The New Open "Edge"
IOT+Telecom+Cloud+Enterprise+Industrial

LF EDGE

Tina Tsou
LF Edge Board Chair
Sep 2022

THE **LINUX** FOUNDATION
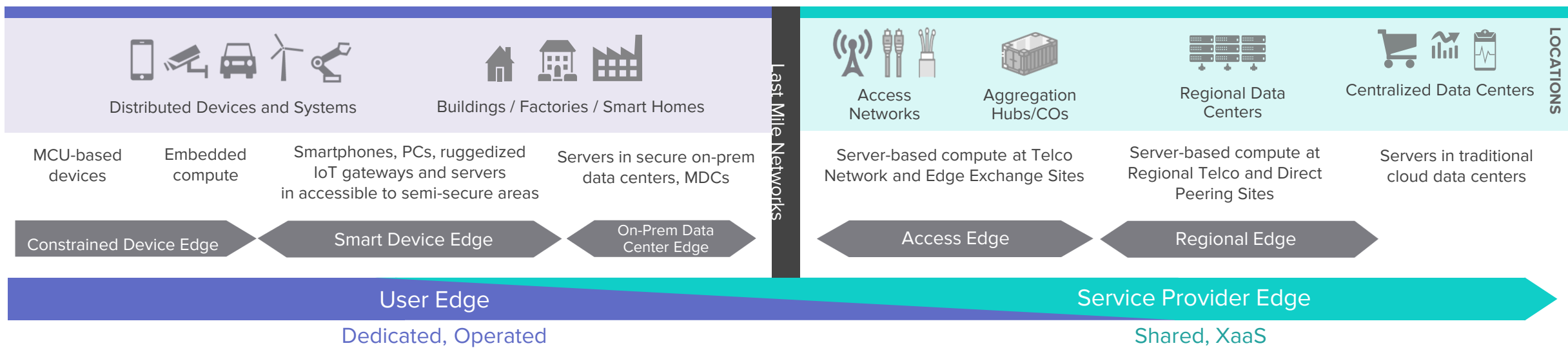
Topics

THE **LINUX** FOUNDATION

LF EDGE

Defining the Edge

THE **LINUX** FOUNDATION

Unified Edge Framework

STATE OF THE **EDGE**
Research and Reports

Applications

Infrastructure

✓ Proximity (compute & storage)
✓ Responsiveness (5-20ms latency)
✓ Mobility

		Last Mile Networks				LOCATIONS
Distributed Devices and Systems	Buildings / Factories / Smart Homes		Access Networks	Aggregation Hubs/COs	Regional Data Centers	Centralized Data Centers

MCU-based devices | Embedded compute | Smartphones, PCs, ruggedized IoT gateways and servers in accessible to semi-secure areas | Servers in secure on-prem data centers, MDCs | Server-based compute at Telco Network and Edge Exchange Sites | Server-based compute at Regional Telco and Direct Peering Sites | Servers in traditional cloud data centers

Constrained Device Edge | Smart Device Edge | On-Prem Data Center Edge | Access Edge | Regional Edge

User Edge | Service Provider Edge

Dedicated, Operated | Shared, XaaS

Taxonomy whitepaper

https://www.lfedge.org/resources/publication-download/

The Edge Taxonomy - Explained

STATE OF THE
EDGE
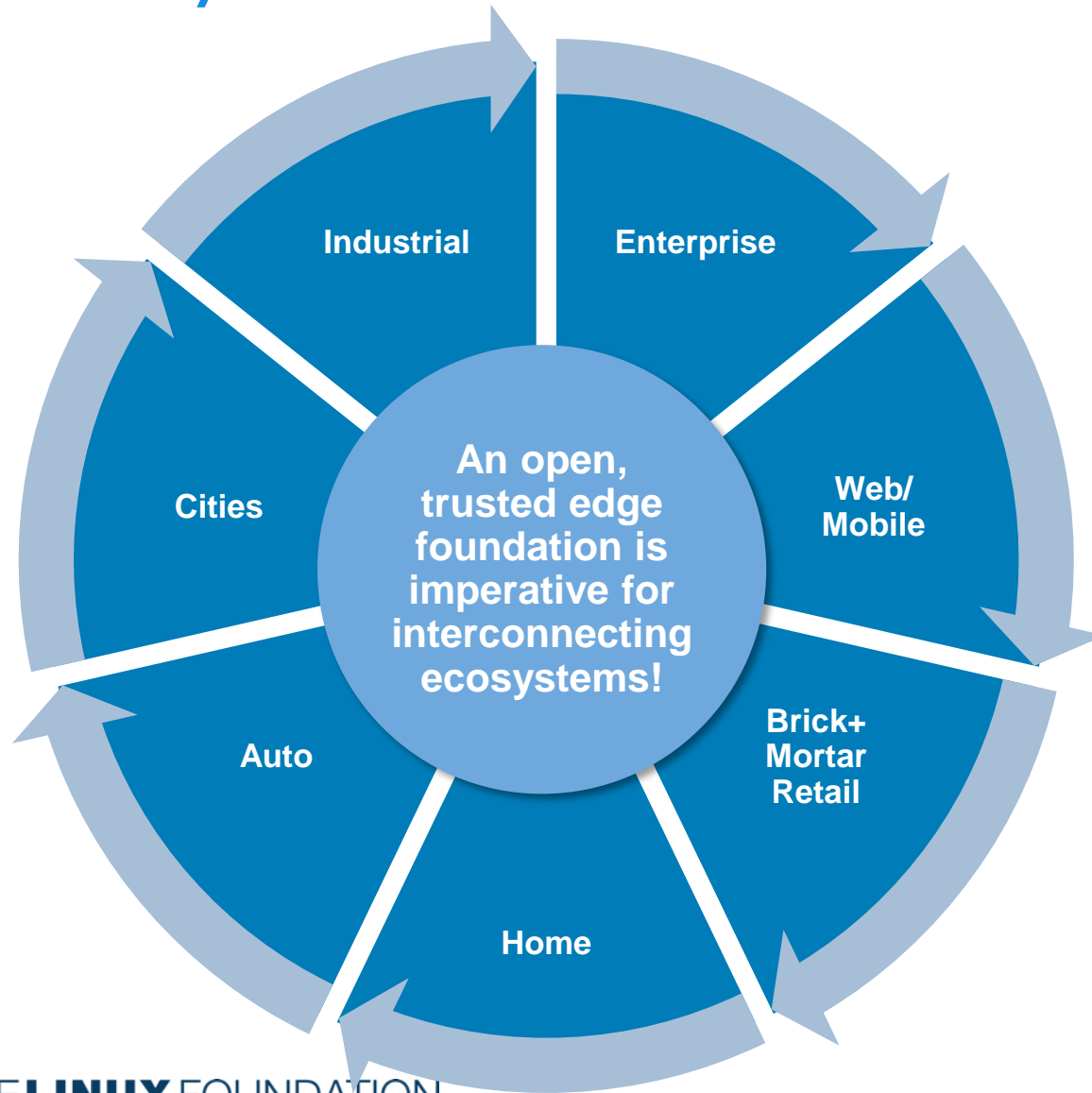Research and Reports
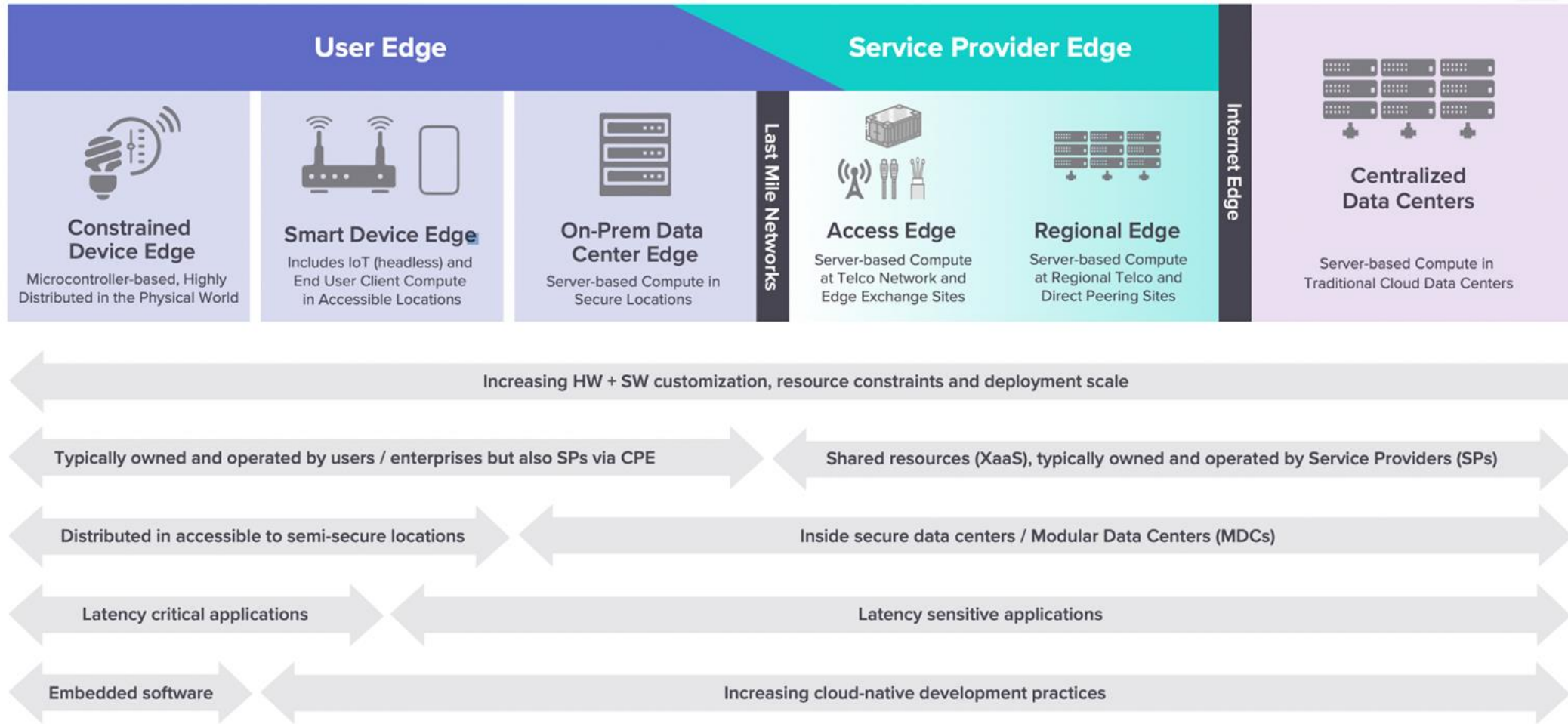
Source: LF Edge June 2020 Taxonomy White Paper
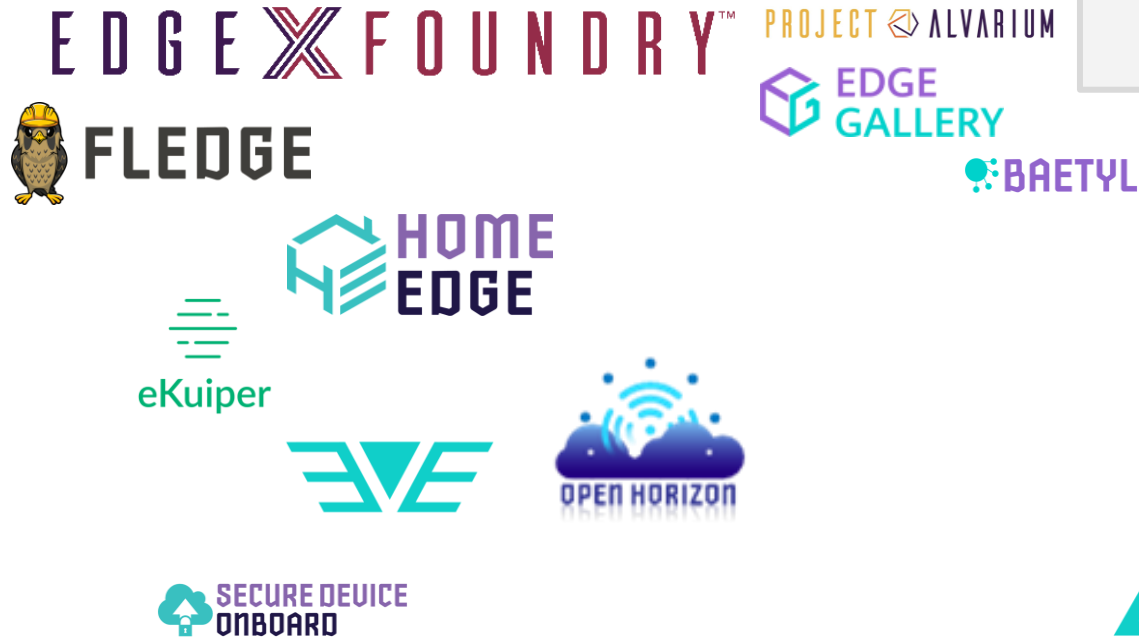
The Holy Grail – B2B2X Across Interconnected Ecosystems

B2X2X innovation is the ultimate opportunity for digital transformation.
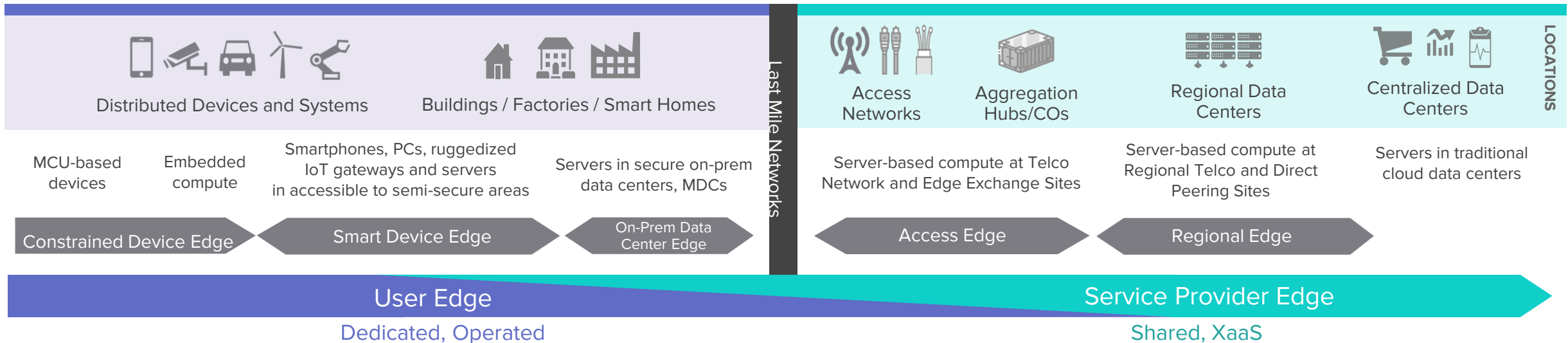
Getting here requires an open edge foundation…

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Introducing LF Edge

THE **LINUX** FOUNDATION

LF Edge Projects

EDGE X FOUNDRY™

PROJECT ALVARIUM

EDGE GALLERY

FLEDGE

BAETYL

HOME EDGE

STATE OF THE EDGE

Research and Reports

eKuiper

EVE

OPEN HORIZON

SECURE DEVICE ONBOARD

AKRAINO

Applications

Infrastructure

Locations

Distributed Devices and Systems	Buildings / Factories / Smart Homes	Access Networks	Aggregation Hubs/COs	Regional Data Centers	Centralized Data Centers
MCU-based devices / Embedded compute / Smartphones, PCs, ruggedized IoT gateways and servers in accessible to semi-secure areas	Servers in secure on-prem data centers, MDCs	Server-based compute at Telco Network and Edge Exchange Sites		Server-based compute at Regional Telco and Direct Peering Sites	Servers in traditional cloud data centers

Last Mile Networks

Constrained Device Edge — Smart Device Edge — On-Prem Data Center Edge

Access Edge — Regional Edge

User Edge
Dedicated, Operated

Service Provider Edge
Shared, XaaS

Vertical Market Adoption of End to End Open Source Software

OPEN NETWORKING, EDGE AND IOT MARKET ADOPTION

Industrial Manufacturing | Energy (Oil, Gas Utilities) | Commerce & Retail | Home | Automotive | Fleet & Transportation | Logistics | Building Automation | Cities & Government | Healthcare

ENTERPRISE NETWORKING
1. Private Networks 5G/LTE
2. Workloads across Multi-clouds
3. End to end visibility and monitoring

SERVICE PROVIDERS
1. Built on end to end open source 5G & edge
2. Developing countries with 5G and edge
3. Global connectivity

END USERS GOVERNMENT
1. Built on Open Source projects
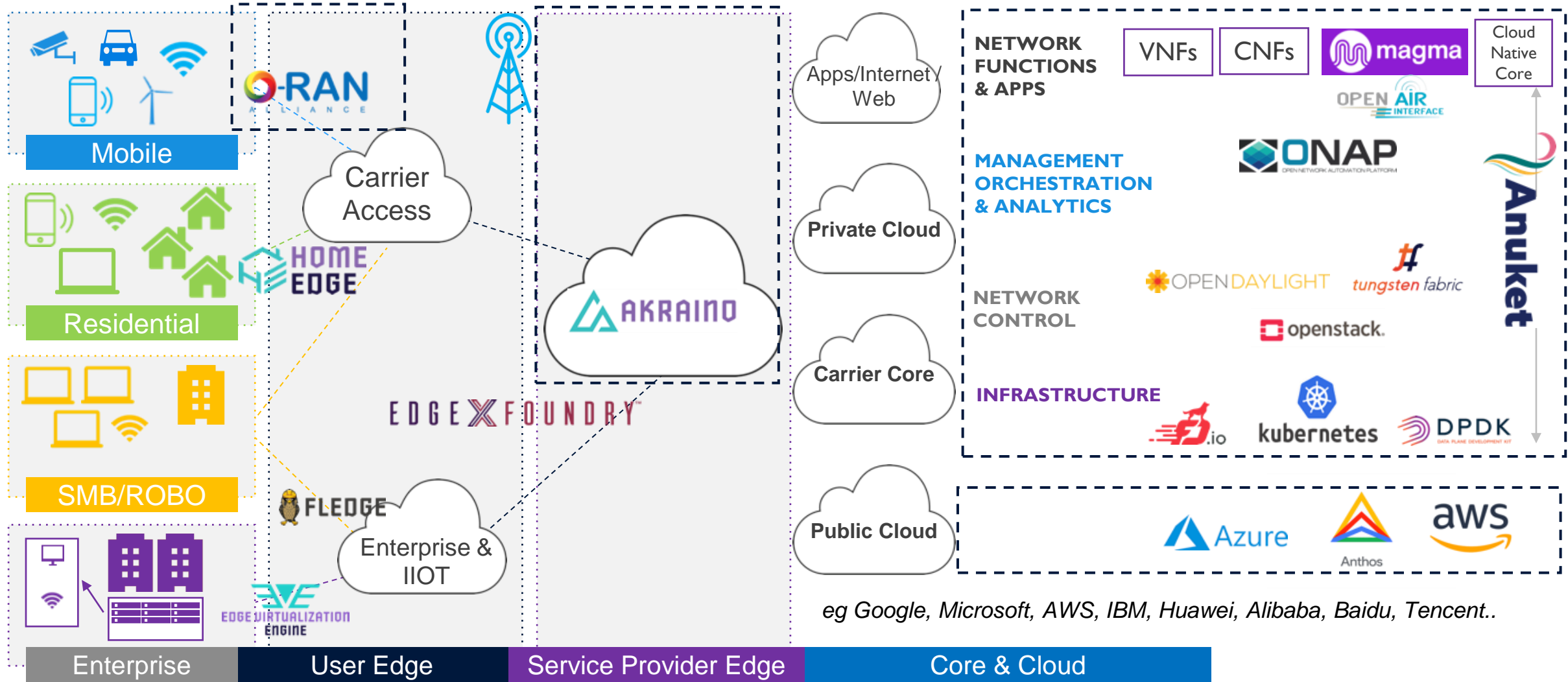2. 5G Super Blueprints
3. Unified Cloud, Enterprise, Telco

BUILT ON END TO END OPEN SOURCE PROJECTS

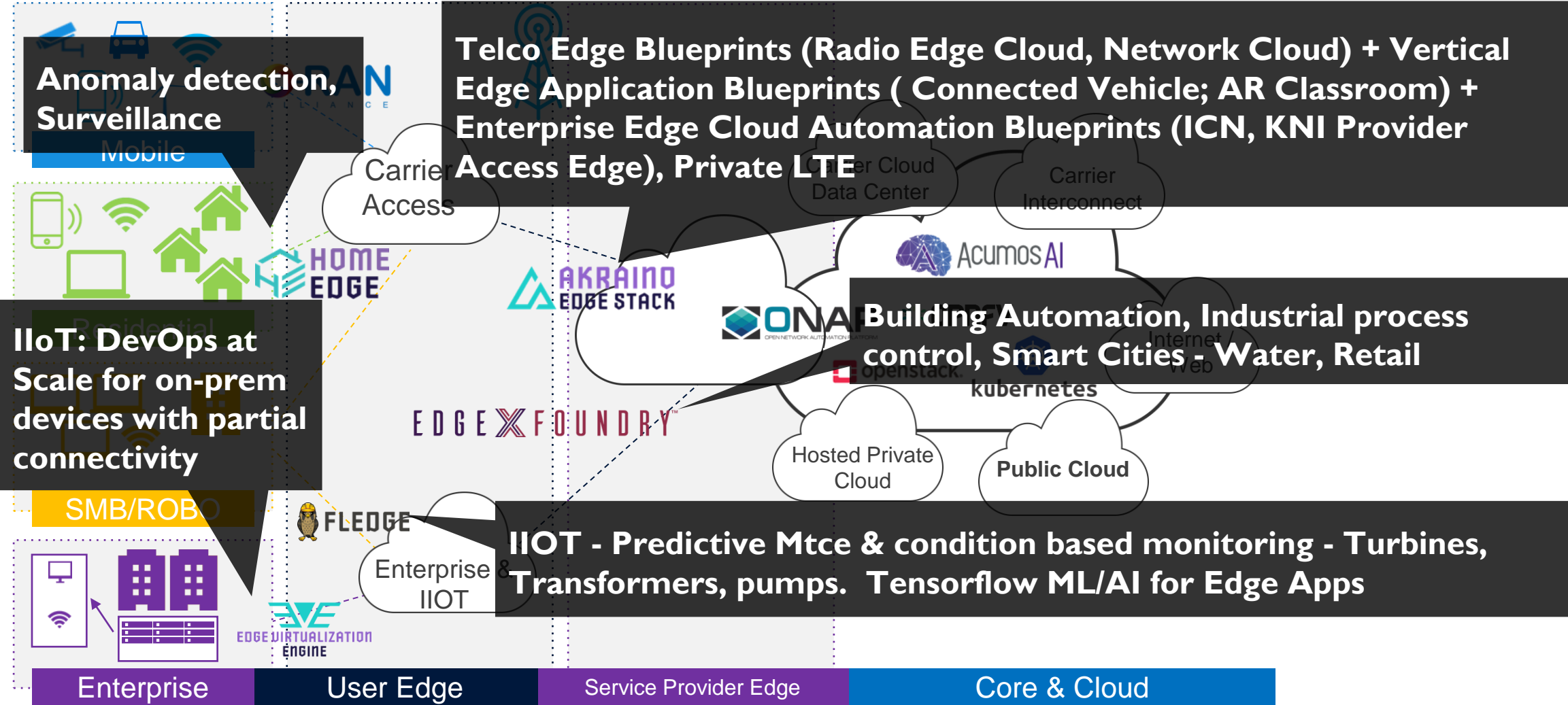O-RAN ALLIANCE | EVE | HOME EDGE | AKRAINO | EDGEXFOUNDRY | FLEDGE | Anuket

fd.io | ONAP | OPEN DAYLIGHT | kubernetes | DPDK DATA PLANE DEVELOPMENT KIT | tungsten fabric | magma

End to End Open Source Software Collaboration

Mobile

Residential

SMB/ROBO

Enterprise

O-RAN ALLIANCE

Carrier Access

HOME EDGE

EDGE X FOUNDRY

FLEDGE

EDGE VIRTUALIZATION ENGINE

AKRAINO

Enterprise & IIOT

Apps/Internet Web

Private Cloud

Carrier Core

Public Cloud

NETWORK FUNCTIONS & APPS

VNFs   CNFs   magma   Cloud Native Core

OPEN AIR INTERFACE

MANAGEMENT ORCHESTRATION & ANALYTICS

ONAP

NETWORK CONTROL

OPENDAYLIGHT   tungsten fabric

openstack.

INFRASTRUCTURE

.io   kubernetes   DPDK

Anuket

Azure   Anthos   aws

eg Google, Microsoft, AWS, IBM, Huawei, Alibaba, Baidu, Tencent..

| Enterprise | User Edge | Service Provider Edge | Core & Cloud |

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* Sample projects only

LF Edge - Deployment ready Open Source Edge - use cases

Anomaly detection, Surveillance

Mobile

Telco Edge Blueprints (Radio Edge Cloud, Network Cloud) + Vertical Edge Application Blueprints (Connected Vehicle; AR Classroom) + Enterprise Edge Cloud Automation Blueprints (ICN, KNI Provider Access Edge), Private LTE

Carrier Access

Carrier Interconnect

HOME EDGE

AKRAINO EDGE STACK

Acumos AI

IIoT: DevOps at Scale for on-prem devices with partial connectivity

Building Automation, Industrial process control, Smart Cities - Water, Retail

ONAP
OPEN NETWORK AUTOMATION PLATFORM

openstack.

kubernetes

Internet / Web

EDGE X FOUNDRY™

Hosted Private Cloud

Public Cloud

SMB/ROBO

FLEDGE

IIOT - Predictive Mtce & condition based monitoring - Turbines, Transformers, pumps. Tensorflow ML/AI for Edge Apps

Enterprise IIOT

EDGE VIRTUALIZATION ENGINE

Enterprise	User Edge	Service Provider Edge	Core & Cloud

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LF Edge Summary

Vision: Our software & projects enable rapid productization of Edge platforms by leveraging end user input to drive and supply the necessary building blocks (and/or frameworks, reference solutions) to facilitate integration and interoperability for Edge Computing across Telecom Service Providers, Cloud Providers, IOT & Enterprises

Projects

IMPACT - STAGE 3

GROWTH - STAGE 2

AT LARGE - STAGE 1

Premier Members

LF Edge Accelerating Community Collaboration

25+%

New Member
Y/Y increase

80%

New Projects increase
SOTE, Open Horizon, SDO…

25+

Global Deployments &
Commercial Products

6M+ /30+

EdgeX Downloads and Akraino
Blueprints in development

160% Growth in Developers Y/Y, 4X Commits Y/Y

Cumulative Git Authors Since Q1 2019

Cumulative Commits Since Q1 2019
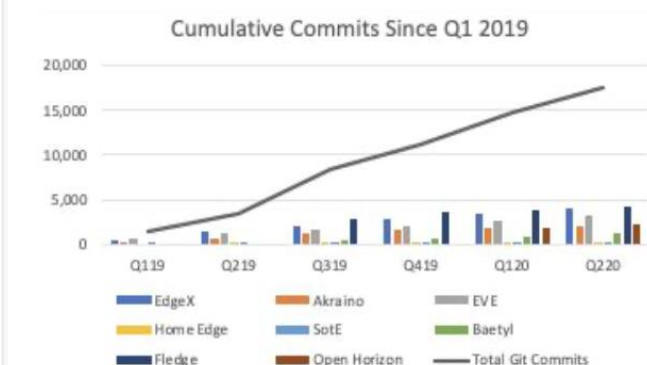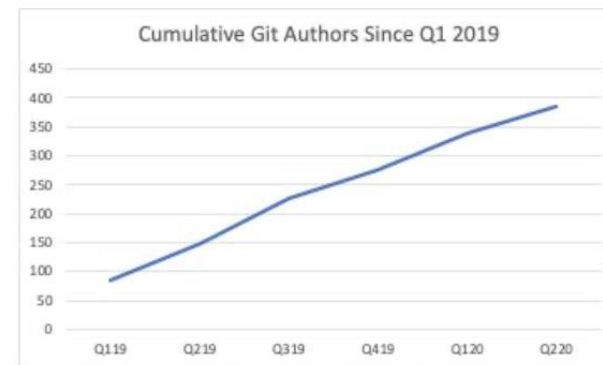
15800 global mentions since launch

Participation from Service Providers (Telco, Cloud, Cable),
IOT, Enterprise ecosystem with a goal of Unifying Edge
Frameworks & Life cycle mgmt

THE **LINUX** FOUNDATION   **LF** EDGE

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.

May 2019

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.

June 2019

EdgeX Foundry Announces Production Ready Release Providing Open Platform for IoT Edge Computing to a Growing Global Ecosystem

- Enables IoT digital transformation for Enterprise, Industrial, Retail and Consumer
- Supports complementary products and services from global open ecosystem including commercial support, training and customer pilot programs
- Deployed in many end user projects; EdgeX also collaborates with IIC on AI testbeds and is the foundation for the Open Retail Initiative (ORI)

SAN FRANCISCO – July 11, 2019 – EdgeX Foundry, a project under the LF Edge umbrella organization within the Linux Foundation that aims to establish an open, interoperable framework for edge IoT computing independent of hardware, silicon, application cloud, or operating system, today announced the availability of its "Edinburgh" release.

July 2019

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LF Edge Announcements

LF Edge Expands Ecosystem with Open Horizon, adds seven New Members and reaches critical deployment milestones

SAN FRANCISCO, CA – April 30, 2020 – LF Edge, an umbrella organization under 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 with the addition a new project and several technical milestones.

April 2020

Welcome new members **CloudBrink, Federated Wireless, Kaloom, Ori Industries, Tensor Networks, VoerEIR** and **ITRI**

□ THE LINUX FOUNDATION

Akraino Release 6: Now available

PCEI R6 Summary

The Public Cloud Edge Interface (PCEI) blueprint continued development and integration of new capabilities into the multi-domain orchestrator to enable infrastructure orchestration and cloud native application deployment across public clouds (core and edge), edge clouds, interconnection providers and network operators.

SmartNIC R6

In R6, we introduce an innovative networking architecture based on PCIe data fabric to lower both the cost (CAPEX) and power consumption (OPEX) in small clusters for edge cloud computing. Based-on innovative data processor (DPU and XPU), the next-generation networking features

IEC Type3 Android Cloud R6

In R6, we introduced a cloud game solution based on robox, batch deployment through K8S, and monitoring and analysis of the built cluster system through promethus.

Smart Data Transactions for CPS

The Smart Data Transactions for CPS (Cyber-Physical Systems) blueprint in Release 6 demonstrates two technologies for expanding the range of available edge solutions

2022 State of the Edge Report

- Aspects of Edge Studied
  - › Community Standardization of Edge Terminology
  - › Market Size / Growth: A use case driven market forecast of the growth and value of edge infrastructure through 2028.
  - › Critical Infrastructure: Edge data centers, wireless towers & cable head ends, traditional interconnection, and service providers.
  - › Edge Hardware: Key trends, processor platforms, open hardware, virtual networking and storage.
  - › Networks & Networking: The networking ecosystem, SD-WAN, edge exchanges, and the wireless edge.
  - › Software at the Edge: The "new edge" stack, code at the edge, orchestration, serverless, hyperconverged, and marketplaces.

Download Today

landscape.lfedge.org

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.

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Get Involved in the LF Edge Technical Communities

› Participation in LF Edge Projects is open to all https://www.lfedge.org/

› Getting involved in the technical communities is the best way to learn

> › **Step 1:** Get a Linux Foundation ID Here:
>
>   https://identity.linuxfoundation.org/
>
> › **Step 2:** Visit LF Edge Wiki (https://wiki.lfedge.org/)
>
> › **Step 3:** Join workflows for the projects and working groups, subscribe to mailing lists, ask questions, contribute!

Way to participate:
- › Attend project meetings
- › Attend developer events
- › Join approved projects
- › Propose a project
- › Write documentation
- › Contribute use cases

- › Analyze requirements
- › Define tests / processes
- › Review and submit code patches
- › Build upstream relationships
- › Contribute upstream code

- › Provide feedback through VSFG
- › Host and staff a community lab
- › Answer questions
- › Give a talk / training
- › Create a demo
- › Evangelize LFE and its projects

What is the new way of supporting our community?

The Linux Foundation initiatives

› ONES NA in Fall (Sept 28-29)

› Training - Free Training and discounted courses

› (New) projects in Multiple areas to help move OSS forward

LF EDGE

› Project-specific Webinar Series
   Two webinars (200+ participation)
› EdgeX Virtual Hackathon (138 registrants)
› Edge training

https://www.lfedge.org/2020/04/16/how-open-source-is-driving-5g-edge-ai-and-iot/

LF Edge Projects

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Unified Edge Interoperability - key architectural tenets

1. **Abstract data, apps and domain knowledge from underlying infrastructure**

    o Invest in data ingestion, security, and M&O tools that are consistent regardless of use case

2. **Untether data from cloud services as close as possible to the edge source**

    o An open edge supports all future permutations of edge to cloud data flow without risk of lock-in

3. **Extend cloud-native principles wherever possible**

    o Plan for CI/CD, while also recognizing technical tradeoffs (e.g. constrained hardware, time critical applications) and need for OT/IT cultural evolution
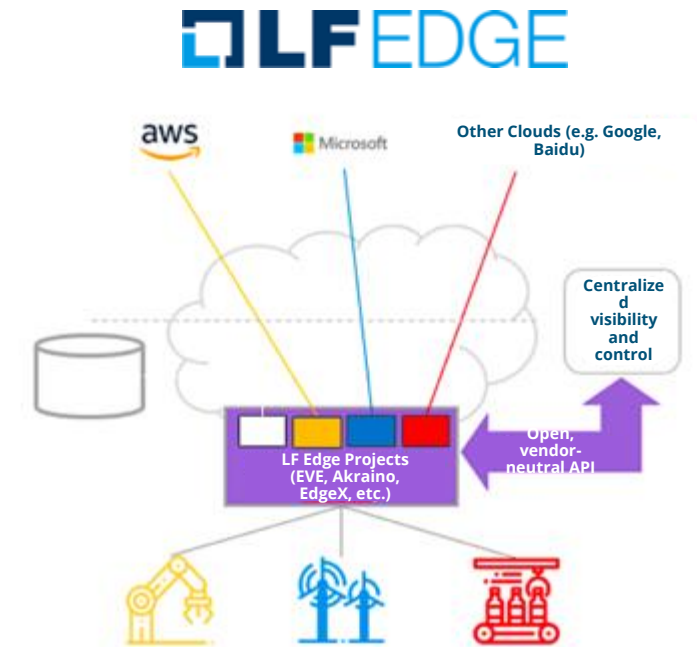
LF Edge – umbrella for Edge Projects

Aims to create an open source software stack that supports high-availability cloud services optimized for edge computing systems and applications.

Highly flexible open source software framework that facilitates interoperability between heterogeneous devices and applications at the IoT Edge, along with a consistent foundation for security and manageability regardless of use case.

LF Edge – New umbrella for Edge Projects

STAGE 2: GROWTH PROJECTS

An open abstraction engine that simplifies the development, orchestration and security of cloud-native applications on distributed edge hardware. Supporting containers, VMs and unikernels, EVE provides a flexible foundation for Industrial and Enterprise IoT edge deployments with choice of hardware, applications and clouds.

Fledge is an open source framework and community for the Industrial Edge. Architected for rapid integration of any IIoT device, sensor or machine all using a common set of application, management and security REST APIs with existing industrial "brown field" systems and clouds.

Interoperable, flexible, and scalable edge computing services platform with a set of APIs that can also run with libraries and runtimes.

Open Horizon is a platform for managing the service software lifecycle of containerized workloads and related machine learning assets. It enables management of applications deployed to distributed webscale fleets of edge computing nodes and devices without requiring on-premise administrators.

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LF Edge – New umbrella for Edge Projects

STATE OF THE EDGE

State of the Edge is an open source research and publishing project with an explicit goal of producing original research on edge computing, without vendor bias. The State of the Edge seeks to accelerate the edge computing industry by developing free, shareable research that can be used by all.

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LF Edge – New umbrella for Edge Projects

STAGE 1: AT LARGE PROJECTS

Baetyl offers a general-purpose platform for edge computing that manipulates different types of hardware facilities and device capabilities into a standardized container runtime environment and API, enabling efficient management of application, service, and data flow through a remote console both on cloud and on prem.

eKuiper is an edge lightweight IoT data analytics / streaming software implemented by Golang, and it can be run at all kinds of resource constrained edge devices. One goal of eKuiper is to migrate the cloud streaming software frameworks (such as Apache SparkApache Storm and Apache Flink) to edge side. eKuiper references these cloud streaming frameworks, and also considered special requirement of edge analytics, and introduced rule engine, which is based on Source, SQL (business logic) and Sink, rule engine is used for developing streaming applications at edge side.

Secure Device Onboard (SDO) is an automated "Zero-Touch" onboarding service.

LF Edge – New umbrella for Edge Projects

PROJECT ALVARIUM

Project Alvarium aims to build a framework and SDK for trust fabrics that deliver data from devices to applications with measurable confidence.

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Security for the Edge - Akraino

Akraino project defines platform and software security requirements, ensure all Akraino blueprints comply with the requirements before the releases.

10:10 am - 10:50 am, 9/20
Security at the Edge
Daniil Egranov System Architect, Arm

Imran Yusuf, Director Hardware Ecosystem, Arm

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ETSI / LINUX Foundation - Edge Hackathon 2022

"Build your Edge Application with ETSI MEC APIs and LF Edge Akraino Blueprints"

- Driven by LF Edge Akraino and ETSI ISG MEC
- Hosted at Edge Computing World, Europe (June '22) & Global (Oct '22)

https://www.edgecomputingworld.com/call-for-edge-developers/

Hackathon of LF Edge and ETSI MEC 2022

Collaboration between ETSI MEC, the LINUX Foundation (LF Edge), and the 5G Automotive Association (5GAA)

"Hackathon Call for Edge Computing Developers":

Realize an innovative edge application, solution, or use-case utilizing ETSI MEC Service APIs and LF Edge Akraino Blueprints
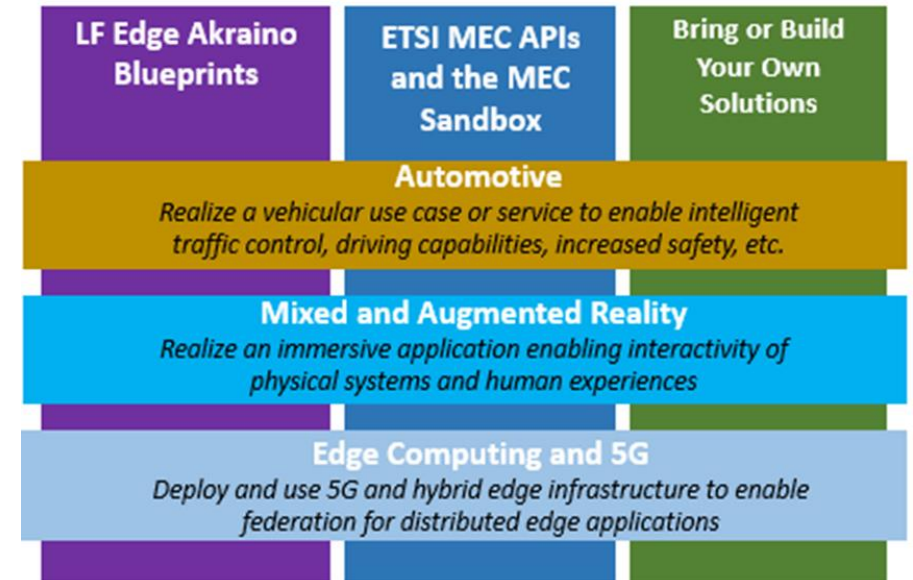
World-wide Edge Hackathon includes Fifteen Teams completing in three application verticals:

- **Automotive, Mixed & Augmented Reality, and Edge Computing & 5G**
- Asia = 11 teams (China, India, Korea); Europe = 2 teams (Spain); the Americas = 2 teams (USA)

Hackathon Format:

- Remote Competition from July 1st – **September 23rd**
  - Teams provided with access to the MEC Sandbox to interact with ETSI MEC Service APIs (including MEC-030 V2X)
- **Onsite Competition - EWC Developer Conference; October 11-12th**
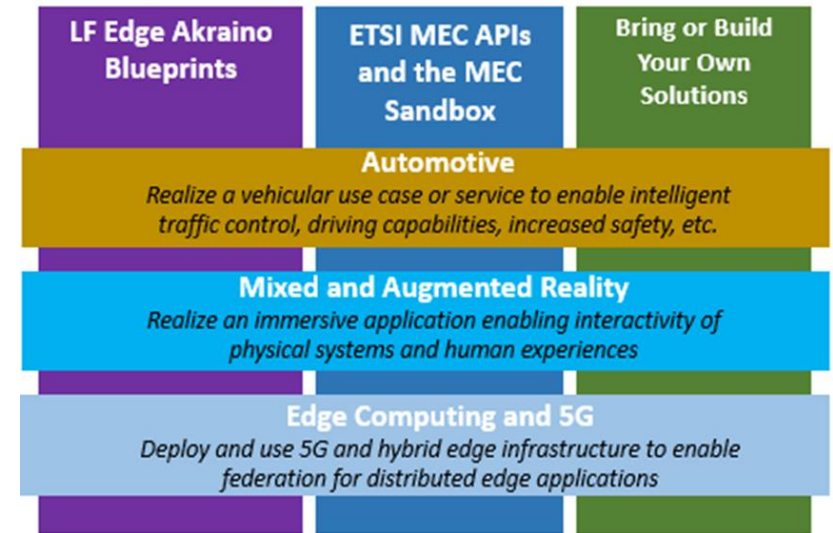 - Best team in each application vertical will be invited to compete in on-site demos and a live "pitch-off" session in Santa Clara, California.

LF Edge Akraino Blueprints | **ETSI MEC APIs and the MEC Sandbox** | **Bring or Build Your Own Solutions**

Automotive
Realize a vehicular use case or service to enable intelligent traffic control, driving capabilities, increased safety, etc.

Mixed and Augmented Reality
Realize an immersive application enabling interactivity of physical systems and human experiences

Edge Computing and 5G
Deploy and use 5G and hybrid edge infrastructure to enable federation for distributed edge applications

https://www.edgecomputingworld.com/edge-hackathon-2022/

intel arm 5GAA Automotive Association

EQUINIX interdigital LF EDGE

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Hackathon of LF Edge and ETSI MEC 2022

1. **Final Submissions – Sept 23rd**

2. First-round remote judging – Sept 26-29th
   - Select final 3 teams for Final Judging

3. Final Judging – Oct 12th
   - Demonstrations
   - "Pitch-off" to Close the Edge Developer Conference @ the ECW

4. Post-Hackathon
   - Informational Report on the Hackathon: use and feedback on MEC APIs, MEC Sandbox, Blueprints, etc.
   - Update MEC Wiki - MEC Hackathons
   - MEC-Tech Series Edition: Hackathon winner
   - Lessons learned for Future Hackathons

https://www.edgecomputingworld.com/edge-hackathon-2022/