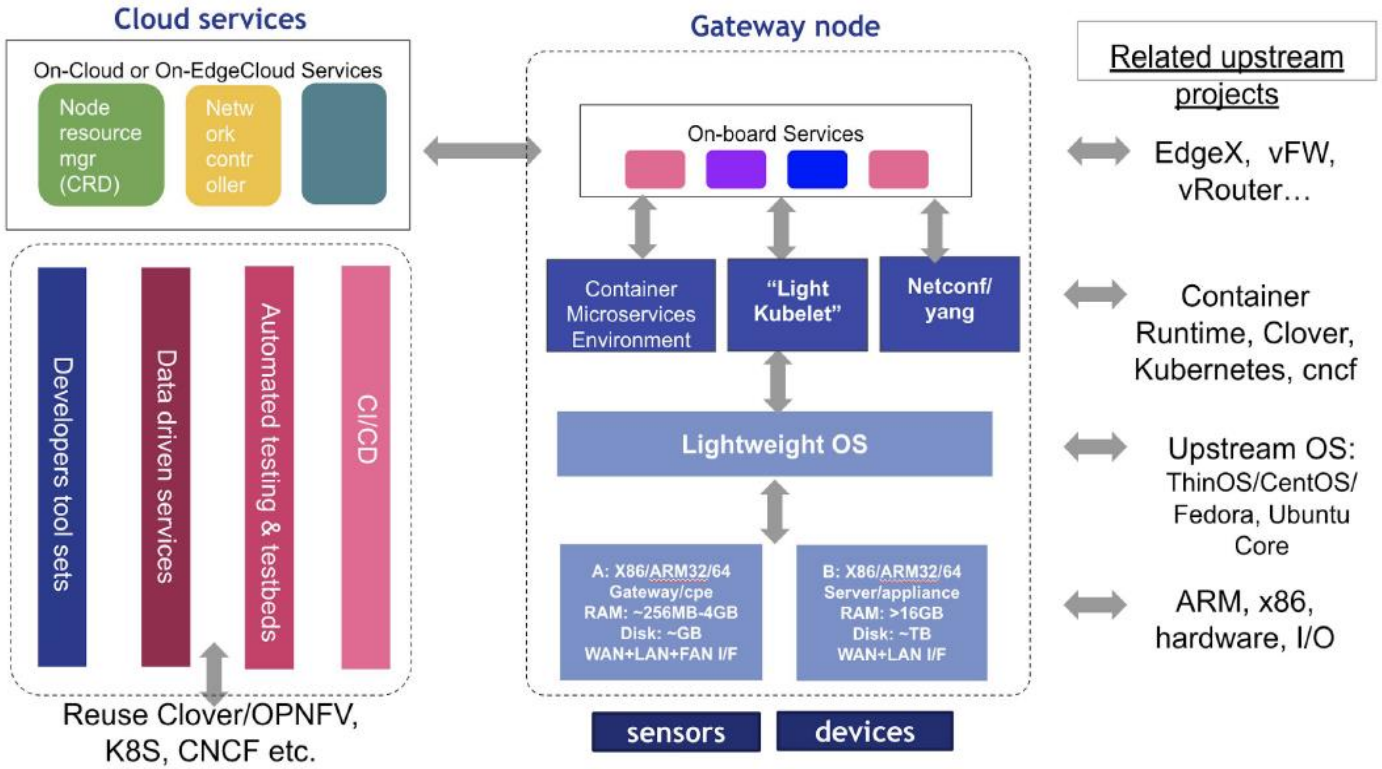
Purpose/Features

- Addresses IOT use cases
- Targets telco edge applications & medium edge cloud deployments with Arm, based on Kubernetes and Calico
- Automated installation, integrated with SDN-Enabled Broadband Access (SEBA) use case

Target Industry: Telco, IoT, Enterprise

Akraino R1 Blueprint: IOT & Far Edge

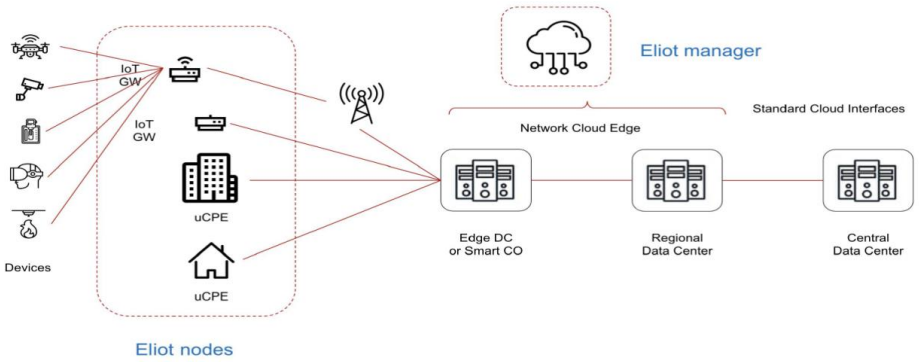
Edge Light & IoT (ELIOT)



Akraino lightweight blueprint – ELIOT - for Edge Lightweight and IoT

Purpose/Features

- Addresses IOT & Universal CPE use cases for IOT Appliances with thin OS and Orchestration
- Full CI/CD deployment ready and verified
- Video Analytics is one of IOT Gateway use case verified on this platform



Target Industry: IoT, Enterprise, Telco

Akraino R1 Blueprint: Provider Access Edge

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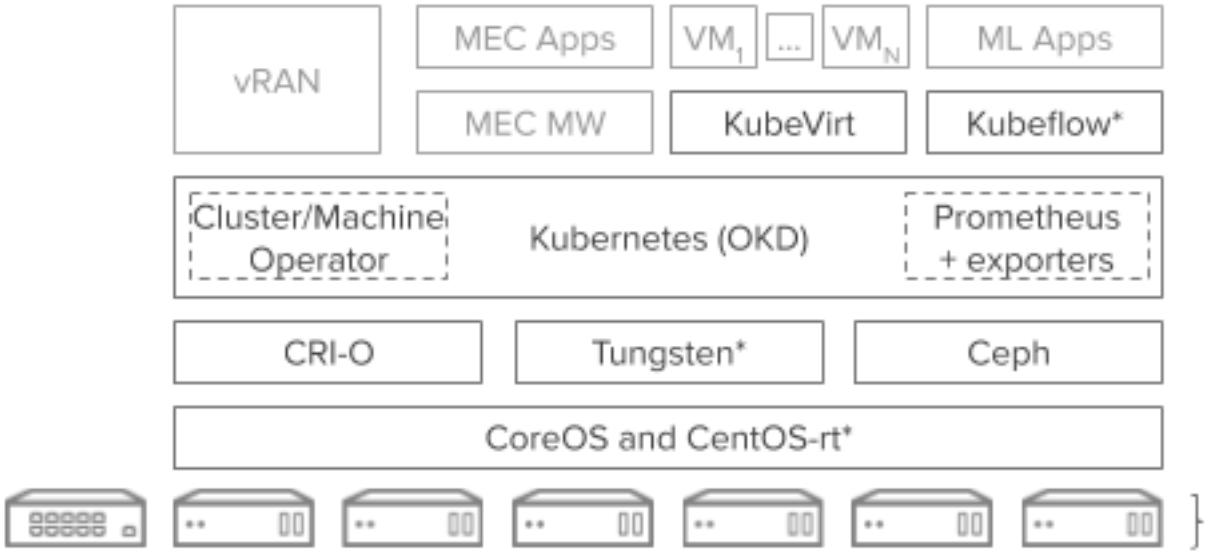
Kubernetes Native Infrastructure for Industrial Automation

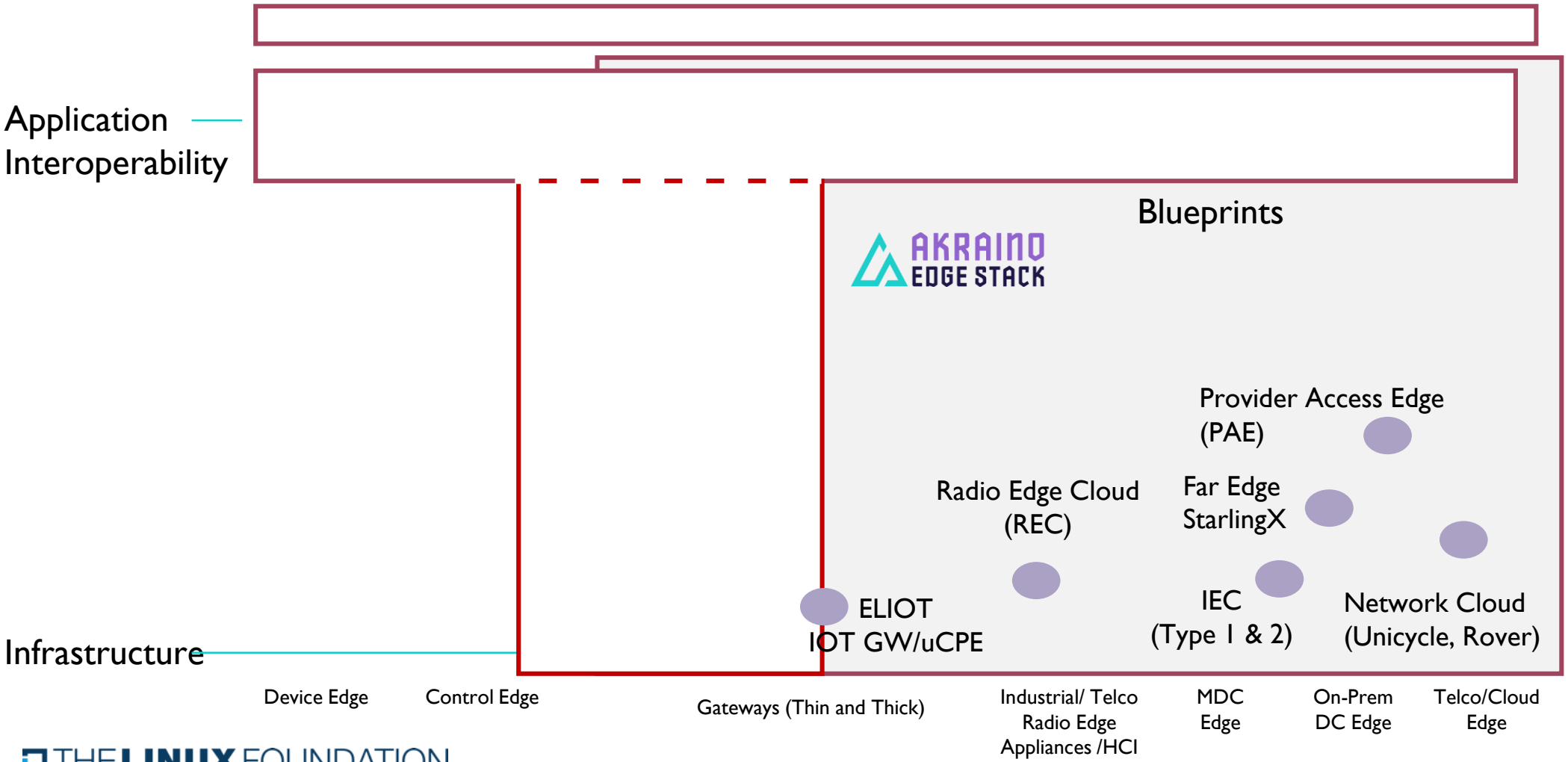


Purpose/Features

- Addresses generic Edge Use cases (small footprints deployments)
- Focused on Native Container workloads able to host NFV and MEC with no OpenStack
- Manage edge stacks at scale and with a consistent, uniform user experience from infrastructure up to workloads, on bare metal or public cloud

Target Industry: Telco, Enterprise

Functional View: R1 Blueprints in Akraino Edge Stack



Akraino R1: Key Takeaways & What's Next in 2019

1. LF Edge Projects gaining community support with Akraino aimed at accelerating time to deployment -> Projects to Products & Production

1. Akraino establishes unified framework for Edge collaboration & validation across projects & community with Blueprints

1. Akraino's R1 releases 10+ Blueprints for IOT, Enterprise and Telco Edge Cloud

On the Horizon

- New blueprints (Gaming, Connected Cars…) + enhancements to existing blueprints
- Tools for automated blueprint validations
- Edge API's in collaboration with LF Edge projects
- New community lab hardware

Project Introduction: EdgeX Foundry

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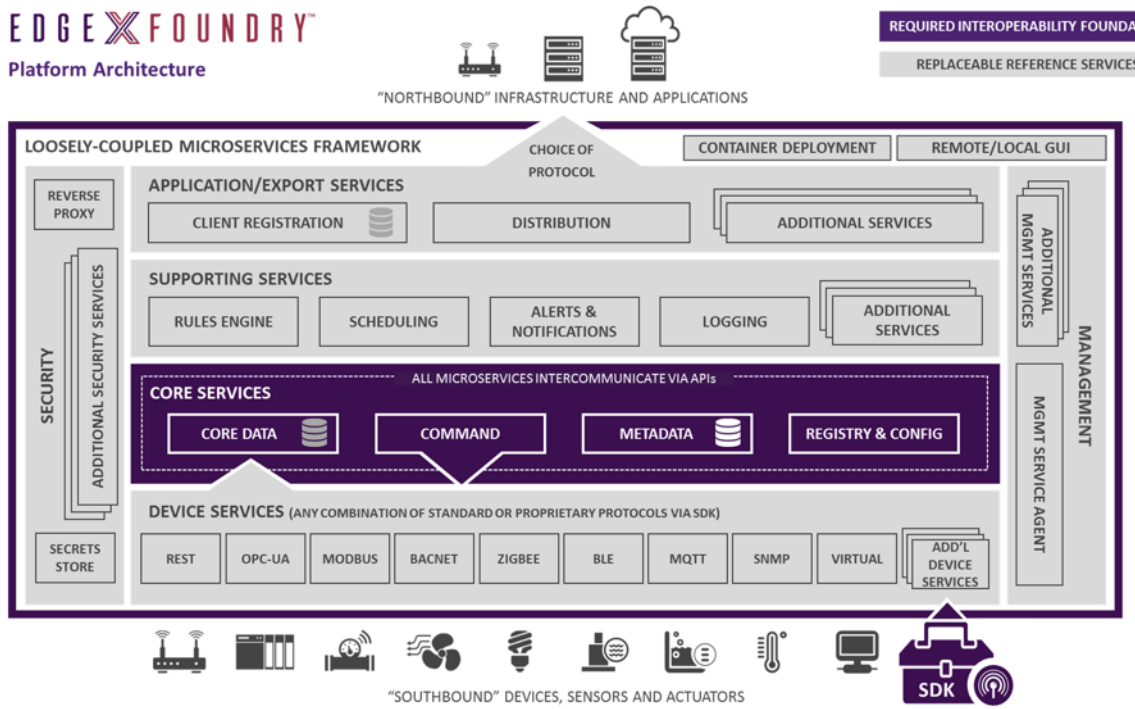
EdgeX Foundry

EDGE X FOUNDRY™

- EdgeX FoundryTM is a vendor-neutral open source project hosted by The Linux Foundation building a common open framework for IoT edge computing.
- At the heart of the project is an interoperability framework hosted within a full hardware- and OS-agnostic reference software platform to enable an ecosystem of plug-and-play components that unifies the marketplace and accelerates the deployment of IoT solutions.
- Architected to be agnostic to protocol, silicon (e.g., x86, ARM), OS (e.g., Linux, Windows, Mac OS), and application environment (e.g., Java, JavaScript, Python, Go Lang, C/C++) to support customer preferences for differentiation

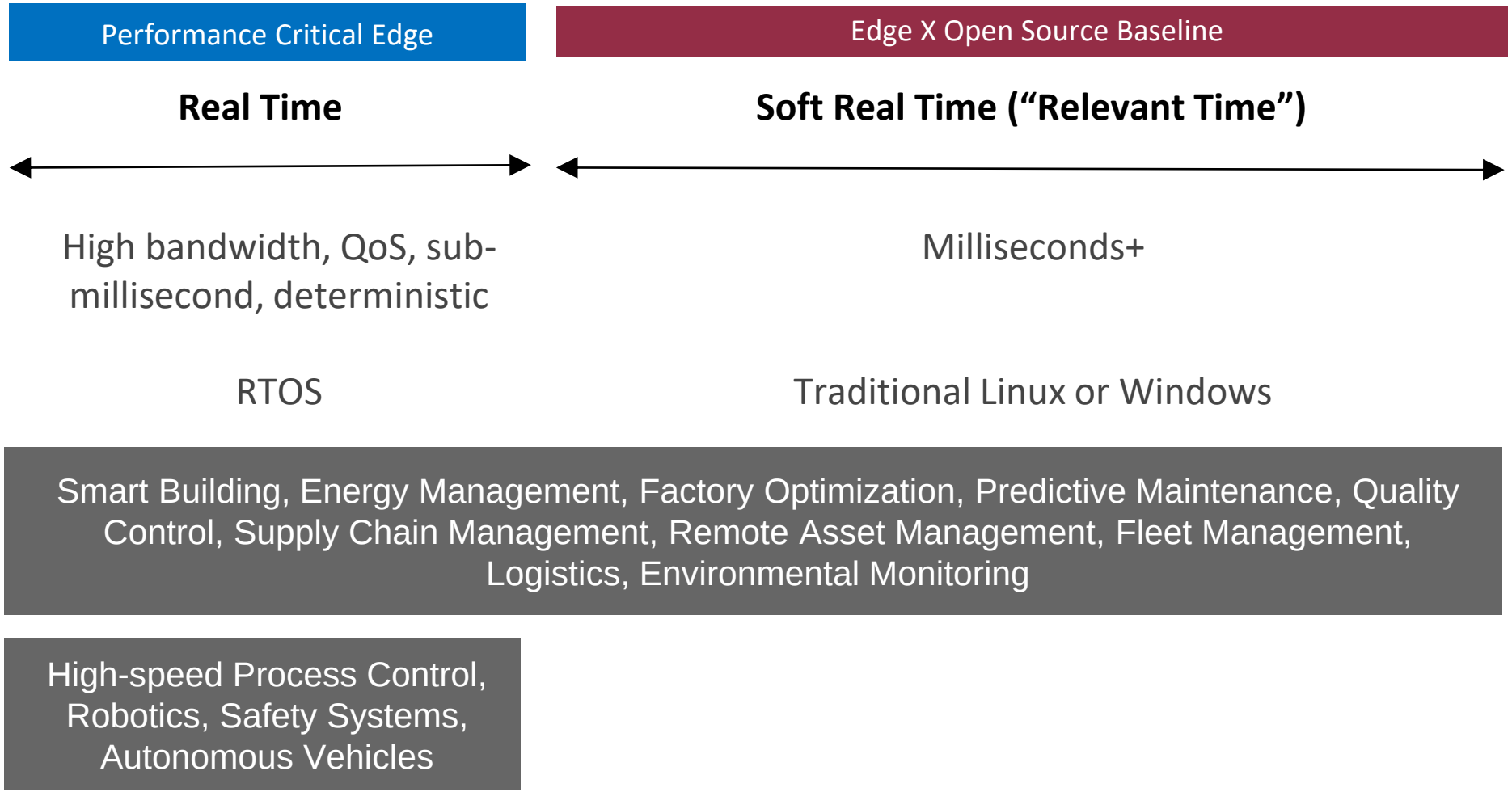
EdgeX: IOT Interoperability framework

- Loosely-coupled microservices bound by common APIs established through vendor-neutral collaboration in Linux Foundation
- HW-, OS- and Protocol-agnostic
- Polyglot: microservices can be written in any programing language (e.g. Java, Python, Go Lang, C) and deployed in containers or VMs
- Granularity in API definition facilitates bringing together heterogeneous OSS and Commercial offerings for various functions
- Once key APIs are established, entire subsections can be replaced, combined, etc. with proprietary, differentiated "EdgeX-compliant" offerings, even Core Services



EdgeX is architected to enable **commercial value-add** around a lowest common denominator interoperability framework.

EdgeX Use Case Scope OS, Hardware, Protocol Agnostic



Project Introduction: Edge Virtualization Engine

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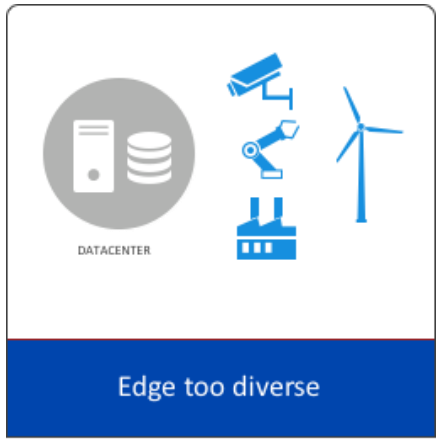
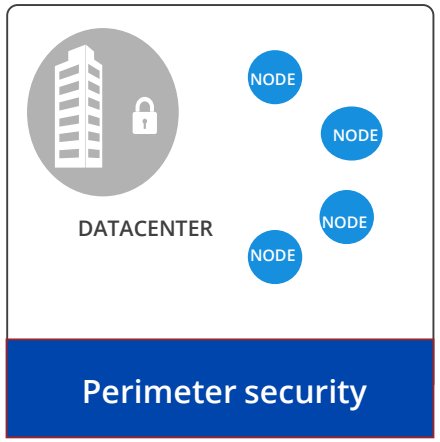
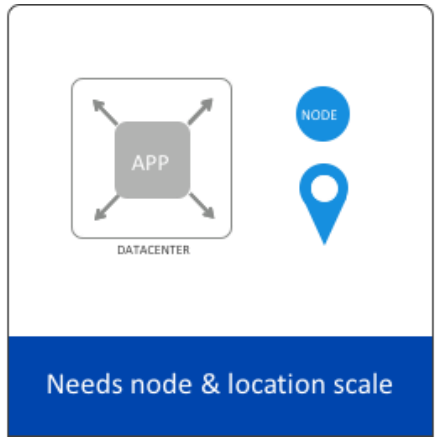
Why Edge Virtualization Engine?

Diversity and complexity of the On Prem IIOT Edge requires a standard architecture that is open and agnostic

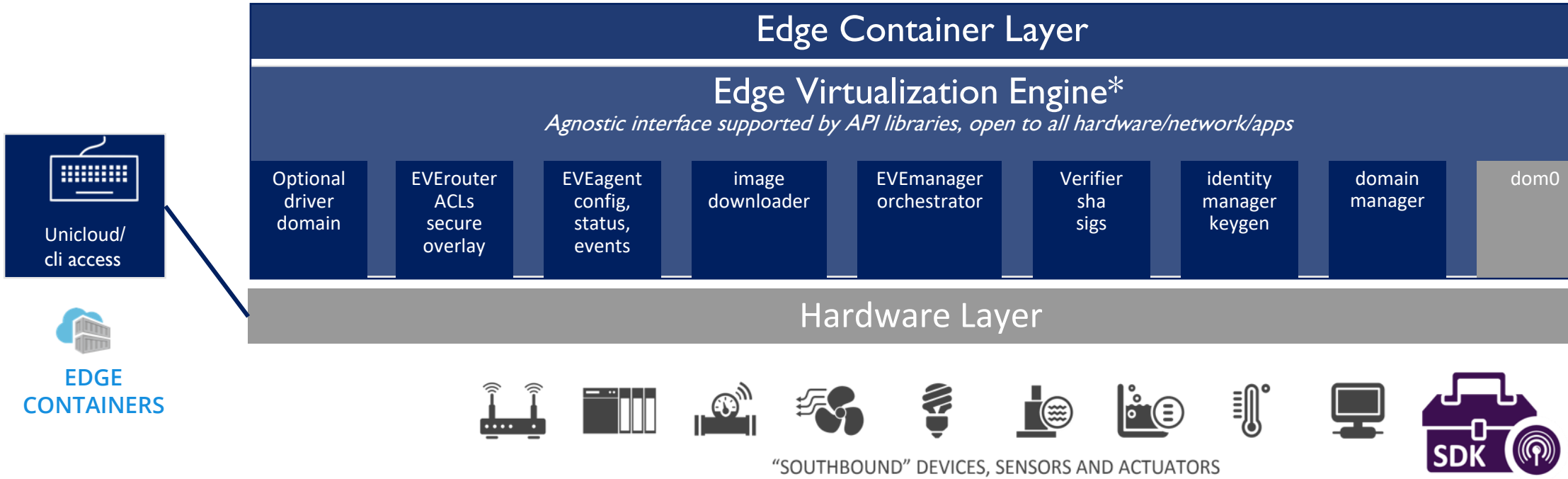
- Must be able to use any hardware, network or applications
- Avoid proprietary lock-in
- Develop common APIs for interoperability across hardware, network and applications







On-Prem IOT Edge Virtualization Engine Architecture



Scope of On Prem IOT Edge (EVE)

- Standardized Edge Container format
- Edge Virtualization Engine
  - EV Engine
  - EVE-EVC Interface
  - API + CLI reference implementation
  - Xen reference implementation

* Zedada seed code for On-Prem Edge based on EdgeX Foundry provides a light virtualization engine for IIOT gateways with inbuild security

Project Introduction: Home Edge Project

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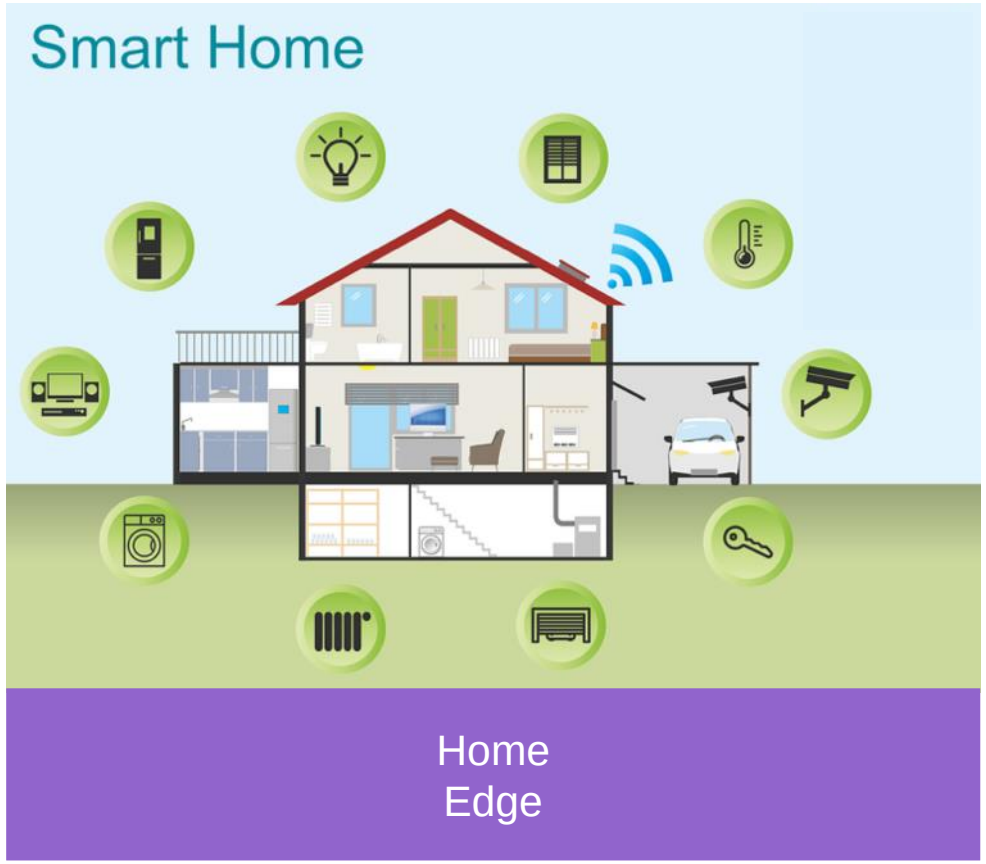
Home Edge: Drivers & Enablers



Drivers

1. Smart Home Products are now mainstream & need common API/Gateway/UI/Lifecycle
2. AI technologies enabling learning and lifestyle/safety prediction requires local but connected Edge computing
3. Real time/low latency requirements increasing as safety, natural disasters and home health become mainstream beyond Telecom "triple play"
4. Data Storage & Data Privacy increasingly important and require sensitive data closer to home/user

Smart Home has a great potential to enable new business apps through home edge computing

Home Edge: High Level Platform Architecture

Edge Setup | Data Service | Device Control Service | Other Edge Services... | Speech Recognition | Vision Service | Other AI Service

New Home Edge Apps and Services based on APIs

Security

Edge Orchestration*
- Edge Discovery
- Service Discovery
- Service Deployment
- Device Management

Data Storage*
- Data Interface
- Core Data
- Metadata
- Command

Home Device Control
- Cloud Interface
- Device Discovery
- Controller Installer
- Controller Discovery
- Controller Adapter
- Air Conditioner

Machine Learning (Future)
- NN Model Interface
- Model Partition Converter
- Distributed worker scheduler
- Distributed Job Executer

Deep Neural Network Framework (eg. TensorFlow Lite)

Container Runtime (based on EdgeX Foundry) / Deep Neural Net Runtime (Future)

Legend: Edge Service (Initial Seed code) | Device Control | AI | Platform Component

* Samsung seed code for Home edge computing platform architecture is based on EdgeX Foundry that is able to provide real-time, locality, and user privacy for various use cases, initially focused on Orchestration & storage

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Project Introduction: Open Glossary of Edge Computing

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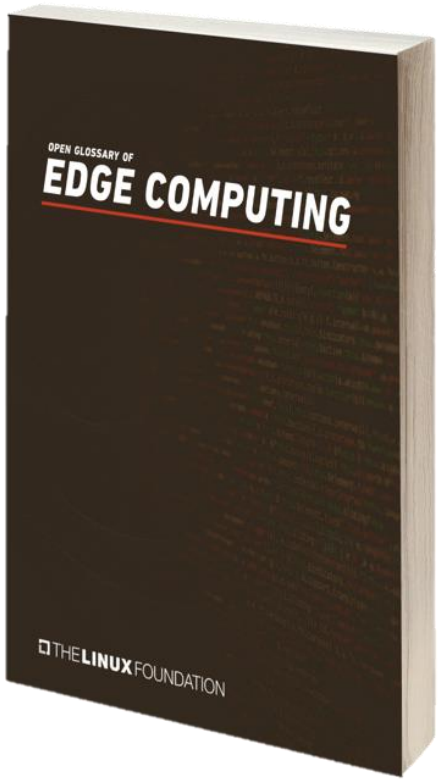
2018 Retrospective

Open Glossary of Edge Computing

Mission
Improve communication and accelerate innovation by crowdsourcing a shared vocabulary for edge; promulgate a vendor-neutral lexicon that is widely adopted and used to discuss compelling solutions offered by edge computing and the next generation Internet.



HIGHLIGHTS

- **Evolved out of the *State of the Edge Report***
- **Contributed to Linux Foundation June 2018**
- **Moved into GitHub repo**
- **V1.0 shipped**

StateOfTheEdge.com/glossary

Outreach and Inclusion

2018

- Telecommunications Infrastructure Association
- EdgeX Foundry
- Akraino
- OpenFog Consortium
- Industrial Internet Consortium
- OpenStack Foundation
- CNCF
- Open19 Foundation

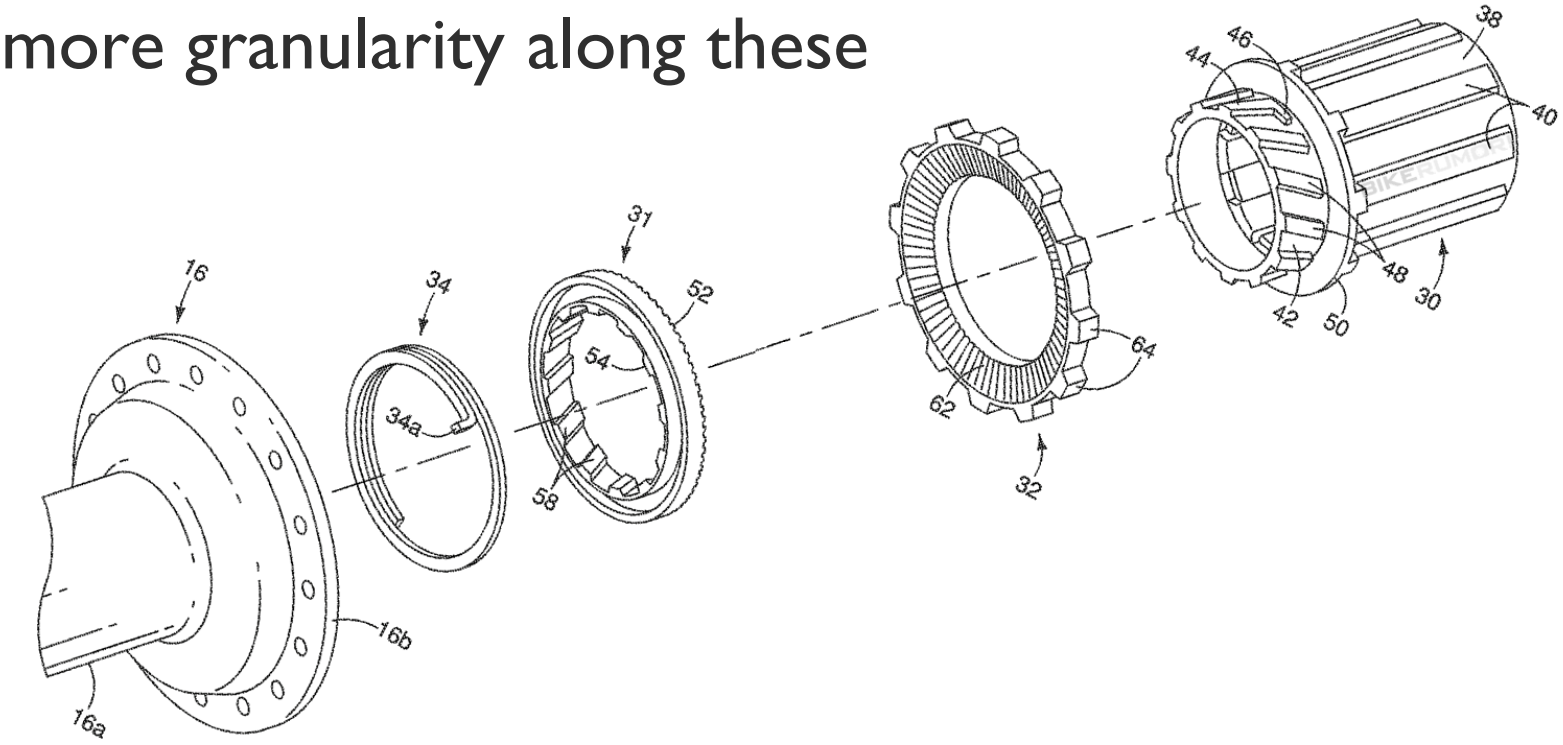
2019

- Infrastructure Masons
- ETSI MEC
- IEEE
- CityTech
- And more to come…

2019: The Taxonomy Project

A collaborative working group that will crowdsource a canonical taxonomy of edge. We'll build upon the Open Glossary but add much more granularity along these three dimensions:

- Infrastructure Edge
- Device Edge
- Edge Software
- Edge Networking



LF Edge
(www.lfedge.org)

Bringing Edge Initiatives Together

IOT | Telecom | Cloud | Enterprise

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