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

October 2021
Topics

1. Linux Foundation Primer
2. Why Edge & Defining the Edge
3. LF Edge Overview
4. LF Edge Membership
5. LF Edge Projects - Overview
6. LF Edge Projects - Deep Dive
   › Akraino
   › EdgeX Foundry
   › EVE
   › Fledge
   › Home Edge
   › State of the Edge
   › Baetyl
LF Overview: Our approach to growing communities
The Linux Foundation’s goal is to create the greatest shared technology investment in history by enabling open collaboration across companies, developers and users.

We are the nonprofit organization of choice to build ecosystems that accelerate open source technology development and commercial adoption on a global scale.
We are behind some of the most critical projects in the world

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<td>OpenColori</td>
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Open Source Journey – First Came Projects

Successful Open Source Development depends on the complete life cycle of projects, products that market will adopt and deploy.
The Linux Foundation’s platform assists projects in 5 key areas

| Governance and Membership | • Governance, Policies, etc.  
|                          | • Ongoing business development and membership recruitment  
|                          | • Membership management |
| Development Process      | • Technical decision making  
|                          | • Project life cycle  
|                          | • Release processes |
| Infrastructure           | • CI/CD infrastructure using open source best practices  
|                          | • Release engineering, DevOps  
|                          | • Security and reliability |
| Ecosystem Development    | • Evangelism and marketing/outreach projects  
|                          | • Events bringing developers, users and solution providers together  
|                          | • Help the project training developers and administrators, establish professional certification programs |
| IP Management            | • Code provenance  
|                          | • Trademark management  
|                          | • IP Policy, license scanning, IP defense |
Building large, sustainable ecosystems requires collective resources

We gathered over 35,000 attendees from over 11,000 organizations across 113 countries in 2018.

We manage IP for the world’s most important tech and have some of the world’s top source legal team in house.

We have trained millions of students through free and paid online training, online skills certification, and on site e-learning.

We have designed and implemented both software and hardware testing and certification programs.

We have the largest share of voice of any open source foundation and a proven method to build large scale developer programs.

We host the infrastructure that develops the world’s largest software communities and provide release mgmts., IT ops and support.

In addition to massive peer review, our projects are regularly audited and pen tested. We offer bug bounties, dependency analysis, and code scanning.
The Linux Foundation is a critical part of the tech ecosystem

2100+
Members From 41 Countries

100%
of Fortune100 Tech & Telecom

40,000+
Developers Contributing Code

630+
Open Source Projects

$54.1B
Shared Value

We are adding a new member every day.
The impact of Linux on the world continues to be more relevant than ever.

Every market Linux has entered it eventually dominates.
The Linux Foundation focuses on being an innovation engine for open collaboration, offering our communities optional capabilities to tap into if they need them

**SCALE** 180 employees, ~100 of the world’s most important open source and open standard projects

**GLOBAL ACCESS** Employees, resources and contractors around the world, including China through LF Asia, LLC

**MARKETING & EVENTS** Turnkey capabilities including press releases, social media, branding, meetups and full events

**LEGAL OVERSIGHT** Three lawyers on staff, and world recognized outside counsel who are unmatched

**CONFORMANCE PROGRAMS** Experience in setting up trademark-based conformance programs and licensing structures

**RESOURCE FLEXIBILITY** Ability to scale up with projects and scale down, including partial resources

**TRAINING** Custom platform for e-learning, skills based certification, and massive open online courseware

**CUSTOM GOVERNANCE** Not all communities are the same; we leverage best practice templates, but tailor governance and process to the communities

**SPEC + SOURCE** We host projects producing open source code, open specifications, or both

**RECRUITING** We attract and hire leadership many cannot, based on our brand and connections

**AUTOMATED CLA MANAGEMENT SYSTEMS** End-to-end automated, encrypted contributor license agreement signing and management platform

**DEVOPS** we can make community resources available to enable distributed, global DevOps
Why Edge
Emerging Edge Applications & Convergence of Technologies are demanding & fueling lower latency + accelerated processing

<table>
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<th>NFV Edge Infrastructure</th>
<th>Wireless (vRAN,vEPC)</th>
<th>Wireline (PON)</th>
<th>uCPE (SD-WAN)</th>
<th>IP Enterprise Services</th>
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<tr>
<td>Autonomous Devices</td>
<td>Drones</td>
<td>Autonomous Vehicles</td>
<td>Industry Robots</td>
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<td>Immersive Experiences</td>
<td>Virtual Reality</td>
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<td>Industrial Sensors</td>
<td>Home Devices</td>
<td>Retail</td>
<td>Healthcare</td>
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<td>On-Demand NFV</td>
<td>Hardware Acceleration</td>
<td>A.I.</td>
<td>Microservices</td>
<td>5G</td>
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- Immersive Experiences: Virtual Reality, Augmented Reality, 360 Video
- IoT & Analytics: Industrial Sensors, Home Devices, Retail
- On-Demand NFV: Hardware Acceleration, A.I., Microservices
- Emerging Edge Applications & Convergence of Technologies: NFV, Wireless, Wireline, uCPE, IP Enterprise Services

THE LINUX FOUNDATION
IOT Killer apps 2020

Top 10 IoT Application areas 2020

1. Manufacturing / Industrial (22%)
2. Transportation / Mobility (15%)
3. Energy (14%)
4. Retail (12%)
5. Cities (12%)
6. Healthcare (9%)
7. Supply Chain (7%)
8. Agriculture (4%)
9. Buildings (3%)
10. Other (3%)

Global share of Enterprise IoT projects

Note: 1. Based on 1,414 publicly known IoT projects (not including consumer IoT projects eg. smart home, wearables, etc.).
2. Trend based on relative comparison with % of projects in the 2018 IoT Analytics IoT project list e.g., a downward arrow means the relative share of all projects has declined, not the overall number of projects.
3. Other includes IoT projects from Enterprise & Finance sectors. Source: IoT Analytics Research - July 2020
5G and Edge Critical in the Next Battle, a new normal!
Edge is 4X the Size* of Cloud Market!

“As businesses and governments establish their own new normal, 5G and Edge computing will be necessary to deliver the automation, performance and cognitive insight required by many industries—including manufacturing, healthcare, energy and utilities, among others. Telecom operators will need to embrace open ecosystems to externalize innovation and accelerate new services.”

Forbes

Top 5 Edge Markets - KPMG

1. Industrial Manufacturing
2. Energy (Oil & Gas, Utilities)
3. Commerce/Retail
4. Homes (including B2B2C use cases)
5. Automotive
6. Fleet/Transportation
7. Logistics
8. Building Automation
9. Cities and Government
10. Healthcare
Defining the Edge
# Unified Edge Framework

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

## LOCATIONS

- **Aggregation Hubs/COs**
- **Centralized Data Centers**
- **Regional Data Centers**

## MCUs and Devices
- MCU-based devices
- Embedded compute

## Applications
- Distributed Devices and Systems
- Buildings / Factories / Smart Homes

## Infrastructures
- Last Mile Networks
- 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

## Edge Locations
- Access Edge
- Regional Edge

## User Edge
- Dedicated, Operated

## Service Provider Edge
- Shared, XaaS
Taxonomy whitepaper

https://www.lfedge.org/resources/publication-download/
The Edge Taxonomy - Explained

Source: LF Edge June 2020 Taxonomy White Paper
Introducing LF Edge
B2X2X innovation is the ultimate opportunity for digital transformation.

Getting here requires an open edge foundation…
LF Edge Projects

Stage 1:
At Large Projects
Baetyl, eKuiper, Secure Device Onboard

Stage 2:
Growth Projects
EVE, Fledge, Home Edge, Open Horizon, State of the Edge

Stage 3:
Impact Projects
Akraino, EdgeX Foundry

Applications
Infrastructure

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

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

Access Networks
Aggregation Hubs/COs
Regional Data Centers

Last Mile Networks

Service Provider Edge
Shared, XaaS

User Edge
Dedicated, Operated
Vertical Market Adoption of End to End Open Source Software

OPEN NETWORKING, EDGE AND IOT MARKET ADOPTION

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

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

GOVERNMENT

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

BUILT ON END TO END OPEN SOURCE PROJECTS

- ORAN Alliance
- EVE
- Home Edge
- Akraino
- EdgeX Foundry
- Fledge
- Anuket
- ONAP
- Open Daylight
- Kubernetes
- DPKD
- Tungsten Fabric
- Magma
LF Edge - the end to end context
Deployment ready Open Source - use cases

Carrier Access
Carrier Cloud Data Center
Carrier Interconnect
Internet / Web
Public Cloud
Hosted Private Cloud

Mobile
Residential
SMB/ROBO
Enterprise & IIOT

THE LINUX FOUNDATION

X-Project Collaboration
End to End Open Source Software Collaboration

- **Mobile**
- **Residential**
- **SMB/ROBO**
- **Enterprise & IIOT**

**Network Functions & Apps**

- **VNFs**
- **CNFs**

**Management Orchestration & Analytics**

- **OPEN DAYLIGHT**
- **tungsten fabric**
- **openstack**

**Network Control**

- **Cloud Native Core**

**Infrastructure**

- **Akairo**
- **Melbourne**
- **Edge Foundry**

**Sample projects only**

- **eg Google, Microsoft, AWS, IBM, Huawei, Alibaba, Baidu, Tencent..**
LF Edge - Deployment ready Open Source Edge - use cases

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

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

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

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

Anomaly detection, Surveillance

Enterprise IIOT
**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**

- Altran
- ARM
- AT&T
- Baidu
- Charter Communications
- Dell Technologies
- Dianomic
- Equinix
- Ericsson
- Fujitsu
- FutureWei Technologies
- HP
- Huawei
- IBM
- Intel
- NTT
- OSIsoft
- Radisys
- Red Hat
- Samsung
- Tencent
- WD
- Western Digital
- Wipro
- ZEDEDA

**THE LINUX FOUNDATION**
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

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 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.

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 Zededa to LF Edge
- Four new members join existing community of 70+ LF Edge organizations
- LF Edge on Display at IoT World, with Akaino 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, onsite at IoT World.

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.

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.
LF Edge New 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.

Welcome new members CloudBrink, Federated Wireless, Kaloom, Ori Industries, Tensor Networks, VoerEIR and ITRI
Akraino Release 4 Enables Kubernetes Across Multiple Edges, Integrates across O-RAN, Magma, and More

- 7 New Akraino R4 Blueprints (total of 25+)
- Akraino is Kubernetes-ready with K8s- enabled blueprints across 4 different edge segments (Industrial IOT, ML, Telco, and Public Cloud)
- New and updated blueprints also target ML, Connected Car, Telco Edge, Enterprise, AI, and more

SAN FRANCISCO – February 25, 2021 – LF Edge, an umbrella organization within the Linux Foundation that creates an open, interoperable framework for edge computing independent of hardware, silicon, cloud, or operating system, today announced the availability of Akraino Release 4 (“Akraino R4”). Akraino’s fourth release enables additional blueprints that support various deployments of Kubernetes across the edge, from Industrial IoT, to Public Cloud, Telco, and Machine Learning (ML).
2021 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.
The LF Edge landscape (org. elf) is dynamically generated from a community-supported Github account. It is modeled after the LF Open Projects and is based on the same open-source code.

If you would like to contribute, please open a pull request with projects in the edge ecosystem. Please make sure all images submitted must be in .SVG files, include a URL to the company’s site, and a Crucible/issue link. Please open a pull request to correct any issues. Graphean logos are not open source. Last updated: 2023-01-01 10:08:01 PST.

You are viewing 183 cards with a total of 105,149 stars, a market cap of $5.91T and funding of $5.25B.

landscape.lfedge.org

STATE OF THE EDGE 2020

THE LINUX FOUNDATION
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.
Get Involved in the LF Edge Technical Communities

› Participation in LF Edge Projects is open to all

› 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 Membership
LF Edge Governance

Board Committees (As Needed)
- Audit & Finance
- End User Advisory Group
- Compliance & Verification

Technical Advisory Council (TAC)
- Akraino TSC
- EdgeX TSC
- Home Edge TSC
- Project EVE TSC
- Fledge TSC

Developer Communities

LF Edge Governing Board
- Strategy & Priorities
- Budget
- Marketing Strategy & Events
- Legal & overall governance

External Focus (SDO/OSS)
- Vertical Solutions focus (e.g., O&G, Retail, Industrial/Manuf, Home, Telecom, etc)
- Cross-project collaboration
- New Project Induction
- Developer Voice to GB

Outreach Committee
- WG project x
- WG project y

Annual Marketing Plan
- PR
- Events
- Content/Web
- Branding
- Market Development
## LF Edge Membership Structure, broad base – lower dues

### Summary
1. Premier Member, Annual cost for LF Edge $50,000 (similar to Akraino)
2. Simplified EdgeX general category to match LF levels
3. Dues for existing projects will be credited towards LF Edge or any LF projects.

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<tr>
<th>Level</th>
<th>Not Yet LF Member</th>
<th>Already LF Member</th>
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<tr>
<td>Premier</td>
<td>$70,000</td>
<td>$50,000</td>
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<tr>
<td>General</td>
<td>$45,000 (USD) 5,000 and above</td>
<td>$25,000 (USD) 5,000 and above</td>
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<td>$30,000 (USD) From 500 to 4,999</td>
<td>$15,000 (USD) From 500 to 4,999</td>
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<td>$20,000 (USD) From 100 to 499</td>
<td>$10,000 (USD) From 100 to 499</td>
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<td>$7,500 (USD) Up to 99</td>
<td>$2,500 (USD) Up to 99</td>
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LF Edge membership also requires companies to corporate members of The Linux Foundation (similar to Akraino and EdgeX Foundry).
A discount of $5,000 to $20,000 is available for existing Linux Foundation members who join LF Edge.
LF Edge Membership – the benefits

**Premier**

**Influence Strategic Direction of LF Edge & its projects (as a Voting GB member)**
- Budget Influence/approval, how and where the project spends money.
- Direct Influence on messaging, developer events, training.
- Influence the marketing, messaging, and positioning to best represent the project for your uses.
- **Marketing Committee Voting Seat**

**Direct Interaction with Leadership – within LF and across peers**
- Premium access to the project ED/VP to understand business goals.
- Premium access to the Operations staff, IT, Marketing, Operations, Leadership.
- Participate in any Cross project strategy discussions on harmonization and future direction of Edge.
- LF Leadership support to Keynote member events, participate in outreach (eg roadshows, events, conference meet ups etc.)

**Technical and Roadmap Direction Influence (through the technical community)**
- **TAC (Technical Advisory Council) voting seat**
  - Find like-minded companies/developers to build a coalition to get an idea accepted and prioritized by the community.
  - Aid the developers in actions they can take to improve their standing, position, and influence in the community, etc.

**Brand Momentum – ability to show Leadership in Open Source which drives end user adoption and talent.**
- Open Source Brand Affinity, prove to your customers that you are a leader in the project, hire talented software engineers.

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**General**

**Learning and Engaging to create the largest Open Source Edge shared technology roadmap**
- Work together across company lines and industries.
- Participate in elected board seat process.

**Marketing & Thought Leadership**
- Logo on the website once your membership has been announced. LF will support with quotes on Press releases related to the project.
- Marketing Committee comprised of a representative from each Member company. General Members may appoint a representative as an observer of the Marketing Committee meetings on a non-voting basis. The objective of this Committee is shaping the marketing direction for edge. The Linux Foundation will do the heavy lifting, so this is more to oversee and shape the discussion/direction with the other Members for the Marketing efforts. This person can also funnel all Marketing information back to your organization so that the key stakeholders are in the loop.
- Participate in our hosted projects and attend our events, meetups, and roadshows.

**Technical Steering Committee & Technical Community**
- TSC meetings are open to the public and we encourage all members of the technical community to participate in the discussion moving forward.
<table>
<thead>
<tr>
<th>How Members Engage: LF Edge Marketing and PR</th>
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</thead>
<tbody>
<tr>
<td><strong>Co-promotion of</strong>&lt;br&gt;project related updates, releases, and news via LF Edge social media accounts</td>
</tr>
<tr>
<td><strong>Attend Outreach</strong>&lt;br&gt;Committee meetings and participate in LF Edge driven marketing and outreach activities</td>
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<tr>
<td><strong>Publish use cases, case studies, white papers, and deployment insights</strong></td>
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<tr>
<td><strong>Marketing and PR support for demos at meetups and events</strong></td>
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<tr>
<td><strong>Host vendor neutral content via LF Edge blog site</strong></td>
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<tr>
<td><strong>Get support for</strong>&lt;br&gt;artwork, web site, content creation, etc., related to LF Edge and its projects</td>
</tr>
<tr>
<td><strong>Be featured in the LF Edge Member Spotlight series</strong></td>
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<tr>
<td><strong>Coordination at events</strong>&lt;br&gt;– speaking proposals, booth attendance, demos, etc.</td>
</tr>
<tr>
<td><strong>Volunteer for planning initiatives such as developing annual marketing plan, preparing for major event, etc.</strong></td>
</tr>
<tr>
<td><strong>Identify LF Edge speaking opportunities in your region and help secure speakers from the LF Edge community</strong></td>
</tr>
<tr>
<td><strong>Help secure user stories about LF Edge based deployments.</strong></td>
</tr>
<tr>
<td><strong>Participate on the LF Edge Speakers Bureau</strong></td>
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</tbody>
</table>
## How Members Engage: LF Edge Technical Projects

<table>
<thead>
<tr>
<th>Participate in the development efforts: Review and submit code patches, report bugs, request new features, etc.</th>
<th>Attend developer events for LF Edge projects</th>
<th>Contribute to documentation</th>
<th>Provide your testing and deployment feedback via appropriate project channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Join the projects’ mailing lists and participate in the discussions</td>
<td>Start a local User Group Meetup</td>
<td>Join the LF Edge Technical Advisory Council (TAC) calls and subscribe to the TAC mailing list</td>
<td>Contribute to the Open Glossary of Edge Computing</td>
</tr>
</tbody>
</table>
# How Members Engage: Technical Advisory Council (TAC)

| Support TAC leadership in inviting speakers | **Attend TAC**  
**Bi-weekly calls, participate in the discussion, volunteer** | Share success stories, opportunities and challenges with the broader technical community to seek input from peers | Identify opportunities for collaboration on common interests and initiatives |
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<tbody>
<tr>
<td>Support technical leadership for harmonization efforts with other open source communities within and beyond LF Edge</td>
<td>Support TAC in hosting and sponsors intra-project and inter-project in-person developer events for LF Edge projects</td>
<td><strong>Support TAC in evaluating new projects for inclusion in LF Edge</strong></td>
<td>Support TAC Chair who works with the Governing Board to highlight the Projects’ collective opportunities and any resource needs</td>
</tr>
</tbody>
</table>

**THE LINUX FOUNDATION**

**LF EDGE**
Join Us!

Contact Mike Woster, mwoster@linuxfoundation.org

LF Edge, bringing Edge initiatives together

IOT+Telecom+Cloud+Enterprise
LF Edge Projects
Unified Edge Interoperability - key architectural tenets

1. Abstract data, apps and domain knowledge from underlying infrastructure
   - 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
   - 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
   - Plan for CI/CD, while also recognizing technical tradeoffs (e.g. constrained hardware, time critical applications) and need for OT/IT cultural evolution
STAGE 3: IMPACT 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.
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.
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 Spark, Apache 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.
Project Alvarium aims to build a framework and SDK for trust fabrics that deliver data from devices to applications with measurable confidence.
Stage 3: Impact Projects
Aims to create an open source software stack that supports high-availability cloud services optimized for edge computing systems and applications.

**Top LF Edge Blueprints**
- Network Cloud & Radio Edge
- 5G & MEC
- Connected Vehicle
- AI/ML and AR/VR Applications at the Edge
- Automated Factory

**Technical Summary**
- Finite set of configurations to reduce complexity
- Cloud Native/Edge Native- optimized for the Edge in all of its forms
- Autonomous, turn-key solutions for service enablement to enable rapid introduction
- Low latency placement and processing to support edge drivers
- Zero-touch provisioning, operations, and lifecycle (reduce on OpEx)

**Project Release Status (as of Q1 2020)**
- Current Release R4, 30+ Blueprints
- Next release (Nov 2020)

[https://wiki.akraino.org/](https://wiki.akraino.org/)
**Akraino R4 Blueprints**

- **Applications**
  - IIoT – Predictive Maintenance
  - Micro-MEC
  - IEC - Type 1
  - ELIOT
  - IOT GW/uCPE

- **Infrastructure**
  - Distributed Devices and Systems
  - Buildings / Factories / Smart Homes
  - 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

- **Last Mile Networks**
  - Access Networks
  - Aggregation Hubs/COs
  - Regional Data Centers
  - Centralized Data Centers
  - 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

- **User Edge**
  - Access Edge
  - Regional Edge
  - Dedicated, Operated

- **Service Provider Edge**
  - Shared, XaaS
  - R4 Blueprints (New)
  - R1/R2/R3 enhanced Blueprints
  - KubeEdge
  - Public Cloud Edge Interface
  - 5G MEC - Enterprise
  - The AI Edge – Security, Autonomous Vehicle, Federated Learning
  - ICN Private 5G
  - Network Cloud Family
  - Telco Appliance -Radio Edge
  - Connected Vehicle
  - IEC - Type 2-5
  - KNI Provider Access Edge (PAE) & Industrial Edge

- **LOCATIONS**
  - Aggregation Hubs/COs
  - Centralized Data Centers
  - Regional Data Centers
  - Servers in traditional cloud data centers

**Miniaturization**

- **Micro-MEC**
- **IoT GW/uCPE**

**Applications**

- **Smart Devices**
- **Connected Vehicle**
- **Industrial Edge**
- **Network Cloud Family**
- **KNI Provider Access Edge (PAE)**

**Innovation**

- **Akraino R4 Blueprints**
- **Public Cloud Edge Interface**
- **Private 5G**
- **The AI Edge**
- **ICN Private 5G**

**R4 Enhancements**

- **Blueprints**: R1/R2/R3
- **Public Cloud Edge Interface**

**Technologies**

- **5G MEC - Enterprise**
- **ICN Private 5G**
- **Network Cloud Family**
- **KNI Provider Access Edge (PAE)**

**Networking**

- **Access Networks**
- **Aggregation Hubs/COs**
- **Regional Data Centers**
- **Centralized Data Centers**

**Server Use Cases**

- **Server-based compute**
- **Regional Telco and Direct Peering Sites**
- **Traditional Cloud Data Centers**

**Educational Resources**

- **Akraino R4 Blueprints**
- **Public Cloud Edge Interface**
- **Private 5G**
- **The AI Edge**
Project Summary: EdgeX Foundry

Stage 3-Impact, founding project

A highly flexible IOT open source software framework that facilitates integration and interoperability between heterogeneous devices and applications.

Top Use Cases

EdgeX provides a common set of horizontal capabilities to support use cases across any IOT vertical. Examples:

- **Manufacturing** Remote monitoring of production equipment, get data from multiple sources and filter/transform it to react at edge before sending to the cloud for aggregation, analysis and to optimize production and maintenance.

- **Retail** - the Open Retail Initiative (ORI) promotes the EdgeX framework in retail to ingest data from cameras (OpenVino), POS systems, RFID, etc and use it at the edge for use cases like Loss Prevention and Inventory Management.

- **Building Automation** - Edge Control (control devices via a common API), use edge data to control building environment (HVAC, lighting, access). Connect to the cloud to optimize power consumption using ML.

Technical Summary

- Agnostic to: HW, OS, OT protocols, sensors and Cloud & Enterprise endpoint
- Distributable set of microservices for scalability and fault tolerance
- Enables autonomous operations and intelligence moving to the edge to address low latency decision making/actuation, bandwidth & storage, and remote ops

Project Release Status (as of Q2 2020)

- 4 Million downloads! Growing at 1 million a month!
- Geneva (1.2) commercial deployment release
- Next release Hanoi (1.3)- Oct 2020- Improved Security, better performance statistics, dynamic device provisioning/on boarding ...
Stage 2: Growth Projects
Project Summary: EVE
Stage 2 - Growth, founding project

An open edge computing 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.

Top Use Cases
- Consolidating a mix of container and VM-based workloads (e.g. for legacy apps) on the same IoT edge hardware
- Deploying edge hardware to serve as secure network proxy for downstream IoT nodes and systems
- Deploying out-of-band security and analytics apps leveraging a network SPAN port

Technical Summary
- Fully-featured bare metal orchestration foundation
- Targeted at the IoT edge: x86/Arm nodes with 1GB+ memory up to small clusters
- Supports VM, OCI/Docker and Unikernel app deployment models
- Supports zero trust security with all key functions built on HW root of trust
- Enables zero touch onboarding with no device username/password required
- Supports rollback/forward updates
- Enables IO port disablement, CPU/GPU assignment to apps, distributed firewall
- Open orchestration API for use with console of choice

Project Roadmap (as of Q1 2020)
- Increase modularity to support more deployment options
- Add support for Kubernetes via K3S and clustering
- Add mesh networking capabilities
- Continue to shrink the footprint of EVE in order to run on smaller and resource-constrained embedded edge devices

https://www.lfedge.org/projects/eve/
Project Summary: Fledge
Stage 2- Growth

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.

Top Use Cases

- Eliminate route based monitoring and deploy modern condition based monitoring, predictive maintenance and situation awareness in industrial plants, mines and factories.
- Integrate IIoT with existing OT systems (no data silos)
- Edge based anomaly detection, machine learning and AI to determine machine state and/or part quality.

Technical Summary

- Pluggable microservices based architecture to rapidly connect any new or legacy machine, sensor or PLC using Python or C.
- Easily build REST based applications and services that aggregate, buffer, transform, analyze and deliver machine data from sensors to any/all OT systems and clouds.
- Consistent IIoT management and security APIs to scale up and out

Project Release Status (as of Q1 2020)

- Deployed in manufacturing, energy, water/waste water, and oil and gas operations since Q1 2019.
- Release 1.8 March 30, 2020
  - ML/AI Tensorflow Support
  - Google Cloud North
  - Vibration Data Management 8000khz
  - New mgt/security API

https://wiki.lfedge.org/display/FLEDGE/Fledge+Home
Concentrates on driving and enabling a robust, reliable and intelligent home edge computing open source framework and ecosystem running on a variety of devices at home. To accelerate the deployment of the edge computing services ecosystem successfully, the Home Edge Project provides users with an interoperable, flexible, and scalable edge computing services platform with a set of APIs that can also run with libraries and runtimes.

**Top Use Cases**

- Service offloading in a home environment when device doesn’t have required capabilities
- Distributed computing framework to maintain low latency and high data privacy

**Technical Summary**

- Device/Service Management: Device/Services which are in home network are discovered and managed based on their service capabilities.
- Service Offloading: Low end devices request high end devices to perform computing on behalf of them using the scoring manager.
- Scoring Manager: Helps to pick a right device to perform service

**Project Release Status (as of Q1 2020)**

- Baobab (Oct 2019) with Device/service discovery, Service offloading was released
- Coconut (Oct 2020) is planned with VPN, Data Storage modules

[Link: https://wiki.lfedge.org/display/HOME/Home+Edge+Project]
A Deeper look at key highlights, project Open Horizon

Open Horizon is an application and metadata delivery and management platform.

- policy-based mechanism to securely and autonomously deliver containerized workloads to diverse edge compute nodes
- It allows workload and ML model management across fleets at hyperscale, from a single device to deployments of 10,000 nodes or greater, without requiring on-premise administration.

Seed contribution: IBM

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.

Collaboration with
- EdgeX Foundry
- Glossary
- Home Edge
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 hyperscale fleets of edge computing nodes and devices without requiring on-premise administrators.

**Top Use Cases**

› Management of ML models and containerized workloads on constrained devices

**Technical Summary**

› Provides a policy-based mechanism to securely deliver containerized workloads to edge compute nodes of varying sizes and capabilities and in various connected states.
› Fully autonomous agent runs on every edge device to enable orchestration and manage the lifecycle of your containers
› Autonomous Agreement Bots (agBots) monitor each edge node
› Model Manager automatically syncs assets bi-directionally based on policy

**Project Summary: Open Horizon**

**Stage 1 - At Large**

Project Release Status (as of Q22020)

› Launched Q2 2020 with LF Edge and incubated with LF Edge’s EdgeX
Project Summary: State of the Edge
Stage 2 - Growth

*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. The SotE Project contains LF Edge’s Glossary and Landscape projects.

**Principles**

› The edge is a location, not a thing;
› There are lots of edges, but the edge we care about today is the edge of the last mile network;
› This edge has two sides: an infrastructure edge and a device edge;
› Compute will exist on both sides, working in coordination with the centralized cloud

Project Release Status (as of Q2020)

› Moved under LF Edge April 2020

https://www.lfedge.org/projects/stateoftheedge/
Stage 1: At Large Projects
Project Summary: Baetyl
Stage I-At Large

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.

Top Use Cases
› Light, secure, and scalable edge applications
  › On drone processing
› AI/ML- Allows for processing at the edge, reducing latency
  › Quality Inspection by AI via video images
› Automated/Zero touch onboarding- remote management

Technical Summary
› Works with x86, arm, MIPS and OS agnostic
› Services to speed development
  › Video Ingress Service, ML Inference as a Service
› For unstable Networks- has local persistence

Project Release Status (as of Q1 2020)
› Baetyl as a Container- Mid 2020
› Remote Management- API Server: Certification, application config & OTA Mid 2020

https://docs.baetyl.io/en/latest/overview/WhatsIt.html
Project Summary: eKuiper
Stage I - At Large

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 Spark, Apache Storm and Apache Flink) to edge side. eKuiper introduced rule engine, which is based on Source, SQL (business logic) and Sink to develop streaming application at edge side.

Top Use Cases

› IIoT: Real-time processing of production line data
› Telematics: On-the-fly analysis of data from the car data bus
› Smart city: Real-time analysis of data from various urban facilities

Technical Summary

› Lightweight: Core server package is only about 4.5M, initial memory footprint is about 10MB
› Cross-platform
› Data analysis support by SQL
› Highly extensible
› Management CLI, REST API and web based dashboard

Project Release Status (as of Q2 2021)

› Release 1.2.0 May 2021
  › AI service func
  › Table support
› Release 1.3.0 July 2021
  › Plugin system based on rpc
Secure Device Onboard (SDO) is an automated “Zero-Touch” onboarding service.

Top Use Cases

- Enables Build-to-Plan Model — ODMs can build identical IOT devices in high volume using a standardized manufacturing process.
- SDO “Late Binding” – allows the device’s target platform to be selected “late” in the supply chain, at first power-on.
- It’s Open – means its service & cloud independent.

Technical Summary

- Secure Device Onboard provides easier, faster, less expensive, and secure onboarding of devices. It expands TAM for IOT devices, and in turn accelerates the resulting ecosystem of data processing infrastructure.

Project Release Status

Latest LF Edge Project, release 1.9 in progress
PROJECT DEEP DIVES
Stage 3: Impact Projects
Project Introduction: Akraino
Akraino: Delivering a Fully Functional Edge Solutions

Unifying multiple industry sectors of edge across disciplines, including IoT, Enterprise, Telecom, and Cloud

- Ever since its launch in 2018, Akraino continues to gain community support for innovative creation of deployable Edge solutions with work going in more than 30+ Blueprints.
- Akraino blueprints are now globally adopted in commercial solutions to address several edge use cases.
- Akraino hosts sophisticated community and multiple user labs to speed the edge innovation.
- Akraino delivered fully functional new Blueprints for deployment in R3 to address edge use cases such as 5G MEC, AI Edge, Cloud Gaming at Edge, Android in Cloud, Micro-MEC and Hardware acceleration at the edge.
- Created framework for defining and standardizing APIs across stacks, via upstream/downstream collaboration and published a whitepaper.
- Akraino introduced tools for automated Blueprint Validations, security tools for Blueprint Hardening and Edge API’s in collaboration with LF Edge projects
- Akraino community has participated in several industry industry outreach events that featured participation to foster collaboration and engagement on edge projects across the entire ecosystem.
Robust Community Contribution

Deployable and fully functional edge stack for use cases across IIoT, Telco 5G Core & vRAN, uCPE, Provider Access Edge, SDWAN, Edge Media Processing, and Carrier Edge Media Processing

✔ 40+ companies are engaged across the globe
✔ 80% of LF Edge Premier Members are active in Akraino
Robust Cross-Industry Contribution- 2020 (full year)

Deployable and fully functional edge stack for use cases across IIoT, Telco 5G Core & vRAN, uCPE, SDWAN, Connected Vehicle, AR/VR, Edge Media Processing, and Carrier Edge Media Processing

242 Unique Contributors From 70 Organizations

Top 10 Orgs
Intel Corporation
AT&T Services, Inc.
The Linux Foundation
Nokia
China Mobile
Red Hat
Tencent
Arm
ENEA Software AB
Huawei
ERICSSON
What is an Akraino Blueprint?
Community Integrated, tested, deployable, end to end Edge Stack

Benefits:
- Low Cost
- Large Scale
- Zero Touch Provisioning
- Industry Adoption
- OCP Whitebox/OEM H/W

Since launch in 2018, Akraino continues to gain community support for collaboration and validation with 30+ blueprints.
What’s Next in Akraiino - 1H 2021

› New blueprints and enhancements to existing blueprints
  › Rural Edge for Tami-COVID19
  › IoT Area
    › Project Cassini - IoT and Infrastructure Edge
  › Align Public Cloud Edge Interface with SDOs e.g. MEF LSO
  › REC fully assembled and tested following the cloud ref. design of O-RAN
› Continue API standardization and mapping
› Define Platform Security Architecture and apply to blueprints
› Enhance functionality and automation of edge workloads (e.g., Cloud Native)
› Improvement of Release Process, CI/CD, Security Certification
› Further collaborations with cross-LF Edge projects, downstream and upstream communities.
R4 Details: New Blueprints
Purpose/Features:
The purpose of Public Cloud Edge Interface (PCEI) Blueprint is to specify a set of open APIs and orchestration functionalities for enabling Multi-Domain Inter-working across functional domains that provide Edge capabilities/applications and require close cooperation between the Mobile Edge, the Public Cloud Core and Edge, the 3rd-Party Edge functions as well as the underlying infrastructure such as Data Centers, Compute hardware and Networks.

Use cases & Applications:
- Edge Multi-Cloud Orchestrator (EMCO) - PCEI Enabler
- Deployment of Azure IoT Edge Cloud Native PCE App
  - Using Azure IoT Edge Helm Charts provided by Microsoft
- Deployment of AWS Green Grass Core PCE App
  - Using AWS GGC Helm Charts provided by Akraino PCEI BP
- Deployment of PCEI Location API App
  - Using PCEI Location API Helm Charts provided by Akraino PCEI BP
- PCEI Location API Implementation based on ETSI MEC Location API Spec
- Simulated IoT Client Code for end-to-end validation of Azure IoT Edge
- Azure IoT Edge Custom Software Module Code for end-to-end validation of Azure IoT Edge
Predictive Maintenance with a Thermal Imaging Camera, vibration sensors, etc.

BP Family: IoT Workloads at the Smart Device Edge

Features:
- LF Edge’s Project EVE-OS to provide remote management, Zero Trust security (physical and software)
- LF Edge’s Fledge as an IIoT framework for sensors, historians, DCS, PLC’s, and SCADA systems and connectivity to public or private clouds
- Remote monitoring and updating of applications, without bricking the device
- AI Models, real time data capture, and cleansing at the device edge
- Sample application that can be customized to meet many different Use Cases

Use cases & Applications
- Predictive Maintenance
- Hazards monitoring (People detection in hazardous area)

Target Industry: Manufacturing, Industrial Shop Floor
The AI Edge: Federated ML Application at Edge

BP Family: AI Edge

Purpose

To provide a Federated Learning Platform that trains Machine Learning algorithm across edge devices without them sharing the data that make up the models.

Features

- FATE first unsupervised learning algorithm: Hetero KMeans
- Add Data Split module: splitting data into train, validate, and test sets inside FATE modeling workflow
- Add Data Statistic module: compute min/max, mean, median, skewness, kurtosis, coefficient of variance, percentile, etc.
- Add PSI module for computing population stability index

Landing Applications of The AI Edge: Federated ML Application at edge

Target Industry: Driverless cars, Warehouse
KubeEdge Edge Service

BP Family: KubeEdge

Purpose:
- First Release will focus on the ML inference offloading Use Case

Features:
- KubeEdge managed Application deployment and life cycle management
- ML offloading to Edge server
- Cloud(training), Edge (Inference), Device collaboration

Target Industry: Smart road, Cold chain logistics, Smart building, etc.
BP Family: KNI

Purpose/Features:
- Managing edge computing clusters from a central management hub by using Advanced Cluster Manager
- GititOps based application deployment with ArgoCD
- Cloud Native CI/CD Pipelines with Tekton
- Event streaming from edge to core with Kafka AMQ Streams and Mirror Maker
- Machine learning as a data scientist with Jupyter Notebook.

Use cases & Applications
- Machine inference-based anomaly detection

Target Industry: Manufacturing
The AI Edge: Intelligent Vehicle-Infrastructure Cooperation System (I-VICS)

**BP Family: AI Edge**

**Purpose/Features:**
- Autonomous Valet Parking

**Use cases & Applications:**
- Starting and testing the behavior planner
- Starting and testing the global planner
- Initializing the NDT localizer
- Running the EKF filter for localization
- Trajectory Following

**Target Industry: Autonomous Vehicles**
Private LTE/5G ICN

BP Family: ICN

Purpose/Features:

Creating a EPC/5G “in a box” to enable enterprises and operators to deploy LTE/5G
Uses OSS such as free5GC/Magma

Target Industry: Manufacturing, Retail, Farming, Mining
Existing (R1, R2, & R3) Blueprints
**Purpose/Features:**
Provides a complete ecosystem for enterprise applications on light weight 5G Telco Edge. Can be leveraged by Telco operators to provide edge computing capability to its enterprise users. Overall objective of this blueprint is to provide the following main features.

**R4 Improvements**
- Leverage EdgeGallery to add application/MEC Edge Orchestrator, Dev Platform, Dev and Tenant Portals
- Built a sample ROBO

**Use cases:**
- **ROBO (Remote office Branch office):** Due to limited resource and disaster prone of ROBO sites, edge native storage, Backup and restore on lightweight telco edge is supported. Smart retail with automatic shelf management on ROBO sites is developed and integrated.
- **Machine Vision on Campus Networks:** Centralized processing using wireless cameras, real-time response for detection/feedback; provide shared GPU
BP Family: 5G MEC/Slice

Purpose/Features:
The 5G MEC BP consists of two network elements. One is the edge connector which is deployed in the cloud to enable traffic offloading, subscribe edge slice and implement application lifecycle management etc. The other is the edge gateway which is deployed close to the 4G/5G network to perform traffic steering, Local DNS service and traffic management etc.

Use cases & Applications
- Cloud Gaming
- HD Video
- Live Broadcasting
- Small deployment targeting MEC in access sites or enterprise
- Medium deployment targeting MEC in central offices

Target Industry: Gaming, Video, Broadcast
Micro Multi-access Edge Computing (MEC)

BP Family: uMEC

### Purpose/Features:
Enables new functionalities & business models on network edge. Benefits include better latencies for end users; less load on network, since more data can be processed locally; and better security and privacy, since sensitive data need not be transferred to a centralized location.

### Use cases:
- Fixed installation as part of 5G NR base stations; enables new services that leverage especially low latency, such as AR/VR
- As an extension of the previous, the “Smart City” deployments have additional functions such as weather stations, cameras, displays, or drone charging stations. The control software for these functions would run on the uMEC
- In an Industry 4.0 use case set, the uMEC is deployed as part of a 5G network and would provide a platform for running services for the factory floor
- In a train, the uMEC can collect and store surveillance camera data for later uploading

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<tr>
<th>Microservices</th>
<th>Tensorflow</th>
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</thead>
<tbody>
<tr>
<td>k3s container orchestrator</td>
<td></td>
</tr>
<tr>
<td>openSUSE Linux operating system</td>
<td></td>
</tr>
<tr>
<td>Das uboot</td>
<td>PXE boot</td>
</tr>
</tbody>
</table>

Target Industry: Telco Networks
BP Family: AI Edge

Purpose/Features:
Focuses on establishing an open source MEC platform combined with AI capacities at the Edge; can be used for safety, security, and surveillance sectors as well as Intelligent Vehicle-Infrastructure Cooperation Systems.

Use cases:
- Hierarchical cluster management
- Duplex channel between cloud center and edge cluster
- Kubernetes native support
- Accurate routing of messages between clusters
- Support both x86 and arm64
IEC Type 3: Arm-Enabled Android Cloud Applications

Purpose/Features:
Supports Android applications and services running on Arm-enabled cloud architectures with GPU EC management. Arm-based cloud games need basic "cloud" features, such as flexibility and broad availability, which is the blueprint's purpose. IN R4, Android application environment is based on Robox and adding GPU Support.

Use cases:

- **Android Cloud Games**: compress the rendering of game scenes into video and audio streams on the edge Android platform. Then edge cloud server transmits the compressed game pictures to the players' game terminals through a 5G network, and obtains the players' input instructions to realize interaction. End to end latency better =< 20ms.
IEC Type 5: SmartNIC

BP Family: IEC

<table>
<thead>
<tr>
<th>Datacenter Clouds</th>
<th>Enterprise/Campus Edge</th>
<th>Mobile Edge Clouds</th>
<th>Telco Core</th>
</tr>
</thead>
</table>

Application Services Layer: Containers, Virtual Machines, and Bare Metal

Isolation and Encryption
QoS and Performance Scaling
Unified Management
Packet Processing Services
VNF’s and Container Re-Use

Purpose/Features:
IEC Type 5 is focused on SmartNIC, which can accelerate network performance and provide more management convenience. In general, the architecture consists of two layers: IaaS (IEC), SmartNIC layer. But in R4, we have two simple layers: Host Layer, SmartNIC Layer.

Use cases:
- **CT based OVS-DPDK offload into SmartNic:** accelerates network performance, saves computing resources and providing security managements.
- **Part of the UPF and VPC functions**, like load balancing, forwarding, dpi, etc offloaded into SmartNIC to enhance the performance of UPF that will be deployed in carrier’s edge cloud datacenters.

Target Industry: Telco and other carriers
**Akraino R4 Connected Vehicle Blueprint**

**Connected Vehicle**

**Purpose/Features:**
Establish OSS edge MEC platform for customized v2x application development. Tested on BM, VM and containers.

**Use cases:**
- **Smarter Navigation:** Real-time traffic info, reduced latency - minutes to seconds.
- **Reduce traffic violation:** Alerts drivers to local traffic laws.
- **Cooperative vehicle and infrastructure system:** Identifies potential risks not be seen by driver.

**Target Industry:** Transportation, Auto, Enterprise, IOT, Telecom
Akraino R2 Integrated Edge Cloud

IEC Type 4: AR/VR Oriented Edge Stack

**Target Industry**: Entertainment, Gaming, Cloud

**Purpose/Features**:  
- Architecture consists of three layers: IaaS (IEC), PaaS (Tars), SaaS (AR/VR Application)

**Use cases**:  
- (now available) **Virtual classroom**: Simulates virtual classroom, improves online education experiences  
- (in progress) **Operation Guidance**: Predicts next step for operations (e.g., assembling Lego blocks, cooking sandwiches, etc)  
- (in progress) **Sports Live**: Augments/simulate sports live, providing immersive watching experience  
- (in progress) **Gaming**: Augments/simulates game scenario, provides immersive game world
Integrated Cloud Native (ICN)

Target Industry: Telco, Cloud, Enterprise, IOT

Purpose/Features:
- Addresses overall challenges of edge deployments

Use cases:
- Zero Touch provisioning (ZTP) using BPA (Metal3, Ironic), BM provider (BMdeployment) and libvirt provider (KVM)
- Kubernetes Deployer (KuD) is being containerized - single solution deploys Multus, OVN, Flannel, accelerator plugins (SRIOV & QAT), NFD, OVN4NFV, EMCO; applications such as Edgex Foundary (IoT Framework), Containerized Firewall (cFW), and SDEWAN
- Enables nested k8s: K8s used to manage both under cloud (BM provider) & over cloud (k8s inside VM)
Akraino R2 Blueprint IOT & Far Edge

Edge Lightweight & IoT (ELIOT) - Gateway & uCPE Blueprints

**Purpose/Features:**
- Addresses IOT & Universal CPE use case
- Targets IOT Appliances
- Very thin OS and Orchestration
- Full CI/CD deployment ready and verified
- Platform is ready to support different IOT Gateway use cases for Edge computing. Video Analytics is one of use case verified on this platform.

**Updates in R2:**
- Integrated EdgeX framework for IIOT
- Supported/verified on Tailored OS, Ubuntu and CentOS
- Single-click installation
- Portal for IOTgateway or uCPE with enabled features like application and platform management
- Enables community validation testing in CI for Hardware, OS and K8s layers.
- OPC-UA test enabled on ELIOT platform.

**Target Industry:** IoT, Enterprise, Telco
Akraino R2 Network Cloud & Tungsten Fabric

Network Cloud Powered by Tungsten Fabric

Purpose/Features:

- Implements the Network Cloud with Tungsten Fabric as an SDN Controller, supports CNI for K8s & Neutron plugin for OpenStack
- Enables telco operators to take control of infrastructure

Use cases:

- Supports telco grade applications and a wide variety of VNFs & CNFs
- Offers advanced networking features supported by Tungsten Fabric, such as service chaining, network policies, security, VRRP, route advertisement, flow management, etc.
- Enables deployment of multiple remote edge sites from a single regional controller
- Consolidates settings into a single input file that defines the edge site configuration
Akraino R2 Provider Access Edge

Kubernetes Native Infrastructure (KNI)

**Purpose/Features:**
- 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.
- Supports both containerized and VM-based applications.

**Use Cases/Key Features for R2:**
- Lightweight, self-managing clusters based on CoreOS and Kubernetes (OKD distro)
- Support for VMs (via KubeVirt) and containers on a common infrastructure
- Application lifecycle management using the Operator Framework
- Support for real-time workloads using CentOS-rt

Target Industry: Enterprise, IoT
Akraino 5G RAN Telecom Access Use Cases

Purpose/Features:
- Telco-grade edge cloud platform for near-real time container workloads.
- open-source RAN Intelligent Controller (RIC)
- RIC enables telcos to deploy customizations, in the form of apps, that tailor cell network for specialized needs of customers’ own industries
- Automated CD pipeline testing the full software stack
- Integrated with Regional Controller (Akraino Feature Project) for “zero touch” deployment of REC to edge sites

Target Industry: Teleco 5G, Enterprise
Akraino R2 Network Cloud Blueprint

Network Cloud Blueprints: Unicycle with Rover & SR-IOV

Purpose/Features in R2:

- enables hardware configuration and automated deployment of multiple edge sites from a remote Regional Controller
- Supports telco-grade applications and a wide variety of Virtual Network Functions (VNFs)
- Enables deployment of multiple remote edge sites from a single Regional Controller
- Consolidates settings into a single input file that defines the edge site configuration
- Supports single server (Rover) and multi-server (Unicycle) deployments
- Deploys Openstack using Airship Treasuremap release v1.3

Target Industry: Telco, Enterprise
Network Cloud Blueprints: Unicycle with OVS-DPDK

Purpose/Features in R2:
- OVS-DPDK support into existing Network Cloud Unicycle Blueprint Family
- Joint community effort by Ericsson and AT&T
- Integration with Akraino feature project to add OVS-DPDK support to Airship distribution
- Based on Dell PowerEdge R740XD Servers to deploy Kubernetes (undercloud) and containerized Openstack platform (overcloud) using Airship
- Network Cloud Edge use cases to support vRAN & 5G core Telco grade applications

Target Industry: Telco, Enterprise
### Akraino R2 SEBA for Telco Appliance

**SDN-Enabled Broadband Access (SEBA)**

**Purpose/Features:**
- Provides an appliance tuned to support the [ONF SDN-enabled Broadband Access](https://www.onf-csf.org/) (SEBA) platform.

**Use cases:**
Utilizes a reusable set of modules introduced by the [Radio Edge Cloud (REC)](https://www.akraino.org/akraino-projects/radio-edge-cloud-rec/) from Akraino R1:
- Installation of host OS
- Configuration of network
- Installation/setup of Kubernetes cluster
- Installation/validation for SEBA components
- Utilization of reusable components of the “Telco Appliance” blueprint family
- Automated Continuous Deployment pipeline testing the software stack (bottom to top, from firmware up to but not including application)
- Integration with Regional Controller (Akraino Feature Project) for “zero touch” deployment of SEBA to edge sites

**Target Industry: Telco**
Akraino R2 Blueprint IOT & Remote Edge Use Cases

Integrated Edge Cloud Types 1 & 2

**Target Industry:** Telco, IoT, Enterprise

**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

**Updates in R2:**
- Supports both single node deployment and a 3-node deployment
- Deployment is automated in CI
- The SEBA (on Arm) use-case is integrated with the IEC platform
- Uses project Calico as main container networking solution
- Running environment deployment with multiple VMs
- PONSim installation support
- SEBA-charts submodule update, multi-arch etcd yaml files, etc.
Akraino Commercial Ecosystem Support
Akraino Commercial updates

POC & Deployment

- **SmartNic**: In R4, provides the POD environment for ByteDance, realized the offload of CT based OVS-DPDK for SmartNIC, to increase the throughput of edge network VPC and provides the security management needs.
- **Android**: In R4, used ROBOX to deploy a containerized Android system on an Arm-based server and conducted initial functional tests. Cooperated with ARM and Nvidia respectively to provide private lab environment, implement CI/CD environment deployment in the private lab.
- **PCEI**: transplant ETSI MEC location APIs and will verify them in China Mobile private lab in China.

Community Contribution Focus

- **SmartNic**: Focus on offloading network functions, improving network throughput and enhancing management of network card resources.
- **Android**: Focus on the virtual deployment of Android cloud native applications on the Arm edge cloud.
- **PCEI**: Focus on providing 5G core network functions to public cloud, improve the ETSI MEC APIs and build a unique API enabler between Telco and Cloud.

Lab resource: China Mobile provides MEC POD environment in Beijing for multiple BPs. 5G resources and accesses are under coordinating.

Public Cloud Edge Interface (PCEI) Blueprint

PCEI blueprint pursues development of multi-domain interworking capabilities to enable Mobile Operators, Public Clouds Core and Edge Compute providers as well as 3rd-Party Edge Compute providers utilizing distributed data center infrastructure, interconnection and edge services for mobile edge cloud use cases such as Mobile Hybrid/Multi-Cloud, Multi-MEC access.

- Joined PCEI blueprint as Project Technical Lead
- Proposed PCEI Reference Architecture
- Participated in the development of first PCEI feature based on OMA Zonal Presence API / ETSI MEC Location API
- Lead development and implementation of PCEI for Akraino Release 4 demonstrating EMCO orchestrator and deployments of Public Cloud Edge apps from Azure and AWS

- **KubeEdge Edge Service Blueprint**

  - This blueprint family showcases an end-to-end solution for edge services with KubeEdge centered edge stack. The first release will focus on the ML inference offloading use case.
    - Initiated blueprint project
    - Proposed the Architecture
    - Contributing to the development of end-to-end lab validation environment

- **Contributed to ELIOT: Edge Lightweight and IoT Blueprint Family project**
Akraino Commercial updates

- **Open Source ONAP software company** focusing on 5G/edge computing application automation
- New ONAP integration in the Akraino Private LTE/5G Blueprint
- Successfully completed 12 ONAP engagements
- Aarna Networks ONAP Distribution 4.0 (El Alto) available
- Recently joined PAWR, 5G Open Innovation Lab to drive 5G use cases with ONAP
- Number#1 Instructor led ONAP training provider

**Arm**

Enabled Arm architecture based hardware and software support for multiple blueprint families. These include several blueprints that share a similar set of use cases, software, and continuous integration and deployment.

- Connected Vehicle Blueprint
- Edge Lightweight and IoT (ELIOT)
  - IoT Gateway Blueprint
  - SD-WAN/WAN Edge/uCPE Blueprint
- Integrated Edge Cloud - Type 1 - 5
- Telco Appliance
  - Radio Edge Cloud (REC)
  - SDN Enabled Broadband Access (SEBA)
- 5G MEC System
  - Ent Apps on Lightweight 5G Telco Edge
  - Slice System to Support Cloud Gaming, HD Video and Live Broadcasting
- Micro MEC
- AI Edge
  - School/Education Video Security Monitoring
  - Federated ML application at Edge
  - Intelligent Vehicle-Infra Coop System(I-VICS)
- Public Cloud Edge Interface
- IIoT

POC & Deployment

AI Edge supports video security monitoring, classroom concentration analysis, factory safety production, kitchen hygiene monitoring, and also scenarios in Intelligent Vehicle Infrastructure Cooperation System. In R3, cooperated with Arm, Intel, and Huawei, set up a private lab environment, implemented CI/CD environment. More AI application for Arm architecture will be released in the future.

Community Contribution Focus

Focuses on establishing an MEC platform that combined with AI capacities at the Edge site. And it also could be used to enable the autonomous driving industry.

Predictive Maintenance with a FLIR Camera
Akraino Commercial updates

As part of Akraino R4, Huawei is associated with following blueprints family:

**Enterprise Applications on Lightweight 5G Telco Edge**: BP intends to provide an ecosystem for enterprise application on lightweight 5G Telco Edge which can be leveraged by Telecom operators to its enterprise users. BP having following salient features:

- Lightweight MEC Solution with reference to ETSI MEC Architecture.
- Developer Centric approach empowering developers to innovate & ship faster:
- Rich platform capabilities (Network, PaaS, aPaaS etc.) for Enterprise use cases.
- Autonomous Edge Sites

**Enterprise Lightweight IOT Blueprint family**: Contributing two Blueprints under this BP Family:

1. ELIOT IoT Gateway
2. ELIOT SD-WAN/WAN Edge/uCPE Blueprint

Develop an lightweight edge platform for Industrial IoT and SDWAN use cases.

Intel co-founded Akraino Edge Stack, continuously supported and contributed to the growth of the Edge ecosystem.

- Donated IA servers in Akraino Community Lab, plus supporting partners working on ICN and 5G MEC w/ Intel hosted PODs.
- Drove Integrated Cloud Native BP Family created SW Platforms for Enterprise, IoT and Telco markets, including MICN BP and Private 5G BP.
- Enabled Akraino R3 active community BPs with Intel architecture based hardware and software supported:
  - 5G MEC Slice System to Support Cloud Gaming, HD Video and Live Broadcasting BP
  - Connected Vehicle BP
  - Edge Lightweight and IoT (ELIOT) - ELIOT SD-WAN/WAN Edge/uCPE BP
  - Kubernetes Native Infrastructure (KNI) – Provider Access Edge BP
  - The AI Edge - School/Education Video Security Monitoring BP
  - The AI Edge: Intelligent Vehicle-Infrastructure Cooperation System(I-VICS)

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Juniper Network has been an active contributor in the Akraino community from the early days of its formation. They have been contributor for all three Akraino releases.

**Network Cloud with Tungsten Fabric Blueprint**

This blueprint is part of release 3 which integrates Tungsten Fabric in Network Cloud. It integrates with Regional Controller to deploy edge sites that supports both Kubernetes as well OpenStack based workloads. Tungsten Fabric provides advanced networking SDN features to the edge sites.

**Juniper is also engaged with in the Akraino Private LTE/5G Blueprint**
Akraino Commercial updates

- Worked on validating the O-RAN Near-Real Time Radio Intelligent Controller (RIC) in a live network, using the Akraino REC project
- Promoted the emerging ETSI MEC ecosystem
- The RAN Intelligent Controller Project utilized the NokiaAirframe Open Edge Server Hardware that is based on Open Compute Project Design. Open Edge provides Ultra-small footprint for easy installation at the network edge; an extended temperature range, robust seismic tolerance enabling deployment worldwide; and provides the performance and low latency required by Cloud RAN and MEC.

SmartNIC for Integrated Edge Cloud (IEC) Blueprint

- SmartNIC (DPU) can be used to accelerate network performance, save computing resources and offer isolated control plane, etc.
- In R4, to enable network security but also guarantee network performance, OVS-DPDK based connection tracking (CT) full offload (both control plane and data plane) is validated on DPU with extraordinary performance.
- The solution covers not only edge use cases in Telco, such as EC infrastructure, VPC and 5F UPF, but also industries elsewhere.
Akraino Commercial updates

POC & Deployment

- Connected Vehicle Blueprint can be flexibly deployed in physical machines, virtual machines, containers and other environments. TARS framework is an important open source component of Connected Vehicle Blueprint, which can efficiently complete the massive deployment and governance of micro-services.
- IEC Type 4 AR/VR applications, in general, the architecture consists of three layers: IaaS(IEC), PaaS(TARS), SaaS(AR/VR Application). TARS framework can efficiently complete the massive deployment and governance of micro-services, and make AR/VR applications deployed in physical machines, virtual machines, containers and other environments.
- 5G MEC/Slice system to support cloud gaming, HD video and live broadcasting; provides an edge connector and edge gateway to enable traffic offloading to edge applications, and supports application lifecycle management by using openNESS in R3. Means to subscribe edge slice, intelligent traffic management and enhanced local DNS will be provided in the future release.

Community Contribution Focus

- Connected Vehicle Blueprint, focuses on Internet of Vehicles (IoV) application MEC platform, which helps the rapid landing of IoV applications.
- IEC Type 4 focuses on AR/VR applications running on edge.
- PCEI: Focus on use the 5G MEC open API provided by operator to support 5G MEC solution based on public cloud (i.e., ECM)

1. POC & Deployment
The AI Edge: Federated ML application at edge provide Federated Learning Platform for data stored locally, improves accuracy in the edge computing. FedVision is provided in R3. More federated applications and quick validations will be provided in the future release.

2. FedVision
A machine learning engineering platform to support the development of federated learning powered computer vision applications.

3. Community Contribution Focus
Focuses on providing a federated learning platform which can be used in privacy protected and distributed edge applications such as vision, financial technology, Marketing Intelligence.

- Proof of Concept (PoC) completed for Akraino KNI R2 release on baremetal servers in 5G Lab.
- Proof of Concept (PoC) completed for Akraino KNI R3 release on virtual baremetal in 5G Lab.
- Implementing OpenAirInterface (OAI) use case on KNI R3.
- Showcasing Akraino and KNI blueprint to customers
Akraino Executive Summary

Akraino is an Edge project targeted to

› Address Telco, Cloud, Enterprise and Industrial IoT use cases

Akraino 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}.
   Production deployable means the blueprint has passed unit and integration testing and meets the blueprint's use case characteristics.
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]}
4. 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 Mission: Delivering a Fully Functional Edge Stack

1. Unify multiple sectors of edge across disciplines, including IoT, Enterprise, Telecom, and Cloud

2. Deliver tested and validated deployment-ready blueprints

3. Create framework for defining and standardizing APIs across stacks, via upstream/downstream collaboration
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.
Project Introduction: EdgeX Foundry
EdgeX Foundry Addresses the Inherently Fragmented IoT Edge

<table>
<thead>
<tr>
<th>Domain Expertise</th>
<th>Connectivity</th>
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<tbody>
<tr>
<td>Analytics</td>
<td>IoT standards work is progressing, but there will always be widespread fragmentation in connectivity</td>
</tr>
<tr>
<td>Data MGMT</td>
<td></td>
</tr>
<tr>
<td>Security</td>
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<tr>
<td>System MGMT</td>
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<tr>
<td>Services</td>
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</tbody>
</table>

Many different tools and skill sets are required to address myriad industry verticals and use cases

<table>
<thead>
<tr>
<th>Application Environments</th>
<th>Operating Systems</th>
</tr>
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<tbody>
<tr>
<td>Java</td>
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</tr>
<tr>
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<td>Windows</td>
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<td>.NET</td>
<td>Pulsar Linux</td>
</tr>
<tr>
<td>Go</td>
<td>VxWorks</td>
</tr>
<tr>
<td>C/C++</td>
<td>yocto</td>
</tr>
</tbody>
</table>

Variable preferences for coding and application environments among developers

No line of sight to consistent choices across Linux, Windows and embedded/RTOS variants
EdgeX Foundry Overview

EdgeX Foundry is the world’s first plug and play Open Source platform for the IoT Edge with a vendor-neutral global ecosystem

- **Interoperability for Heterogeneity and Variations:** At the heart of the project is an interoperability framework hosted within a full silicon-, hardware-, OS-, protocol- and cloud/application- agnostic software reference platform, enabling an ecosystem of plug-and-play components that unifies the marketplace and accelerates the deployment of IoT solutions.

- **Speeds time to market:** Provides replaceable reference services for device data ingestion, normalization, analysis and sharing in support of new IoT data services and advanced edge computing applications.

- **Global Open Ecosystem:** Global open ecosystem offers range of complementary products and services, including commercial support, training and customer pilot programs in addition to plug-in enhancements for device connectivity, applications, data and system management and security.
EdgeX Foundry Architecture

LOOSELY-COUPLED MICROSERVICES FRAMEWORK

EXPORTING AND APPLICATION SERVICES
- ADDITIONAL SERVICES
- APPLICATION SERVICE

SUPPORTING SERVICES
- RULES ENGINE
- SCHEDULING
- ALERTS & NOTIFICATIONS
- LOGGING
- ADDITIONAL SERVICES

CORE SERVICES
- CORE DATA
- COMMAND
- METADATA
- REGISTRY & CONFIG

DEVICE SERVICES (ANY COMBINATION OF STANDARD OR PROPRIETARY PROTOCOLS VIA SDK)
- REST
- OPC-UA
- MODBUS
- BACNET
- ZIGBEE
- BLE
- MQTT
- SNMP
- VIRTUAL

"SOUTHBOUND" DEVICES, SENSORS AND ACTUATORS

“NORTHBOUND” INFRASTRUCTURE AND APPLICATIONS

THE LINUX FOUNDATION

Your data liberated
EdgeX Foundry Goals

1. Create an open and unified IoT Edge platform to drive innovation, global market adoption, velocity and scale

2. Enable and encourage a rapidly growing global ecosystem
   ○ of IoT solutions providers to create a rich set of interoperable plug-and-play components
   ○ Certify both OSS and commercial value-add from the ecosystem against the defacto standard EdgeX APIs to ensure interoperability and compatibility
   ○ Provide tools to quickly create EdgeX-based IoT edge solutions

3. Collaborate with relevant open source projects, standards groups, and industry alliances to ensure consistency and interoperability across the IoT landscape
What Public Clouds Are Saying

From Amazon:

“AWS will collaborate with open source EdgeX Foundry to create IoT edge interoperability.

The EdgeX framework is the perfect complement to AWS IoT to enable our customers with an open foundation to simplify integration across inherently heterogeneous solution stacks

EdgeX provides open data ingestion for AWS services like AWS IoT Greengrass at the edge and AWS IoT Core in the cloud, made even better with plug-in value-add from the growing EdgeX Foundry and LF Edge ecosystems.”
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. Created collaboratively by a global ecosystem, EdgeX Foundry’s new release is a key enabler of digital transformation for IoT use cases and is a platform for real-world applications both for developers and end users across many vertical markets.

● 4th EdgeX Foundry release, now deployment-ready to enable IoT digital transformation across Enterprise, Industrial, Retail/Commerce and Consumer use cases

● Anchor Release for Commercial Adoption

  ○ Complementary products, services, support, training and customer pilot programs
  ○ Plug-in enhancements for device connectivity, applications, data/system management & security
  ○ Stable API’s protecting future investment and supporting future long term support
  ○ Improved SDKs for vendor agnostic north and southbound connectivity plus many standard connectors

● New Features including binary support, database “swapability”, improved APIs to help facilitate management/monitoring capability

● Collaboration w/ Consortiums & Verticals

  ○ AI test beds within the Industrial Internet Consortium (IIC) and the foundation for the Open Retail Initiative (ORI) led by Intel
EdgeX Foundry Edinburgh Release - Key Highlights

- **4th EdgeX Foundry release, now deployment-ready to enable** IoT digital transformation across Enterprise, Industrial, Retail/Commerce and Consumer use cases
  - Anchor Release for Commercial Adoption
  - Complementary products, services, support, training and customer pilot programs
  - Plug-in enhancements for database and messaging infrastructure
  - Enhancements around device connectivity, application services, management and security
  - Stable API’s protecting future investment and supporting future long term support
  - Improved SDKs for vendor agnostic north and southbound connectivity plus many standard connectors both open source and commercial

- **Important New Features**: including binary support, database “swapability”, improved APIs to help facilitate management/monitoring capability

- **Collaboration w/ Consortiums & Verticals**
  - Foundation for new AI/Analytics test bed within the Industrial Internet Consortium (IIC)
  - Foundation for the Open Retail Initiative (ORI) led by Intel
Edinburgh Key Enhancements

Generic Platform Enhancements

• Additions of unit and black box testing over the entire platform as well as the inclusion of automated security feature testing
• Improvements to on-boarding EdgeX users
• Construction of a new performance framework
• Improvements and cleanup around configuration bootstrapping, scheduler service, device profiles, API gateway and security secret store
• Ability to trace sensor data from the sensor to export while also supporting better debugging and performance metrics tracking

Support for Redis & MongoDB for all database; new vendor neutral API for easy swap-out to improve vendor choice

New improved Northbound Applications Service
Improved Device Service SDKs in Go and C; Many new Open Source and Commercial connectors to popular ‘Thing’ protocols

Advancement for the ingestion, use and export of binary data in CBOR format

Enhancement of the system management facilities (track/report on service CPU usage and metrics + track the operational status of each EdgeX service)
Example EdgeX Foundry Use Cases and Market Utilization
EdgeX in Building Automation

Cloud

Edge

Dell 3000 Gateway Series

Cloud Vendors
- Storage
- Big Data Analytics
- Dashboard

Pulse™
- Systems Management
- Security
- Project IRIS

RSA

Data / control

PHOTON OS™

- Data Collection & Aggregation
- Edge Analytics
- Edge Control
- Cloud Integration

Data

Data / control

Dell 3000 Gateway Series

 Project IRIS

• Data Collection & Aggregation
• Edge Analytics
• Edge Control
• Cloud Integration

Data / control

Climate control

Lighting control

Energy Management

Occupancy tracking

Data

Energy Monitor

Key Reader Access Control

Vendors

THE LINUX FOUNDATION

12
EdgeX in Industrial / Process Control
EdgeX in Smart Cities (Water Treatment)

- Developed by the SI Technotects after an end customer independently recognized the potential for EdgeX to provide them with more flexibility and reduce costly runtime licensing fees
- Leveraged Dell Edge Gateways, IOTech Edge Xpert, VMware Pulse IoT Center for management, Photon OS, RedisEdge for data persistence, and both Inductive Automation Ignition and native EdgeX Device Services for data ingestion
- Technotects was able to successfully reproduce the customer’s use case with EdgeX while also providing them with more options from the open ecosystem
- See the case study blog for more detail
EdgeX in Commerce – Intel RRK for the Open Retail Initiative (ORI)

- EdgeX serves as the foundation for the Intel-led Commerce Working Group within the EdgeX project
- Related Intel RFP Ready KiT (RRK) includes content from IOTech (Edge Xpert), Pixeom (container orchestration), HPI and Dell (edge HW) in addition to linking to Intel’s OpenVINO computer vision framework
- Video events from OpenVINO ingested into EdgeX for analysis in concert with telemetry from other sensors (e.g. building and energy systems, RFID)
EdgeX in the OMPAI AI Testbed within the IIC

- Within the Industrial Internet Consortium (IIC), the Optimizing Manufacturing Processes by Artificial Intelligence (OPMAI) testbed leverages ML algorithms, technologies, and technical frameworks to apply optimally distribute AI from edge to cloud to solve specific production quality, cost & efficiency problems in an automotive manufacturing environment.

- Leveraging the EdgeX framework, AI models and edge applications are run for the local optimization of manufacturing processes. In the cloud platform, they are run to enable global and long-term optimization, e.g. across production lines and plants.
Industrial AIoT Edge Applications based on EdgeX

- **EdgeX 1.0 Release**
  - 2019 05

- **Power Grid Monitoring Solution**
  - 2019 07

- **Edge Camera Service and Video Analysis**
  - 2019 09

- **Water Affairs Solution**
  - 2019 12

- **JX IoT Edge Platform, EdgeBox Dev Kit**
  - 2020 01

- **Sensing and Control Device Services**
  - 2020 02

- **Connect to Baidu BIE**
  - 2020 03

- **Smart Substation Solution**
  - 2020 04

- **Energy Router**
  - 2020 05

- **Edge IoT Gateway**

**Commercialization**

- **Grid Company**
- **Power Plant**
- **Water Affairs**
Examples of Commercial Offers in the Open EdgeX Foundry Ecosystem
IOTech Edge Xpert

Edge Xpert uses the latest stable release of EdgeX Foundry to create a commercially supported solution from the baseline open source technology. IOTech will also soon announce hard real-time extensions to EdgeX.

For more info: http://www.iotechsys.com/what-we-do/products/edge-xpert/
## VMware Open IoT Edge Stack

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Management & Orchestration** | - Application management  
                              - Health monitoring  
                              - Updates                                                             |
| **Data & Application Services** | - Reference services for devices, applications, processing and orchestration  
                              - Backed by open EdgeX ecosystem                                      |
| **Operating System**         | - Curated with Photon (lightweight, optimized for containers) but can used with alternate OS’es |
| **Hardware**                 | - Curated with Dell Edge HW  
                              - Several reference boards  
                              - Any BYOD hardware (x86 or ARM)                                           |
RedisEdge from Redis Labs

EdgeX + RedisEdge

- RedisEdge is a commercially supported, purpose-built data service platform for IoT Edge Computing
- Ingest and react to data at speed with <1ms latency
- Multi-model data with Streams, AI, Time-Series
  - Replace reference rules engine
  - Support TensorFlow inference
  - Support analytics/visualization
- Orchestrate data with Gears

Redis Labs

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Mainflux MFX-1 IoT Edge Gateway

The Mainflux MFX-1 IoT Edge Gateway is an edge computing solution based on EdgeX because it supports communications “north, south, east and west” as needed in the IoT “fog” and can be deployed on a variety of edge nodes in a tiered computing architecture.

For more info: https://www.mainflux.com/edge.html
Stage 2: Growth Projects
Project Introduction: EVE
What is Project EVE?

An open edge computing engine that simplifies the development, orchestration and security of cloud-native applications on distributed edge hardware.

Supporting containers, VMs and unikernels, EVE aims to provide a flexible foundation for Industrial and Enterprise IoT edge deployments with choice of hardware, applications and clouds.

Any centralized orchestration controller can take advantage the EVE foundation and open APIs to abstract complexity and prevent proprietary vendor lock-in.

Visit the project site for more information.
Why EVE?

EVE addresses the unique properties of IoT edge computing nodes deployed outside of the traditional datacenter.

**Diversity**
Inherent diversity of technology and domain expertise required.

**Scale**
Unprecedented scale and geographic distribution of deployed nodes.

**No Perimeter**
No physical or network perimeter dictates a zero trust security model.

The IoT edge needs a standard foundation for orchestration and virtualization that is flexible, open and agnostic.
EVE Aims to be the Android for the IoT edge

<table>
<thead>
<tr>
<th>App and OS Sandboxing</th>
<th>Containers and hardware-assisted virtualization</th>
<th>JVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>App Bundling</td>
<td>Edge Compute Objects (ECOs)</td>
<td>APK</td>
</tr>
<tr>
<td>App Deployment</td>
<td>Remotely deployed by IT/OT</td>
<td>Downloaded locally by end user / remotely deployed by IT</td>
</tr>
<tr>
<td>HW Support</td>
<td>x86, Arm (+RISC V), co-processors (e.g. GPU, FPGA)</td>
<td>x86, Arm, MIPS</td>
</tr>
</tbody>
</table>

*Targeting edge compute nodes with 512MB+ of available memory up to small clusters*
Comparison of Architectural Approaches

**EVE Edge Computing Engine**
- Bare metal foundation enables deep security and networking functionality
- 100% open orchestration API with vendor-neutral governance through LF Edge
- Supports both containers and VMs
- No risk of bricking during updates
- Optimized for constrained IoT edge compute hardware

**Proprietary Bare Metal**
- Similar story for security, networking and update resiliency
- API lock-in to proprietary controller
- Current solutions for IoT edge support either containers or VMs, not both
- Data center solutions do not work for constrained IoT edge hardware

**Agent-based (OSS or Proprietary)**
- Security gaps without investment in OS integration and hardening
- Risk of bricking during updates
- Only support containers
- Proprietary variants create lock-in
- Can be complementary by leveraging EVE as foundation
EVE Edge Computing Engine Architecture

### Project Scope

- Establish standardized Edge Compute Object (ECO) format
- Build EVE edge computing engine and controller interface
- API + CLI reference implementation
Summary of Key Capabilities

› Access to hardware root of trust (e.g. TPM) when deployed on bare metal, supporting functions such as crypto-based ID (no device usernames and passwords), measured boot, signed updates, encryption, etc.
› “Secure by default” deployment profile
› High efficiency and usage of device resources including remote control of CPU, memory, networking and device ports
› Hosting of any combination of apps in virtual machines and containers
› Hosting of any operating system deployable in a virtual machine
› Serverless capability via unikernels
› Ability to assign CPU and GPU cores to specific apps
› Ability to block unused I/O ports
› Remote updates of entire software stack with rollback capability to prevent bricking
› Automated patching for security updates
› Automated connectivity to one or more backends (cloud or on premises)
› Distributed firewall
Example Use Cases

- Extract data for local analysis / cloud and connect to new sensors
- Consolidate legacy and cloud-native workloads with no interference to existing setup
- Secure apps with private networks

IoT Edge Workload Consolidation

- IT, ERP, MES
- Legacy Hardware

Edge Security and Analytics

- Added security for current/legacy IoT installations
- Deploy a network proxy application (e.g., MQTT)
- Add app to update firmware of legacy hardware

- Deploy and manage security and analytics apps
- SPAN port collector on network enables non-intrusive, out of band data collection
- Gain visibility, monitor traffic and trigger events

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LF EDGE
Target Project Roadmap for 2020

› Increase modularity of EVE architecture to support more deployment options
› Add support for managed containerd and deploying composite containerized applications via Docker Compose
› Add support for Kubernetes via K3S and clustering
› Expand hypervisor support to include KVM and ACRN for time-sensitive workloads
› Add mesh networking capabilities for edge-to-edge data flow
› Add cloud networking using standard VPN technologies available in public clouds
› Continue to shrink the EVE runtime in order to run on smaller and resource-constrained embedded edge compute
Project Introduction: Fledge
Fledge is an open source framework and community for the industrial edge focused on **critical operations**.

Fledge is architected to integrate IIoT, sensors and modern machines all sharing a common set of administration and application APIs with industrial “brown field” systems.

Fledge developers build smarter, better, cheaper industrial solutions for:
- Condition-based monitoring
- Predictive maintenance
- Smarter/Autonomous machines
- Situational Awareness for security and safety

Using Fledge APIs, modern factories and plants operate efficiently and secure.

Open Source is new to manufacturers and manufacturing is new to the Linux Foundation so the Fledge community consists of manufacturers, equipment suppliers, integrators, OT system suppliers and technology suppliers to accelerate Industrial 4.0 adoption – join us.
Industrial Operators

Critical Operations Plant Wide
- Condition-Based maintenance
- Predictive maintenance
- Situation awareness
- Increased safety
- OEE, TPM

How
- Connect all machines, sensors
- Put all data in plant wide context
- Eliminate fragmentation and complexity
- Use Fledge’s common APIs to manage, secure and operate as a system

Industrial SIs

Lead Industrial 4.0 Transformations
- Accelerate deployments
- More/tighter Integrations
- Own and re-use your value-add code
- Develop ML/AI expertise
- Increase value delivered/hour

How
- Connect all machines, sensors to old and new OT/IT Systems
- Put all data in plant wide context
- Build services around latest ML/AI tools
- Use Fledge’s common APIs to manage, secure and operate as a system

Industrial Equipment Vendors

Smarter more Autonomous Machines
- Machines that learn
- Machines that maintain themselves
- Machines that integrate
- New business models/higher margins
- Machines that compete

How
- Use latest ML/AI tools
- Use modern architectures
- Avoid proprietary APIs and cloud lock-in
- Save development time and money
- Use Fledge’s common APIs to manage, secure and operate as a system
Fledge Architecture

- Collect Data - from any/all sensors
- Aggregate - combine and organize data
- Transform - filter and transform data
- Buffer – protect data
- Edge Analytics - understand data
- Deliver Data - to multiple destinations

Fledge is architected to enable industrial interoperability, advanced application development, cloud portability and system management.
Fledge - Feature, Quality, Cost and Time Benefits

› Micro service based – scalability, robustness, faster build-test-deploy
› Plugins – simple to add new protocols, devices and processes
› Exponentially grow combinations of inputs, outputs and processing – huge development/community leverage
› Apache License – Business and technical flexibility
› Any Linux and embedded - More tools, HW choices, very small footprint
› Multi-language support (C++, Python, …) – Performance and easy to add value
› Plug and play input, output and processing – no coding required
› Commercially supported
Fledge Use Cases
and Market Utilization
Fledge and Google Tensorflow
Edge ML/AI for Industrial Applications

- Use Google tools for edge ML/AI applications
- Supervised, un-supervised, semi-supervised learning
- Run models in Fledge
- Alert
Fledge In Energy
Predictive Maintenance - Wind Turbine Bearings

- Data Collection & Aggregation
- Edge Analytics
- Alerting
- IT-OT System Integration

- Monitors pitch motors/time
- Predictive maintenance vs break fix
- Integrated with DCS data
Fledge In Energy
Replace Route Based Monitoring – Chemical Totes

Advantech
UNO 2271G

Siemens LU180
Ultrasonic Level Transmitter
4mA Analogue

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250 Gallon
Chemical Totes

Advantech
UNO 2271G

Siemens LU180
Ultrasonic Level Transmitter
4mA Analogue

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Data Collection & Aggregation
Edge Analytics
Alerting
IT-OT System Integration

• Monitors chemical levels in totes
• Replace manual processes – RBM
• KPI data for plant efficiency
• Integrated w/ SCADA data
Fledge In Energy
Predictive Maintenance/Monitoring - Transformers

• Data Collection & Aggregation
• Edge Analytics
• Alerting
• IT-OT System Integration

• Monitors oil pump and fans
• Monitors oil and air temp
• Predicts transformer life-time
• Eliminates break fix maintenance
• Serves maintenance processes
Fledge In Energy
Condition Based Monitoring - Transformers

- Data Collection & Aggregation
- Edge Analytics
- Alerting
- IT-OT System Integration
Fledge In Municipal Water
Condition Based Monitoring - Pumps

- Data Collection & Aggregation
- Edge Analytics
- Alerting
- IT-OT System Integration

FLIR AX8
High-Low-Avg Temp
Focused on pump's bearings

Ethernet to Nexcom
Fledge In Mining
Condition Based Monitoring – Slurry Pumps

• Data Collection & Aggregation
• Edge Analytics
• Alerting
• IT-OT System Integration

Advantech
1124

MTS
Vibration Sensors
X-Y-Z Planes

Dianonomic
System Management
Commercial Support

OSIsoft
T&D Operations & Management

AWS
Storage
Big Data Analytics

ADVANTECH ADC

Current Sensor
HO21-100A 5B

KSB
Slurry Pump
Ingress/Egress Processing Plant

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OLF EDGE
Fledge In Manufacturing
Situation Awareness – Aircraft Paint Booths

- Data Collection & Aggregation
- Edge Analytics
- Alerting
- IT-OT System Integration

- Monitors paint booth micro-climates
- Go/No-Go start paint process
- Integrated with CNC machine and autoclave status
Synergy and Engagement with Other LF Edge Projects

› Fledge is working closely with Project EVE. Project EVE provides system and orchestration services and a container runtime for Fledge applications and services. Together industrial operators can build, manage, secure and support all their non-SCADA, non-DCS connected machines, IIoT and sensors as they scale.

› Fledge is also driving towards opportunities with Akraino, with the Project’s verticals starting to roll out 5G and private LTE networks. Using Akraino blueprints, Fledge applications and services can be consistently managed as they utilize 5G and private LTE networks. Fledge’s first public use case was a private LTE network serving a wind farm where Fledge predicted maintenance conditions for turbine’s bearings.
Project Introduction: Home Edge Project
Facts: Existing Systems

- **Latency**
  - **Latency**: 0.82 milliseconds for every 100 miles
  - **IoT devices** → **Edge computing device** → **Firewall** → **Cloud data center**

- **Data Privacy**

  - **81%** Believe they are safer
  - **72%** Feel more relaxed
  - **13%** Are fearful of personal data
  - **52%** Worried about being spied on

---

**COST OF DATA BREACHES**

- The average cost of a data breach is $3.86 million.
- In 2019, healthcare had the highest data breach cost at $6.8M.
- The average cost per lost or stolen record in a data breach is $154.
Growth: Smart Home

Local data processing
for secure workloads, latency-sensitive data analytics, IoT and media services.

Real-time IoT and AI analytics
for optimising, building and innovating for robotics, mixed reality and automation tools.
Need: Home Edge

- What Smart Devices Do
  - Self-diagnosis
  - On/off control
  - Motion sensors
  - Energy saving
  - Security
  - Shopping

- Large volumes of image data — consuming large bandwidth
- Secure passcodes
- Image data - privacy

- Sensitive health data
- Private health record

- Always on listening
- Time NLP

The Linux Foundation
**Trend: Edge Platform**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>AWS Greengrass (Started: '18)</th>
<th>MS Azure IoT (Started: '18)</th>
<th>Google IoT Edge (Started: '18)</th>
<th>EdgeXFoundry (Started: '17)</th>
<th>Home Edge (Started: Oct '19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported Hardware</td>
<td>CPU/GPU</td>
<td>CPU/GPU</td>
<td>CPU/GPU/Edge TPU</td>
<td>CPU/GPU</td>
<td>CPU/GPU</td>
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<tr>
<td>SDKs</td>
<td>Device SDK/Core SDK/</td>
<td>Device SDKs</td>
<td>Android Things SDK</td>
<td>EdgeX Device SDK Service SDK</td>
<td>Application SDK</td>
</tr>
<tr>
<td></td>
<td>Machine Learning SDK</td>
<td>Service SDKs</td>
<td>Weave SDK</td>
<td></td>
<td></td>
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<tr>
<td>Messaging Support</td>
<td>MQTT/HTTPS/WebSocket</td>
<td>MQTT/HTTPS/WebSocket/</td>
<td>MQTT/HTTPS/gRPC</td>
<td>MQTT/BLE/ZIGBEE/SNMP/REST/BACNET/MODBUS...</td>
<td>HTTP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AMQP/CoAP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Learning</td>
<td>Amazon SageMaker services</td>
<td>Microsoft Cognitive services</td>
<td>Tensor Framework Colab</td>
<td>NA</td>
<td>Scoping</td>
</tr>
<tr>
<td>Server less functions</td>
<td>Lambda function</td>
<td>Azure function</td>
<td>Cloud Run</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device State Sync</td>
<td>Device Shadow</td>
<td>Device Twin</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Embedded OS</td>
<td>Amazon FreeRTOS</td>
<td>Windows 10 IoT Azure Sphere</td>
<td>Android Things</td>
<td>Custom OS</td>
<td>Custom OS [linux/Android/Tizen]</td>
</tr>
<tr>
<td>Open Source</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Container Registry</td>
<td>Amazon Elastic Container</td>
<td>Azure Container Registry</td>
<td>Docker Registry</td>
<td>Docker Registry</td>
<td>Docker Registry</td>
</tr>
<tr>
<td></td>
<td>Registry (ECR) and Docker</td>
<td>(ACR) and Docker Registry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Containerization Support</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Compute Offloading</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes (Scoring Manager)</td>
</tr>
<tr>
<td>Multi NAT support</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes (VPN)</td>
</tr>
<tr>
<td>Platform Supported</td>
<td>Linux</td>
<td>Linux</td>
<td>Linux</td>
<td>Linux</td>
<td>Linux, Android and Tizen</td>
</tr>
</tbody>
</table>

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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 Executive Summary

Home Edge is a project targeted to

› Enable Home Edge Computing Framework, platform and ecosystem

Home Edge Scope

› Define use cases, architecture and technical requirements
› Develop and maintain the features and APIs targeting Smart Home use cases and requirements in a manner of open source collaboration
› Upstream the core features back to the existing/upcoming LF edge open source projects.
› Connect with Blueprints on Smart Home & Akraino through testbed validation

Technical requirements

› Dynamic device/service discovery at “Home Edge”
› Quality of Service guarantee in various dynamic conditions (eg devices On or Off)
› Distributed Machine Learning
› Multi-vendor Interoperability
› User Privacy
## Achievements

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Impact</th>
</tr>
</thead>
</table>
| **TSC Maintainer/Committer** | • Technical Steering committee chair member, Maintainer and Committer  
• Community members – IBM, EdgeX, Ericsson, Intel, Kong | Community presence and expansion of platform |
| **Home Edge – Base code** | Base Feature.  
Platform: Linux  
Release plan:  
(https://github.com/lf-edge/edge-home-orchestration-go/tree/Baobab) | Device/Service discovery in Home environment and service offloading. This helps in data security by local execution and reduced operational cost with less cloud involvement. |
| **Multi Edge Communication** | Multi NAT Device Discovery  
Platform: Linux (Containers)  
Release plan:  
*Completed*: Feature development 100%  
*In Progress*:  
Release to LF Edge – Coconut release – Oct 2020 | Device can seamlessly communicate in home network, even though devices are connected to different APs. |
| **Data Storage Framework** | Centralized Storage of data from various multi edge devices  
Platform: Linux  
Release plan:  
*Completed*: Device Service module on the device has been completed  
*In progress*:  
Release to LF Edge – Coconut release – Oct 2020 | Low end devices with memory constraint can take advantage to store data locally. Faster exchange of data between devices with no cloud involvement. ML models can be applied locally at the “Superior” device. |
**Home Edge: High Level Platform Architecture**

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
- Controller Installer
- Controller Adapter
- Air Conditioner
- Other Devices

Other Edge Services...*

Speech Recognition

Vision Service

Other AI Service

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

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

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

* 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
Technical Aspects

● Edge Orchestration for easy connection and efficient resource utilization among Edge devices.
● REST based device discovery and service offloading
● Service Offloading to other device
  ○ Sharing of resource information to all the edge devices. (CPU/Memory/Network/Context)
  ○ Selecting Edge Device for execution of service based on device capability

● Multi Edge Communication for multi NAT device discovery
● Data Storage – Single node to store all device data and exchange to devices when requested
● Moved from Java based to Go
● Go over rules over Java in terms of:
  ○ Execution time – Compiled to machine code and executed directly
  ○ Memory Management – No reference and only pointers
  ○ Minimalist language - Simple, Orthogonal features
## Major Components

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discovery Manager</td>
<td>Provide to register/discover/manage of edge device/app in the network</td>
</tr>
<tr>
<td>Configuration Manager</td>
<td>Provide to create/delete/update configuration/capability of the edge apps</td>
</tr>
<tr>
<td>Scoring Manager</td>
<td>Provide measure to score each connected device based on the available resource.</td>
</tr>
<tr>
<td>Orchestration API</td>
<td>Provide API interface for using orchestration agent.</td>
</tr>
<tr>
<td>Network Manager</td>
<td>Provide NAT Traversal in the edge network</td>
</tr>
<tr>
<td>Storage Manager</td>
<td>Provides the interface with EdgeX with data storage</td>
</tr>
<tr>
<td>MNEDC</td>
<td>Necessary functionality for running MNEDC server and managing virtual IP’s.</td>
</tr>
</tbody>
</table>
Home Edge: Intro of Latest Release (Baobab)

- Edge Device/App. discovery
- Device resource monitoring and preliminary service offloading
  - Called “Scoring Manager” based on formula basis
  - Will be improved by adopting Machine Learning (based on usage patterns)
- Edge App. Remote execution
- Support Android (*.apk)
- Secure messaging TLS
- Sample service (Distributed Web Engine)

* Details:
  (Wiki) [https://wiki.lfedge.org/display/HOME/Release+Notes+for+Baobab](https://wiki.lfedge.org/display/HOME/Release+Notes+for+Baobab)
  (GitHub) [https://github.com/lf-edge/edge-home-orchestration-go/tree/Baobab](https://github.com/lf-edge/edge-home-orchestration-go/tree/Baobab)
Release

**Alpha** (June, 2019)
Edge orchestration: Edge device/service discovery and remote service execution among edge devices.
- Edge orchestration features: Basic features of Service Management (Lifecyle management), Monitoring.
- Service Offloading to other device
  - Sharing of resource information for all the edge devices (CPU/Memory/Network/Context)
  - Selecting Edge Device for service execution based on the capability of the device.

github: [https://github.com/lf-edge/edge-home-orchestration-go](https://github.com/lf-edge/edge-home-orchestration-go)

**Baobab** (October, 2019)
Custom edge device selection for service execution, Secure messaging
- Secure messaging: HTTPS, TLS
- github: [https://github.com/lf-edge/edge-home-orchestration-go/tree/Baobab](https://github.com/lf-edge/edge-home-orchestration-go/tree/Baobab)

**Coconut** (Target: Oct, 2020)
- Edge Orchestration Module: NAT discovery (requires STUN/TURN server), VPN
- Local Data Storage – EdgeX Foundry collaboration

License: Apache 2.0  Contributor: Samsung (Korea/India/Ukraine)
Play Around - Azure IoT Edge
Global Presence | Achievements

[1] **Surveillance camera tampering**: Offloading of video analytics service computation from low to high computing device.

[2] **Unsupported video playback**: Offloading of video conversion from low to high computing device.

Home Edge devices can extend services through offloading of computation by sharing capability of connected devices.
Home Edge: Use Cases – Anomaly Detection

ANOMALY DETECTION
Tampering surveillance camera

CCTV Camera
Low End Computing device
Home Environment surveillance camera with low computing power just records and sends the camera feed.

CCTV (Camera Tampering/Malfunction)
Anomaly detected
When there is camera Tampering / Malfunction happens, it requests high computing devices in Home Environment to do detailed analysis of the video.

Home Environment
Edge Computing Device
Service offloading to a high capable device(s) (phone, Mobile, TV) based on the scoring method to perform the video analysis (Local Execution).

Identifies the clause to notify user

CCTV Camera Tampering
Alert user with tampering video clip
Identify the type of tampering by sending a short clip of proof to the user for taking further actions.

Device Faulty
Raise service ticket
Identifies and collects the malfunction report as a service ticket by notifying the user to take further actions.

* Presented in IoT Solutions World Congress in Barcelona (@LF Edge Booth, Oct. 29th ~ 30th)
Home Edge: Use Cases – Anomaly Detection

* Presented in IoT Solutions World Congress in Barcelona (@LF Edge Booth, Oct. 29th ~ 30th)

CCTV Camera (Low End Computing device) → Laptop (Master Edge Computing device) → Mobile (Edge Computing device)

Device Faulty → CCTV Camera Tampering

Select a device to execute AI model

Classify Anomaly detected

Mobile Alert

Offload service to raise service Ticket

CCTV Camera Tampering

Mobile video alert (anomaly clip is sent)

Alert via AI Speaker

Use nearby camera to get intruder details

Notify User

Mobile Alert

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Possible Consideration - Y`21

- Broader Protocol Support – MQTT, CHIP
- Centralized management – Primary/Secondary devices
- Self learning Scoring Manager
- ML Framework
- Cloud Synchronisation

- Collaboration
  - EdgeX
  - Open Horizon
  - Zededa
Home Edge: Stay Tuned!

› Cross-Project Collaboration
  › With EdgeX Foundry: Secure data storage
    › https://github.com/lf-edge/edge-home-orchestration-go/issues/74
  › With Project EVE: Containerized OS
    › https://github.com/lf-edge/edge-home-orchestration-go/issues/72

› Please subscribe our community activities through
  › GitHub: https://github.com/lf-edge/edge-home-orchestration-go/
  › Wiki: https://wiki.lfedge.org/display/HOME/Home+Edge+Project
  › Home Edge Monthly TSC: Every 1st week Tuesday at 14:30 UTC
    › Online meeting access: https://zoom.us/j/578529293
    › Email subscription: https://lists.lfedge.org/g/homeedge-tsc
  › Slack Channel: lfedge.slack.com #homeedge #homeedge-tsc
Project Introduction: Open Horizon
Open Horizon Use Cases and Market Utilization
Project Introduction: State of the Edge
State of the Edge Merges with LF Edge to Provide Unified Edge Computing Thought Leadership

› State of the Edge will continue as the industry’s first open research program on edge computing

› Under LF Edge, State of the Edge, Open Glossary of Edge Computing and the Landscape will continue to pave the way for industry alignment

SAN FRANCISCO, CA – April 8, 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 that it has acquired State of the Edge, a vendor-neutral platform for open research on edge computing. The State of the Edge will merge with Open Glossary of Edge Computing and the combined project will assume the State of the Edge name as a Stage 2 project (growth) under LF Edge.
Retrospective

› Founded in 2017 by a coalition of like-minded companies that believe in vendor-neutral research.

› Its mission is to bring clarity and simplicity to the critical infrastructure required to support the future of edge computing.

HIGHLIGHTS

• Published three major edge research reports, all offered free of charge under a Creative Commons license (with more to come this year).

• Created the Open Glossary of Edge Computing and Edge Computing Landscape (already a part of LF Edge).

• Catalyzed a broad shared understanding of edge computing.
## The Companies Behind It

### Founding Members
- arm
- EDGE Gravity™
- packet
- Vapor

### General Members
- edge.com
- MACROMETA
- Pluribus Networks
- StackPath
- Seagate
- Mutable
- Section

### In Kind Members
- 1MF
- Connected
- EDGE Research Group
- MISSION.ORG
- Deltic
- Mission.org
- DartPoints
What We’re Announcing Today

- State of the Edge assets conveyed to LF
- Merged with the Open Glossary of Edge Computing
- Open Glossary project renamed to State of the Edge
- State of the Edge project will have four working groups:
  - Research & pubs
  - Edge Landscape
  - Open Glossary of Edge Computing
  - Edge Taxonomy
Additional Details

- All State of the Edge projects will continue to be produced and funded collaboratively, with an explicit goal of producing original research without vendor bias and involving a diverse set of stakeholders.

- The State of the Edge project will manage and produce the following assets under the LF Edge umbrella:
  - **State of the Edge reports**
    The 2020 report was published in Q4 2019; the 2021 report is scheduled for Q4 2020.
  - **Open Glossary of Edge Computing**
  - **LF Edge Interactive Landscape**
2020 Look Forward

• Continue working to standardize language across all LF Edge projects
• Ship v1.0 of the LF Edge Interactive Landscape
• Research and publish the 2021 State of the Edge Report (Q4 2020)
• Ship v3.0 version of the Open Glossary
Stage 1: At Large Projects
Project Introduction: Baetyl
Introducing BAETYL

- An Open Source & Vendor Neutral Project
- Bring microservice orchestration to IoT edge computing
- Extend cloud computing, data and service seamlessly to edge devices
- Standardize application model on kinds of Hardware and OS
- Apache License, Commercial Friendly
BAETYL Goals

- Provide a standard cloud native environment for all types of edge scenarios
- Achieve a massive remote management and configuration, allowing devices to operate autonomously and make decisions intelligently under unattended conditions
- Provide developers with end-to-end application development tools and services that use edge technology to make innovation at your fingertips
A Brief History of BAETYL

- Launch
  - 2017 Fall, Baidu IntelliEdge

- Open Source
  - Dec 2018, OpenEdge Project
  - General Edge Computing Framework
  - Monthly Agile Release
  - Edge AI

- Contribute to LF Edge
  - Aug 2019, BAETYL
  - Open Edge Infrastructure
BAETYL Architecture

Baetyl master
- RESTful API
- Orchestration
- ConfigMap
- OS Kernel

Runtime | Container, Kubernetes, Bare metal
- OTA Agent
- User APP
- MQTT Broker
- MQTT Client
- Core Queue
- FaaS
- Python27 Func
- Python36 Func
- ML Inference

Custom Services & Data Plane
- Pub Device
- Sub Device
- Baidu IoT
- AWS IoT
- Other OpenEdge
- RPC Caller

Remote Management API
- Web UI
- K8S API

Essential
Built-in
3rd Party
BAETYL Activation & OTA

- No password
- No root console
- No remote shell
- Ready for massive delivery
BAETYL Future, Edge OS

Kubernetes Semantic Orchestration

Cloud Native Application & Experience

BaetylOS | Lite
- Embedded App
- Firmware
  - lightweight IoT kit
  - lightweight ML kit
  - BAETYL OTA
- RTOS
- Smart IoT Device

BaetylOS
- Containers
- Immutable Layer
  - BAETYL
  - OCI | Hypervisor
  - busybox
  - Kernel Drivers
- Linux Kernel
- Unattended Single Machine

BaetylOS | Cluster
- Worker Node
  - kubelet
- Master Node
  - kubeadm
  - etcd
  - kubelet
- Offline Autonomy Region

THE LINUX FOUNDATION
BAETYL Technology

- Completely written in Pure Golang
  - Static link and Standalone
  - Support x86/x86_64/armv7/aarch64/mips/mips64/ppc/ppc64
  - Support Linux/Windows/macOS
- Deeply integrated with Docker
  - Operate with docker on images and containers
  - Emulate docker style by bare process on legacy windows
- Non-injection Data Interaction
- A Core Queue for built-in IoT services
  - Use MQTT 3.1
  - QoS: at most once & at least once
- FaaS engine on single machine
BAETYL Tested and Confirmed hardware

- Common PC & laptops with Linux and macOS
- Limited support on Windows & Windows Container
- Raspberry Pi Model 3B, Linux-armv7, Raspbian stretch
- NXP LS 1043 ARDB, Linux-aarch64, Ubuntu 16.04
- Xilinx ZC702, Linux-armv7
- CT3-CPU-38, Linux-armv7, LinuxRT
- Intel Apollo Lake Atom, Linux-x86_64, Ubuntu 16.04
- Nvidia Jetson Nano, Linux-aarch64
BAETYL Links

- The Code
  - https://github.com/baetyl/baetyl

- Documents
  - https://baetyl.io/

- How to contribute
  - https://github.com/baetyl/baetyl/blob/master/CONTRIBUTING.md

- Join the Mail Lists
  - https://lists.lfedge.org/g/baetyl
  - https://lists.lfedge.org/g/baetyl-tsc

- Join the Slack channels
  - https://slack.lfedge.org/
  - #baetyl
  - #baetyl-tsc
Project Introduction: Secure Device Onboard
Secure Device Onboard Use Cases and Market Utilization
Project Introduction: eKuiper
Why eKuiper?

› Streaming analytics
  › A software or framework for stateful computations over unbounded data streams.
  › Allows management, monitoring, and real-time analytics of live streaming data.

› Apache Flink & Spark are not fit for edge streaming analytics
  › Latency
  › Data security
  › Bandwidth costs

› The challenges for edge streaming analytics
  › Lightweight & high efficiency: restricted resource (CPU & Memory) in edge side
  › Agile & flexible: need more agile approach to update the biz logic
  › Deployment & management: not centralized, distributed deployed and weak network access
Overview

› Binary installable & Docker images
  › 8MB install package; 10MB initial mem overhead
  › X86 AMD * 32, X86 AMD * 64; ARM * 32, ARM * 64; PPC
  › Linux distributions, OpenWrt Linux, MacOS and Docker

› Performance
  › Raspberry Pi 3B+
    › TPS: 12k
    › CPU: sys+user 70%
    › Memory: 20M* Refer to

Refer to https://github.com/lf-edge/ekuiper#performance-test-result for more detailed.

› Kuiper - Data ETL
  › Data extraction: sources
  › Data transformation: analytics + transformation with SQL
  › Data loading: Sinks
eKuiper milestones

› May 2021:
  › released 1.2.0, supported external service func;
  › 16k download per week – a new history record

› Feb, 2021: released 1.1.1, supported binary data processing, and ML/AI function support

› Oct, 2020: released 1.0.0, the 1st stable major release

› Jul, 2020: released 0.5.1, and integrated with KubeEdge

› Apr, 2020: released 0.3.2, and integrated with EdgeX Foundry

› Oct, 2019: open sourced & released the 1st version
User scenario

› Embedded rule engine service since Geneva release.
› Subscribe and analyze data from EdgeX message.
› Rules engine invoke command service after processing.
Baetyl & eKuiper integration

- Baetyl
  - Baetyl is an open edge computing framework of Linux Foundation Edge that extends cloud computing, data and service seamlessly to edge devices.
- eKuiper enhanced the edge analytics capabilities
KubeEdge integration

› KubeEdge
  › An open-source project extending native containerized application orchestration capabilities to hosts at Edge

› eKuiper enhanced the edge analytics capabilities

› Benefits – resolved IoT edge computing challenges
  › Lower latency, bandwidth cost saving
  › Easy for user to implement business logic
  › Manage & deploy Kuiper, applications & AI algorithm from cloud.
Customer case: KubeEdge + eKuiper

- K8S+CloudCore
- MQTT broker (Cloud)
- APPs (Cloud)
- APPs (Edge)
- EdgeCore
- Kuiper
- Influxdb
- MQTT Broker (Edge)
- Mapper (OPC-UA)
- Mapper (Modbus)
- Mapper

Cloud Control of command
Edge Dispatch data cleaning rules
Edge Dispatch device information
Data cleaning
Data storage
Other applications
Bypass data
Next steps

› Collaborate with more open-source projects

› More features will be introduced at 2021
  › The 3rd party language plugin development support
  › Persistence support with the 3rd party frameworks, such as Redis
LF Edge
(www.lfedge.org)

Bringing Edge Initiatives Together

IOT | Telecom | Cloud | Enterprise
LF Edge in APAC: A Growing Community

Members

Contributors and Users

- arm
- Baidu 百度
- 北京邮电大学
- ubuntu
- Delivered by Canonical
- CertusNet
- DELL EMC
- EMQ
- ETRI Electronics and Telecommunications Research Institute
- NARI
- 国瑞集团
- Intel
- IoTech
- Linaro
- H3C
- NTT
- IBM
- SAMSUNG
- Tencent
- ThunderSoft
- vmware
- 华为
- 江行智能
- 艾欧嘉
- 上海凝捷
- LD Foundation
LF Edge in China: EdgeX Industry Usage

Manufacturing
› Wanxiang: Automobile Components
› Baowu Steel: Gear Monitoring
› Mingdu: Robot Arm and Industrial Monitoring
› Lingke: Industrial Data Collection and Monitoring
› Yonyou: Intelligent Factories
› Luanying: device monitoring and perf optimization

Telco/IT
› ChinaMobile/CertusNet: Data Collection in Factories
› H3C: server component remote monitoring
› ZTE/ChinaUnicom: integration with MEC solution

Transportation
› SJITU: connected vehicles, AGV/robot control/analysis
› WayClouds: smart 4S stores

Energy & environment
› CertusNet: Air Conditioning and Heat Utilization
› Quarkdata/TrendyTech: Power saving in heating system
› Xinjuzhi: Corrosion, Sewage and Air Monitoring
› Jiangxing.ai: Power grid, water treatment
› State Grid: substation monitoring

Commercial platform integration
› Advantech/TW III: with Wise-PaaS
› EMQ: with EMQ X
› SIA: with Robotics
› Thundersoft: ToburX Edge solution

Retail, Banking, Hospitality, etc.
› Intel: pan-retail (RBHE) solution
› JD: StartLink retail solution
› Agree Technology: Device-as-a-Service gateway in banking branches
› Fangfang: Workspace management
› HYD Miracle: customer & merchandise information co-relation in retail stores
EdgeX China Project: How to Participate

Join the EdgeX China community

› Email info@lfedge.org with your WeChat ID/Phone to be added to the EdgeXFoundry SIG
› Events/Meetups are advertised in the WeChat group
› Join EdgeX portal on software developers community of CSDN, OSChina
› Follow EdgeX video channel on Bilibili

How to contribute

› Code contribution: contribute opensource code to EdgeX Foundry.
› Evangelism volunteers: Join “Volunteers Program” of EdgeX China, expense will be reimbursed.
› Digital Media Volunteers: support EdgeX evangelism on social media
› Content Volunteers: document translation to Chinese, share BKM & how-to document on how to use EdgeX.
› City Leads: Organize face-2-face meetup as guided by EdgeX China community
› Join EdgeX “Adopters Series” program to share EdgeX deployments in commercial solutions
› Join EdgeX Hackathon contest: Organized once a year, join to develop cases with EdgeX

Site EdgeX China Project: https://wiki.edgexfoundry.org/display/FA/China+Project
LF Edge in China: Akraino Community

WeChat: Email info@lfedge.org to be added to the Akraino WeChat community
LF Edge in China: Open Horizon Community

Open Horizon China SIG: 
https://wiki.lfedge.org/display/OH/Open+Horizon+China+SIG

Mail list: https://lists.lfedge.org/g/open-horizon-china-sig
LF Edge in China: Baetyl Community

Wechat-for-Baetyl:
https://baetyl.bj.bcebos.com/Wechat/Wechat-Baetyl.png