



**OLF** NETWORKING

2023 Year In Review

# A Collaboration Hub for New Horizons

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# Introduction

## The Linux Foundation Networking Mission

“Drive an open source ecosystem that revolutionizes the movement or communication of data on a network - including its data plane, control plane, analytic, orchestration, and automation technologies - for enterprise, cloud, and carrier network constituents.”

The Linux Foundation Networking (LF Networking, LFN) is the largest set of open source networking projects in the world formed by a broad industry coalition with the goal of fostering a commercial-ready networking ecosystem that embraces open, emerging and evolving technologies.

Now in its 6th year as an umbrella organization, LF Networking software and projects provide the foundations for network infrastructure and services across service providers, cloud providers, enterprises, vendors, and system integrators that enable rapid interoperability, deployment & adoption. Key tenets of 2023 progress include:

- ▶ Continued collaboration across organizations and sectors, including sister projects, SDOs and other industry alliances
- ▶ Blurred lines between Cloud, Telecom, Enterprise and Hyperscaler-supported by the addition of the Nephio project into the LF Networking umbrella
- ▶ Regional Face-to-face events, via global ONE Summit Regional Days and Developer & Testing Forum

# Introduction

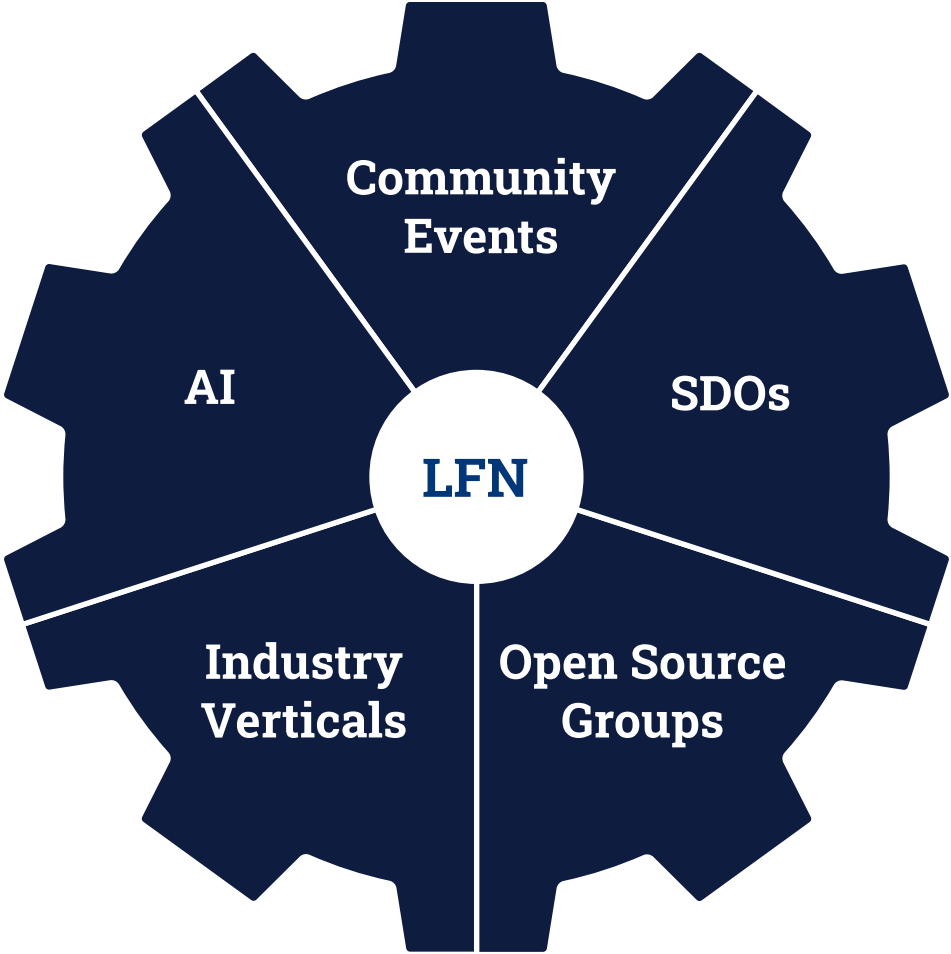
- ▶ Collaboration with CNCF to create the new Linux Foundation Cloud Native Networking program that combines telecom initiatives into one unified LF front for Cloud Native Networking
- ▶ Focus on security and privacy, with ONAP's Configuration Persistence Service project (CPS) achieving the Gold standard.
- ▶ Opening the door for AI in networking (and networking for AI), with the creation of an LF Networking AI Taskforce

As this new year kicks off, LF Networking invites you to get more involved in open source networking projects by [reading about our individual projects](#) and [joining in](#). We look forward to working alongside you!



# LF Networking: a Collaboration Hub

One of the hallmarks of open source software development is that of collaboration among peers, members and the industry at large. Within LF networking, this has the effect of enabling technological innovation and growth of the community as well as commercial success for members that are directly involved in our open source projects.



## Collaboration Across: SDOs

Collaborating with various industry standards bodies is a tenet of our MO, and we could not work to advance the open source ecosystem without this integration to ensure industry alignment.

### Integration & Harmonization with Existing Standards

LFN works closely with established industry standards bodies like the (ETSI), Institute of Electrical and Electronics Engineers (IEEE), and Internet Engineering Task Force (IETF). This ensures that new networking technologies and solutions developed under the LFN umbrella are compatible with existing standards and protocols. This synergy is crucial for the adoption of these technologies in commercial and carrier-grade environments, where adherence to standards is often a requirement. 2023 highlights:

- ▶ Following ETSI's update to its 2013 debut white paper, "Evolving NFV towards the next decade," LFN CTO Ranny Haiby penned a [blog post entitled "ETSI NFV: A decade of transformation"](#) discussing the history of NFV from the open source perspective, along with potential for the next decade.
- ▶ The [Linux Foundation signed a follow-up MOU with ETSI](#) to further collaborate in driving harmonization across open source and open standards, which now includes Nephio.
- ▶ The Linux Foundation and [Innovative Optical and Wireless Network Global Forum](#) (IOWN Global Forum), which seeks to create a smarter, more connected world, [announced a new partnership](#) to collaborate on integrating Linux Foundation software into the IOWN Global Forum platform.



## Collaboration Across: Adjacent Open Source Efforts

LFN works to integrate and harmonize the open source stack across ecosystems, creating a more comprehensive and interoperable ecosystem. Examples include community building, joint development and testing, resource sharing and support, and education and events. 2023 highlights:

- ▶ The 5G Super Blueprint (5G SBP) has remained a mainstay of inter-project collaboration within LFN and its ecosystem. The 5G SBP has gone through multiple iterations and has grown to accommodate new use-cases submitted to the [5G Super Blueprint Library](#) by community members.
- ▶ Expanding the value chain to include network APIs by working with CAMARA. This helps network operators (enterprises, service providers and telcos) monetize their networks and is especially important for Network-as-a-Service use cases. See the [network API white paper](#) LFN co-authored with CAMARA, GSMA and TMForum.
- ▶ Sylva will leverage Anuket's RA2 and cover requirements specific to European Telcos, as well as contribute back specific extensions to Anuket.
- ▶ LFN works closely with LF Edge in developing frameworks and standards that enable seamless edge deployments, critical for IoT and real-time data processing applications. Edge use cases are being built into the 5G Super Blue Print, and many of LF Edge's Akraino telco blueprints integrate across LFN, including [Public Cloud Edge Interface \(PCEI\)](#), [Integrated Cloud Native \(ICN\)](#), [5G MEC System, and more.](#)
- ▶ ONAP's CPS was one of the first 10 open source projects in the world to receive OpenSSF's Gold Standard for security. Collaboration with other open source projects is pivotal in shaping the future of open networking, driving innovation, and building a more interconnected and standardized networking ecosystem.

## Collaboration Across: Industry Verticals

LFN approaches cross-sector collaboration by integrating across related industries, such as Cloud Computing, Telecommunications, Enterprise IT, Energy, Edge computing, Access, Core, and more:

- ▶ **Cloud:** Close collaboration with the cloud sector, most recently with the new, integrated [Cloud Native Networking initiative](#).
- ▶ **Telecommunications:** LFN projects play a crucial role in the evolution of network function virtualization (NFV) and software-defined networking (SDN), streamlining network operations and facilitating the deployment of 5G technologies.
- ▶ **Enterprise:** LF Networking provides solutions that optimize network performance and security, essential for modern business operations.
- ▶ **Energy:** New initiatives focus on leveraging networking technologies to improve grid management and support the integration of renewable energy sources.

- ▶ **Edge & Connectivity:** Networking enables a foundational infrastructure layer on which all Edge and Connectivity use-cases rely.

By bridging these diverse sectors, LF Networking ensures that advancements in networking technologies are holistically integrated, benefiting a wide array of industries.





## Nephio Joins LF Networking



Nephio, a Kubernetes-based intent-driven automation of network functions and the underlying infrastructure that supports those functions; It allows users to express high-level intent, and provides intelligent, declarative automation that can set up the cloud and edge infrastructure, render initial configurations for the network functions, and then deliver those configurations to the right clusters to get the network up and running.

In the last quarter of 2023, Nephio was inducted into the LF Networking as a Graduated project to accelerate collaboration and automated cloud native deployments across Telecom, Cloud Service Providers and Enterprises. This enables accelerated development and deployment of next-gen network technology to produce an end-to-end open network stack fully realized across Linux Foundation, LF Networking and LF Edge communities, as well as across other industry and ecosystem efforts.



## Collaboration: AI on the Horizon

Artificial intelligence was on everyone's mind in 2023: How will it impact their organization? How will they adapt? How can they leverage it to their benefit? This was no different in open source circles, including LFN.

### AI for Networking and Networking for AI

As 5G, IoT and edge computing technologies gain traction, new opportunities arise but also come new complexities for network operations.

- ▶ Operation of leading edge and legacy technologies, hybrid networks, radio spectrums
- ▶ Ever growing number of connected devices
- ▶ Emerging requirements from industrial use cases push the boundaries of network performance and optimization.

AI for networks helps to address these problems.

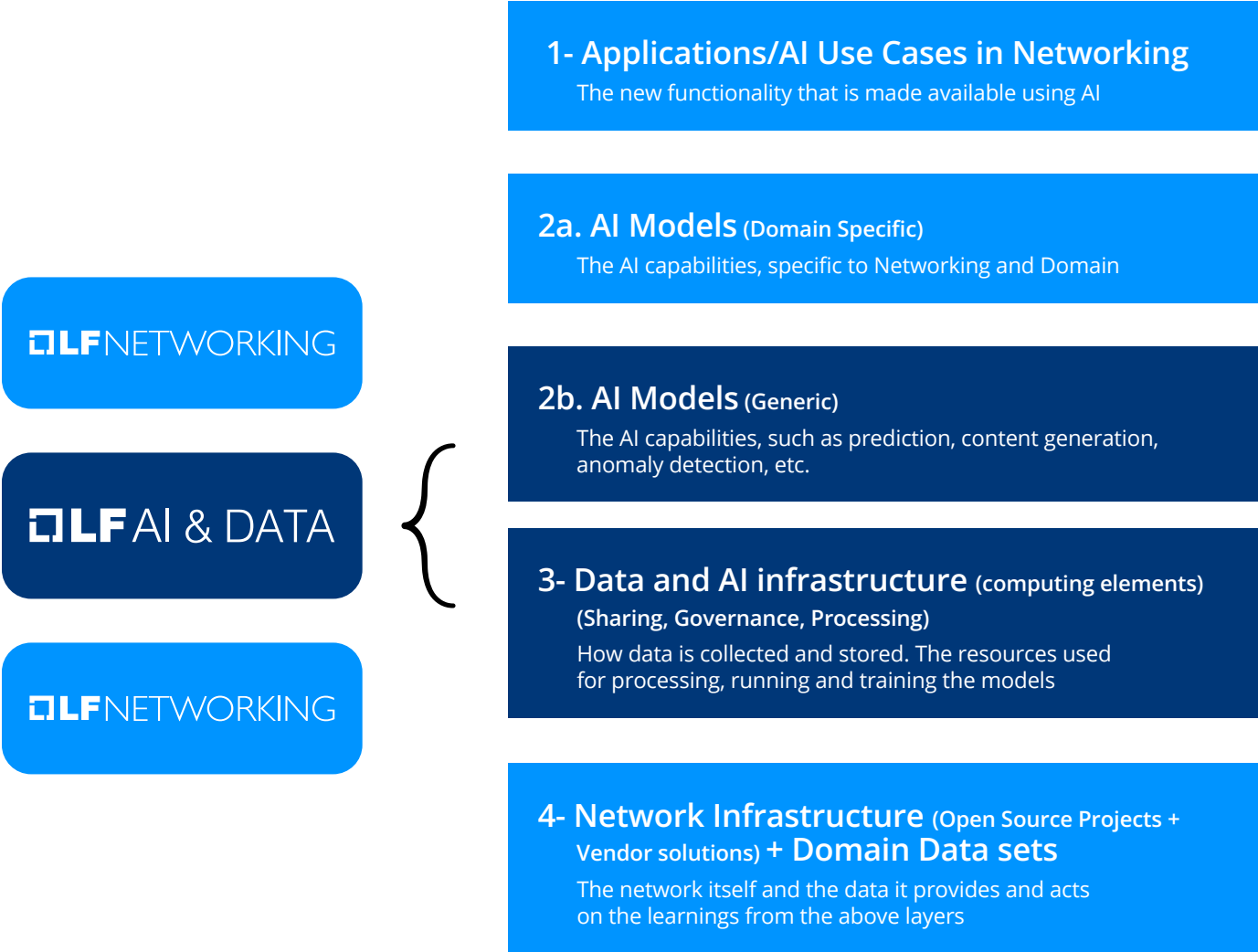
### How LFN Fits into AI for Networks

LFN, as the nexus for open source networking software development, is naturally positioned to build next generation tools for network operators.

- ▶ Locus for industry knowledge
- ▶ Network infrastructure experience (Virtualized and containerized)
- ▶ Community structure geared towards collaboration and innovation

We're looking toward integrating AI into our projects and initiatives as a way to improve the project outputs, with a focus on these key areas:

## Four Key Areas in AI for Networking



# LF Networking: a Collaboration Hub

## LFN AI TaskForce

In 2023, LFN convened the LFN AI Taskforce with goals to help identify, define, and operationalize the role of AI in open networking by exploring use cases, domain-specific AI models, and identifying data sets from large carriers to leverage for training the models.

- ▶ Focus is identifying the real areas in which Telco, Cloud, and Enterprise should work in AI, from “AI for the Network” and “Network for AI” perspectives
- ▶ Some foundations laid via infrastructure projects such as ONAP that are intent-based with large data sets, which is more than 70% of the prep work to enable AI
- ▶ Working closely with our sister sub-foundations, LF AI & Data (a horizontal construct not domain-specific) & the OpenSSF Foundation (a security vertical).
- ▶ LFN focuses on different layers of the solution stack (e.g., the network & network infrastructure layer).



## Collaboration: Community Events

### Events

LF Networking continued its in-person events, but with a twist this year: instead of a single “Foundation-level” event, we pared the event down to what we called, “ONE Summit Regional Days”, a series of smaller, localized ONE Summit events hosted at LFN member companies across the globe. These events featured the same great content expected from our traditional ONE Summit format - in-depth presentations, interactive conversations around Access, Edge, 5G and Cloud open source technology developments - but in a smaller, more localized fashion.

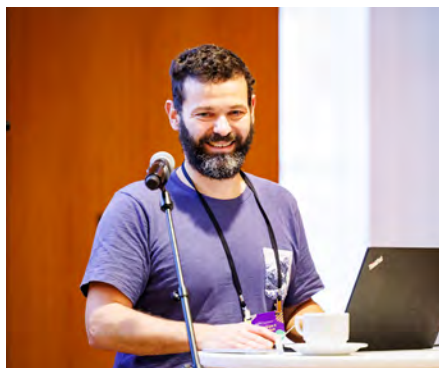
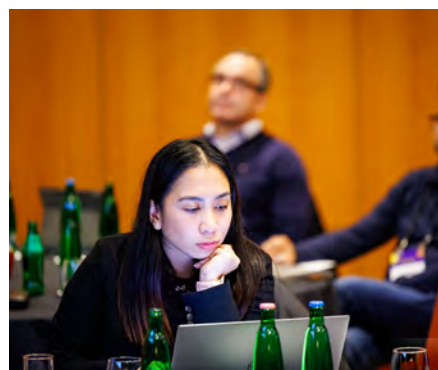


## ONE Summit Regional Days



## LFN Developer & Testing Forum

The Developer & Testing Forum (D&TF) is held three times a year and continues to be a mainstay of the LFN ecosystem helping to bring together the people that actually perform the critical work we do and their ideas for the continued evolution of our projects. In 2023, the community met twice virtually and once in-person in Budapest, Hungary.



# Message from the LFN Board



## **SEBASTIAN ZEHLIN**

*Chair, LFN Governing Board,  
and Lead Architect Technology  
Architecture & Innovation,  
Deutsche Telekom*

Year one after the pandemic is rather quickly coming to end. And, while some of us are still trying to find out what the “new normal” means for our work life, it has been a tremendous year for open source networking technology.

Let me start with THE metatrend of 2023: Generative AI (GenAI). While ChatGPT was released in late 2022 its full impact to society has been visible this year. I can only compare it to the moment when I first used the Google search engine and knew that the world is not the same as before. In my opinion, no one can tell exactly how – or even when – GenAI will change the networking domain, but I see broad consensus that the benefits will be significant and will come sooner than later. Therefore, I am very glad to see that LFN is driving the AI4Telco topic in various projects and especially with its LFN AI taskforce.

The second major impact in 2023 is the growth in size, maturity and business of the mega LEO internet satellite constellations. Literally this takes building and operating networks into a whole new dimension – space. They are very impressive of their own accord, but also contribute to new and interesting opportunities to combine them with ground networks for existing and new innovative use cases. Of course, I would love to see the companies building those constellations also engaging with the LFN one day.

From the LFN perspective we are very happy that the Nephio project joined as a graduated project just last month. It enriches our great Open Source networking portfolio by creating a de-facto standard for the management of cloud-native network deployments across Telecoms, Cloud Service Providers and Enterprises. Congratulations to your first release and welcome!

Looking ahead to 2024, it's safe to say that all of the trends of this year will keep us busy next year as well. The LLMs will incorporate additional modalities and thus evolve into Large Multimodal Models (LMMs) presenting us with ever more opportunities for new use cases.

Taking the Networking perspective – and maybe specifically a Telco perspective – we are an industry which was and still is heavily dependent on standards; this is a good thing for interoperability, but sometimes the development of standards can take very long from idea to production. In contrast, software-defined, cloudified networks have proven that they evolve in ever shorter life-cycles and technologies like GenAI show that they evolve on an even steeper curve. In my opinion the LFN and open source general is in a unique and excellent position to contribute to standards; continue its mission of developing and promoting open source networking software, and help shape the industry and make benefits of the new technologies quickly accessible and ready for production for all contributing parties.

My final but most important thoughts are dedicated to all contributors in the LFN communities. On behalf of the entire Governing Board, I'd like to deeply thank everyone for your passion, dedication, and all hard work you have brought to the community throughout 2023. Please take a moment to lean back, take a deep breath, and be proud of yourself and what you, your team and the community have achieved! You are the ones moving the needle and advancing open source networking to new levels.

Keep your good spirit, and we are looking forward to celebrating even greater achievements in 2024! The best is yet to come!





# LFN Board Members



**Anil Guntupalli**  
Verizon



**Frank Brockners**  
Cisco



**Jonne Soininen**  
Nokia



**Sebastian Scheele**  
Kubernetes



**Ankur Jain**  
Google



**Gnanapriya Chidam-  
baranathan**  
Infosys



**Junlan Feng**  
China Mobile



**Sebastian Zechlin**  
Deutsche Telekom



**Catherine Lefevre**  
AT&T



**Hari Vasudev**  
Walmart  
Global Tech



**Lisa Caywood**  
Red Hat



**Sun Qiong**  
China Telecom



**Christian Olrog**  
Ericsson



**Ibrahim Gideon**  
Telus



**Manish Mangal**  
Tech Mahindra



**Walter Kozlowski**  
Anuket  
Community



**Chuanyu Chen**  
Huawei



**Jie Hu**  
Zte



**Olaf Renner**  
Nokia

# LFN Members

## Platinum Members



## Silver Members



## Associate Members



# Message from the General Manager



**ARPIT JOSHIPURA**  
*General Manager, Networking,  
Edge, & IoT, the Linux  
Foundation*

2023 marks ten years of open networking at the Linux Foundation (with [the start of OpenDaylight](#)), and nearly seven years of the combined LF Networking umbrella. We've become the largest set of open source networking projects in the world, formed by a broad industry coalition with the goal of fostering a commercial-ready networking ecosystem that embraces open, emerging and evolving technologies.

As the world becomes even more interconnected and automated, the lines blur across the market at the use case and architecture level, even more so as AI takes hold. This means our role as the center of collaboration is stronger and more important than ever. The integration we facilitate across projects (such as LF Edge, Nephio, CAMARA, Sylva, etc.), other open source communities (such as Open Compute Project), and standards bodies (such as ETSI, MEF, TMForum, and more) are paramount to scalable digital transformation across the globe. 2023 saw a more concerted effort by our projects to collaborate more closely across verticals and across the entire ecosystem; highlights of these efforts include welcoming Nephio project into the LFN portfolio (closing the gap) and our work with CNCF to create the new, [combined Cloud Native Networking initiative](#), which coalesces efforts from both LF Networking and CNCF to advance cloud native networking.

However, we are most excited about the prospects for 2024 as LFN looks toward AI for networking and networking for AI. (Read more about what we expect for next year in the recent [2024 Predictions blog post](#) from me and our CTO, Ranny Haiby.)

Big thanks to all our LFN community members, including contributors, maintainers, community managers, security professionals, marketers, and more. Join us on this journey and see how the open source networking ecosystem tackles new horizons in 2024.

# Message from the CTO



**RANNY HAIBY**  
*CTO, Networking, Edge, Access  
at the Linux Foundation*

This year our projects and communities were working on implementing our security strategy. Many of the best practices and tools for secure software development that we identified last year were integrated into the project's software production pipeline. We can now not only say that our software is secure, but that it can be used to build the secure critical networks of the future. Security is an on-going task and we will continue to deal with it moving forward, but I am glad to see our communities embrace security best practices and tools as part of their culture.

During 2023, AI news and innovations came at an extraordinary pace, and our open source networking experts were figuring out how to put the latest and greatest developments in AI to use in the networking domain. We spent the year surveying our community members about the use cases that are best suited to be addressed with AI. We also mapped and identified the relevant AI technologies, including Generative AI and LLMs, that will enable these use cases. After weighing in all the input and prioritizing the work, we launched a workgroup of community experts tasked with providing our communities recommendations on how to integrate AI into the existing projects and how to launch new projects and data sets that will power the network use cases.

Another area where we moved from theory to implementation was Cloud Native Networking. During this year we have seen several operators launch their end to end Cloud Native networks, and many other operators and vendors working in earnest in transforming network functions to true Cloud Native Applications. We successfully worked on merging the CNF best practices, testing and certification efforts from across the LFN and CNCF and [announced](#) a unified program in November.

Looking into 2024 it is obvious that the work on integrating AI into the open source networking project will take a big chunk of time and resources. I am certain that through this work we will create new use cases that will benefit both the network end user as well as the network operators. With economical challenges still looming, we will have to be selective in where we invest our resources, making sure we focus on the places that make a difference.

# Message from the Strategic Planning Committee Chair



**LISA CAYWOOD**

*Senior Principal Community Architect, Red Hat – Chair, Strategic Planning Committee*

This year marked the tenth anniversary of the OpenDaylight Project and the fifth of LF Networking.

The excitement in networking in 2013—when SDN was the acronym of the day—was infectious, and the appearance of the first major open source controller with meaningful industry backing signaled a major shift in how networks would be designed and managed. Within a year, a major US telco—and OpenDaylight sponsor—had declared that they were going to teach 10,000 of their network engineers to program.

Over the next 4 years, a flurry of other open source networking projects, large and small, would pop up and begin the work of abstracting various portions of the network. Finally, over the course of 2017, the groups increasingly began to look at how to bring their pieces together, and LF Networking was born, officially, on January 1, 2018.

In the years since, we have, together, focused our efforts on network orchestration and the perennial challenge of interoperability. Some of this has happened within LFN—ONAP was a major effort here—while other work has been done in other industry consortia, building on the development work of the LFN community. And, it must be said, the work continued unabated even throughout a multiyear pandemic and rising geopolitical challenges because we had already learned to work together—asynchronously and across time zones, understanding each others' varying goals—well before the pandemic ever began.

As we enter the next phase of open source networking, our biggest challenges revolve around learning how to operate our new open networking software stack with and atop existing networks, reliably and efficiently. Automation and AI are being explored by many of our members individually, and collaboratively within the Nephio project and AI Taskforce—two new initiatives within LFN in 2023.

In 2024, we plan to tighten our focus on three areas of execution, in order to set these new efforts on a strong course for success:

- Use LFN's position as the collaboration hub of the networking industry to tie together the efforts of our many partner organizations
- Mature the Nephio project to showcase production-ready concepts and code
- Coalesce the AI Taskforce's recommendations into 1-3 concrete initiatives

To be successful, we will need the support and skills of our whole community, from the Board and Marketing Advisory Council to the TAC and broader developer community—and very much welcome “new” individuals with fresh perspectives. Please encourage friends and colleagues to join us as we set the stage for the next half-decade of LF Networking.



# Message from the Technical Advisory Council



## **OLAF RENNER**

*Open Source Program Office,  
Nokia – Chair, LFN Technical  
Advisory Council*

In 2023 the Technical Advisory Council (TAC) undertook a major rework of the LFN Project Lifecycle and induction process. The overall goal was to make it easier for projects to join the LFN umbrella and enable projects to join at various levels of project maturity. To do so, LFN completely rewrote the documentation on how to get started with LFN and revised the tools and services available to prospective projects.

This rework created a new guidance framework to help the assessment of individual projects against the criteria for lifecycle maturity and put it to the test with the successful induction of a new project: Nephio.

We are excited to welcome Nephio as a graduated project to accelerate collaboration and automated cloud native deployments across Telecom, Cloud Service Providers and Enterprises. Using Kubernetes as a uniform automation control plane and implementing a configuration-as-data approach, Nephio enables declarative management with active reconciliation for the entire stack of cloud infrastructure, workload resources, and workload configuration.

The TAC also observed the rise of generative AI and large language models. These exciting tools were on everyone's lips in 2023. We expect that AI will play an integral role in networking – be it for network planning, operations, optimization, security or customer care – and are planning to build the foundations for the networks that will host and connect AI workloads. In order to specifically address the networking needs of AI, a new LFN AI Task Force has been formed under the LFN TAC which is in the process of collecting use cases, identifying missing pieces, and evaluating existing open source projects to reuse and build upon. The AI task force is open for a wider community beyond LFN. If you are excited about exploring AI in networking, join in on the discussion!

Security is another topic that was prominent in 2023. What started in 2022 with the US Executive Order to improve cyber security continued in 2023 with the upcoming EU legislation for the Cyber Resilience Act in Europe which created a concern in the open source community. As security has to be one of the top goals for all LFN projects, best practices have been collected and the adoption of security tools by the projects is being updated. The ONAP project has been spearheading this activity and the goal is to implement these best practices across all LFN projects and streamline the process.

Looking into 2024, these security activities will continue and there will be increased focus on AI through the AI Task Force as we turn our attention towards the transition of mobile networks to 6G. Additionally, the TAC will help to focus the work of a potential merger of the Cloud Native Computing Foundation's Containerized Network Functions (CNCF CNF WG) and LFN conformance and certification activities in Anuket as a new initiative.





# LFX Insights

Open source, like any other industry vertical, tracks its performance and growth through the use of a set of objective performance indicators. LFN does this through the use of our LFX Insights analytics platform that provides an overview on the health and emerging trends regarding each LFN project.

One of the biggest challenges for open source projects is being able to define, track, and review key project metrics. The LFX Insights analytics tool provides insights on the health of LF Networking projects and what trends are happening regarding the number of contributors, number of commits, etc.

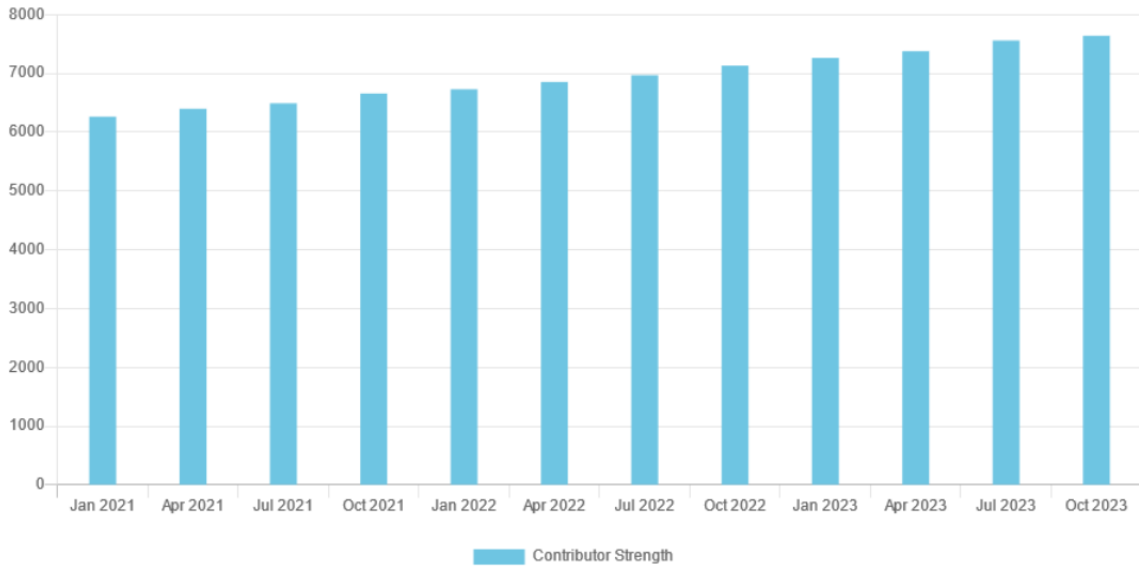
## Community Growth

The addition of Nephio was a key driver in LFN's community growth for 2023, with 120 active contributors and almost 1500 commits since project inception in May 2022, for Nephio alone:



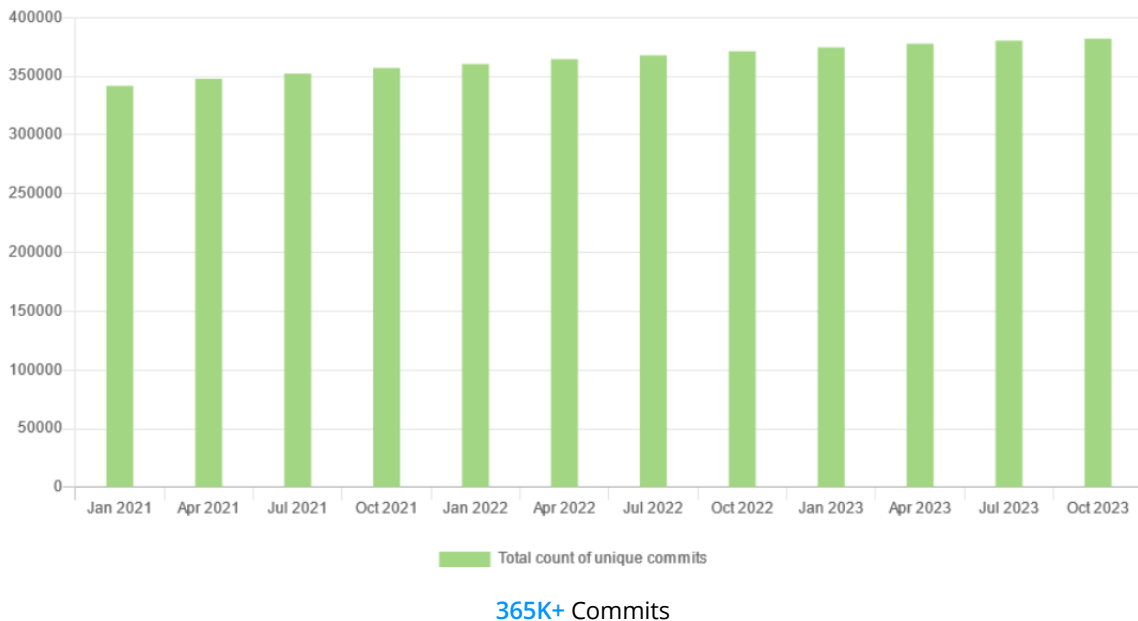
Figure 1. Number of active Nephio contributions, May 2022-Dec. 2023. Source: LFX Insights

Outside of Nephio, the total number of contributors to LFN projects continued to grow by approximately 21% between 2020-2023 (Figure 2), while the number of commits increased by 11%, encompassing over 365K commits overall (Figure 3).



21% Growth in Contributor Strength\*

Figure 2. Percentage growth in code commits (Dec. 2020 - Dec. 2023), Source: LFX Insights



365K+ Commits

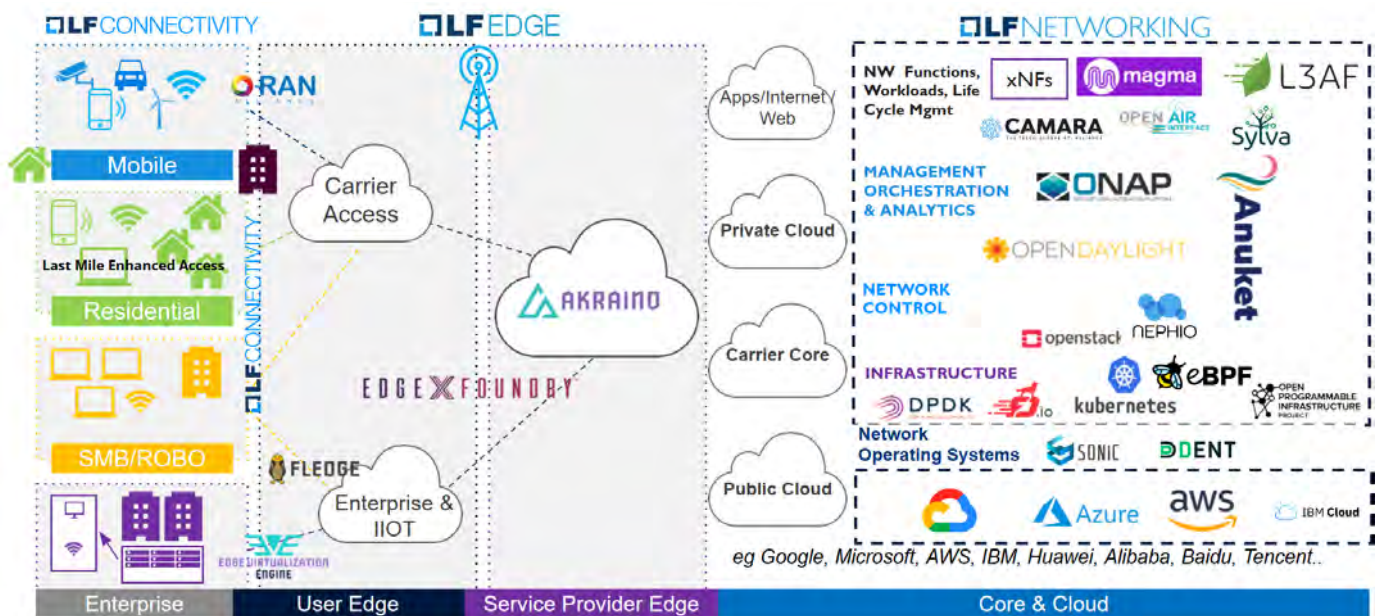
Figure 3. Total number of commits by contributors (Dec. 2020- Dec. 2023).Source: LFX Insights v1

# 5G Super Blueprint: Centerpiece of Open Integration

The 5G Super Blueprint is an LFN-led year-round initiative that provides opportunities for open-source communities to build upon some of the most important technologies across the globe through cross-community collaboration. Bringing these pieces together is often challenging, not just for the developers, but for the real-world end-users who need to stitch together multiple open source and proprietary solutions.

The 5G Super Blueprint addresses open-source solutions for industry challenges bringing together multiple projects, communities, and companies to blueprint, prototype and integrate real-world use cases to showcase the capabilities of open-source projects in the context of the full ecosystem in which they exist.

## 5G Super Blueprint Aspirational Architecture



## Introducing the 5G Super Blueprint Library

The 5G Super Blueprint Library was created, developed, and rolled out in 2023 as a one-stop-shop and the central reference point for completed 5G Super Blueprint projects. Similar to a public or school library, content of the 5G Super Blueprint library varies in topic/technology, project scope, and type and breadth of collateral.

Consume what you need – 5G Super Blueprint projects range from complete end-to-end solutions to technology building blocks that can be consumed, evolved, and expanded upon in vendor solutions.

Ease of Use – Use the Library Index to browse completed projects. Each entry also contains contact information for a project lead. You may contact the project lead with any questions, or request additional information if available.

## Cutting-Edge 5G Super Blueprint Projects Underway

In addition to the completed projects in the 5G Super Blueprint Library, there are multiple exciting leading-edge initiatives underway, including:

- ▶ L3AF-eUPF integration
- ▶ OAI with EMCO
- ▶ ONAP SMO
- ▶ Enhancing Autonomous Network through Generative AI and Intent-Driven Technologies
- ▶ Intent Driven Orchestration for Autonomous 5G Networks
- ▶ SEDIMENT (Remote Attestation)
- ▶ SABREs

And, there are more 5G Super Blueprint projects being born out of our communities every day. You can [see details on all the projects here](#) as well as submit a project proposal:

5G Super Blueprint Use Cases & Submission Template

Ultimately, the 5G SBP democratizes access to technology and provides options to vendors and end users who may want to diversify their technology footprint. We're seeing a transformation in networking away from the confines of the telecommunication environment. Capabilities like private 5G are taking networking and putting it in the hands of enterprises. And, those same enterprises, with initiatives like Industry 4.0, have to be more agile and more automated.



# LFN Project Updates



Anuket, the LFN cloud infrastructure modeling and testing project occupies a unique position in the telecom industry because it incorporates operator requirements, collection and normalization, software and test development, all under a single initiative. The Anuket community has subject matter expert representatives from operators and their technology suppliers who are all very cognizant of the “real world” challenges of the industry.

Due to significant resource constraints over the past year, the project reduced the scope by only completing one release in 2023 instead of the two it has done in the past, cutting the number of workstreams and scaling back overall.

Despite the resource limitations, the project continued its vital work and launched the **Orinoco Release on October 18, 2023**. Some of the highlights from this release include Reference Model changes and acceptance of our Reference Architecture 2 as a GSMA standard.

## Reference Model (RM) - The changes that benefit the Telco community include:

- The alignment of Anuket and O-RAN, enabling operators to stand up an internal Telco Cloud that supports both Core and RAN Network Functions

- Server hardware architectures that support various security technologies to assist in protecting data in use – a major issue with Operators concerned with the increasing threat of cyber attacks
- Use of a new socket type (AF\_XDP) for high performance packet processing.
- Metrics that can be used for design optimization, requirements based on ETSI GS NFV-TST 008 V3.5.1

Reference Architecture 2 ( RA2 ) – The RA2 project focuses on building a Kubernetes based architecture that has now been consolidated into the most comprehensive industry wide set of specifications for Kubernetes Telco Cloud - acceptance as a GSMA standard is confirming this status.

- The K8s release upgrade keeps RA2 aligned with the upstream communities and provides new features and fixes (e.g. IPv6 Dual Stack and Pod Security Admission Controller)
- The addition of Express Data Path is beneficial to data plane users of Anuket as a Linux-native network acceleration technology

## What Worked

Anuket projects and work streams continued their efforts to strengthen container-based open infrastructure specifications and implementations. Continuing strong interactions with GSMA, OpenInfra, and MEF.

## Next Steps and Decisions

For a variety of reasons as a mature project, Anuket is in need of some new thinking about what its mission is:

- Focus resources on RM, R\*2 and functest\*
- Need to drive more support from within LFN and larger Telecom community
- Advance traction of Anuket project with the Telecom community
- Should we archive the inactive projects?

**BETH COHEN** | *TSC Co-chair, and Software Defined Networking Product Technologist at Verizon and Gergely Csatari, TSC-Co-chair, and Senior Specialist, Open Source at Nokia*

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## EMCO



The EMCO community, consisting of seven active EMCO users, continued its maintenance by issuing bug fixes and upstreamed support for SOL005. We also completed documentation of a simplified 5G SBP use-case involving Free5GC and EMCO which is planned to be used in the 5G SBP project SABREs.

- Support for SOL005 has been upstreamed
- Continued maintenance (bug fixes)
- A 5G SBP Simplified Slicing Use Case involving Free5GC and EMCO has been completed. It is planned to re-use the Simplified Slicing Use Case in 5G SBP project SABREs
- Seven (7) active EMCO users



Rollin', rollin', rollin'..."

The FD.io release train continued to steam down the track in 2023 with another year of exceptional performance, and on time delivery of VPP releases and CSIT Release reports.

The FD.io TSC members were highly active in supporting the achievement of the community's goals — maintaining balanced representation via TSC nominated membership, spearheading cost savings, and enabling the acquisition and deployment of the latest hardware into the FD.io performance and CI lab.

While several inactive projects were archived in 2023 as part of cost savings initiatives, the FD.io core projects, VPP and CSIT, continued to excel in raising the bar in data plane performance and benchmarking. Both projects continued the unbroken string of on-time releases since 2021. VPP 23.02 Release introduced 19 new features and 118 fixes, VPP 23.06 Release added 26 new features and 145 fixes, and VPP 23.10 contributed 15 new features and 106 fixes. CSIT completed a major upgrade of the organization and efficiency of the performance benchmarking system, including the new CSIT Dashboard ([csit.fd.io](https://csit.fd.io)), interactive VPP Report data presentation, and implementation of the latest draft of the MLRsearch algorithm (draft-ietf-bmwg-mlrsearch). Due to the vagaries of hardware release cycles, there was a limited deployment of new generation hardware (Intel SapphireRapids & IceLake-D CPUs, and Nvidia ConnectX-7 NICs) in the CSIT performance lab, however, 2024 is shaping up to be a banner year in terms of benchmarking VPP on the latest generation hardware.

*By Dave Wallace*

VPP adoption continues to be a shining light for the FD.io Community. Calico/VPP has achieved General Availability in the Calico 3.27 release, making it a first class citizen as the Kubernetes data plane. Other open source projects are also adopting VPP as the data plane including OpenAirInterface, Surf, Terragraph, Sonic, and VyOS — the following quote from the VyOS Project July 2023 Update makes the FD.io Community very proud:

The question of how to do 40 and 100-gigabit networking with VyOS becomes increasingly frequent as network speeds increase. Currently, kernel bypass networking is the answer to that question. General-purpose hardware and Linux kernel networking stack certainly caught up with 10 gigabits already, but everything beyond that still requires a fast path.

The most promising project for that role, as of now, is VPP.

I am grateful for all the contributions to the FD.io Community and would like to thank each and every one who contributed to FD.io in 2023. I am confident that FD.io will continue to attract and retain the contributions of those with a passion for excellence and continue to keep the train accelerating down the line throughout the year in 2024 and beyond.



# L3AF



L3AF's major achievement for 2023 was its second code release, R2. Since R2's release, L3AF has focused on the core code base for the upcoming R2.1 Release which is targeted for mid 2024 and will likely include XDP support for Windows and L3AFD running on Azure Windows virtual machines.

## R2 Release Highlights:

- Improve eBPF loading and chaining
- Modify existing eBPF programs for l3afd v2.0.0 native go chaining
- Remove hard coding of map paths in eBPF programs
- Open Source Traffic Mirroring Program
- Chaining with multiple network interfaces
- Modify the path of the pin map file
- Metric to monitor ebpf\_program version running on the node
- Update eBPF programs loading from l3afd and chaining

The project also participated in the LFN Mentorship Program: our mentee successfully wrote core L3AF for Windows code and demonstrated it. This code will be used in L3AF R2.1.

Finally, the Community has **compiled a variety of documents** to help newcomers get started. We hope to work with you to keep L3AF growing.

# Nephio



2023 was a big year for the budding Nephio community, highlighted by the availability of its landmark Release 1 (R1), boosting cloud native performance and efficiency with automation and auto scaling capabilities. This release marked significant progress in deploying, managing, and scaling telecom cloud infrastructure and network functions, leveraging Kubernetes and intent-based automation. You can learn more about Nephio R1 [here](#).

## Face to Face Collaboration

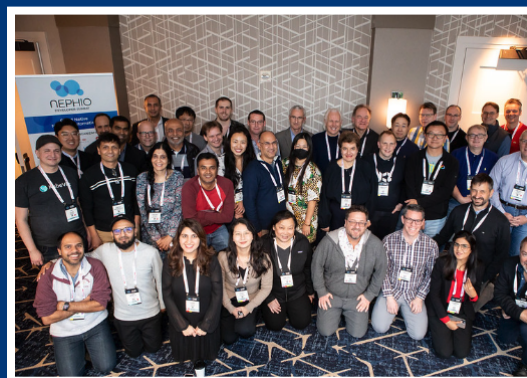
In October 2023, the Nephio community convened at the Nephio R2 Technical Summit. This event brought together developers and strategists to discuss future roadmaps and operational aspects of cloud-native automation, setting the stage for continued innovation and growth in the coming years.



## Nephio Joins LF Networking

Later in the year, Nephio hit another milestone by graduating into LF Networking. This induction bolstered its mission to drive collaboration and automate cloud-native deployments across Telecom, Cloud Service Providers, and Enterprises. It further aligned what Nephio is doing with Linux Foundation's broader ecosystem, including closer alignment with LF Networking and LF Edge project communities, facilitating an even more integrated approach to open network technology.

As we move into 2024, Nephio looks forward to building on existing momentum and achieving even greater milestones in cloud-native automation and network technology.



# ODIM, OpenDaylight



The Open Distributed Infrastructure Management (ODIM) platform was donated to The Linux Foundation and joined LF Networking in 2020. Its goal was to simplify the deployment of large scale distributed telecommunications networks. Unfortunately, the automation and orchestration space is crowded and without strong community support, the project voted to archive late in 2023.



OpenDaylight celebrated its tenth anniversary as a project this year, and has had a fascinating journey as one of the most long lived open source SDNs.

Since its inception, OpenDaylight has witnessed significant progress and evolution. Its early releases focused on providing a modular and flexible framework for network orchestration and management. Over the years, the project has grown its community and expanded its capabilities, addressing a wide range of use cases and integrating with other open-source projects and industry standards. OpenDaylight has played a crucial role in advancing SDN and NFV technologies, fostering innovation, and promoting interoperability within the networking industry.

As it stands, OpenDaylight is at the forefront of network programmability and automation. Its scalability improvements, in particular, have had significant impacts since 2015. With each new release, it continues to make strides in delivering an open and scalable platform for network automation and management.

Looking ahead, OpenDaylight aims to transition to a more microservices oriented architecture, which is a significant shift in its design philosophy. A microservices-based architecture, often used in conjunction with containerization technologies like Docker and orchestration platforms like Kubernetes, will enable OpenDaylight to be even more modular and scalable. This architectural shift will make contributing to OpenDaylight much more manageable, especially for bug fixes given the decoupling of services in such a setup.



ONAP continues to evolve with the availability of one major release this year: **ONAP London**, as the community finalizes the next release, ONAP Montreal. We made efforts to streamline processes and roles, and Montreal will be the first release with the new agreed-upon simplified software development life cycle governance.

The key highlight of 2023 was ONAP's achievement of the OpenSSF Gold Standard! This recognition can give ONAP consumers great confidence in the quality, security and reliability of the code.

### Additional highlights include:

- First ONAP projects (CCSDK, CPS, UUI and Policy) completed their upgrades to Java 17.
- Upgrades were executed for Spring boot (uplift to v3.1.2) and OpenApi 3.
- We introduced new PortalNG as a maintained alternative to the unmaintained Portal project.
- CCSDK continued maintaining alignment with the OpenDaylight release schedule by upgrading to OpenDaylight's Argon version, Service Release 2.
- The ONAP CPS project continued efforts to improve its read/write and query operations, as well as improving overall stability with a huge reduction of memory consumption.

This is seen:

- within the Modeling provision of YANG modules & automation tools, which helps improve YANG

development

- efficiency and checks the version update of the YANG model.
- with the OOM team's added support for Gateway-API in the Ingress template (13.0.1), as well as support for mariadb-operator (13.0.2).
- All ONAP MariaDB instances will now be created--with the latest version, by default, using the mariaDB-operator.
- Additionally added default role creation to ServiceAccount.
- SDC implemented services updated directly in yaml when desired, which brings more comprehensive support for defining behavior of interface operations and adaptability to define CSAR structure and content to suit the requirements of individual models.
- UUI introduced support for offline viewing of intent report information.
- ONAP projects worked on reduction of security vulnerabilities by upgrading component versions that will help improve vulnerability assessment and control risk.

We're eager to see where ONAP goes in 2024, as we look to further align with Nephio

**PAWEL PAWLAK** | *Chair, ONAP TSC & SECCOM, and Product Manager, Incognito Software Systems*

# Tungsten Fabric, XGVela



OpenContrail, an open-source project created in 2013 by Juniper Networks (an open-source version of Juniper Contrail product). After moving to LF Networking in 2018, OpenContrail was renamed Tungsten Fabric and, after almost 5 years of community participation, the project voted to archive in July, 2023.

Our broader community continued to refine and update the community release process as a top priority for XGVela. As always, we're eager to welcome new members into our community and look forward to accelerating the design, development and innovation of telco related services.



# Message from the Marketing Advisory Council



## **SANDEEP PANESAR**

*Chair, LF Networking Marketing Advisory Council, and Technology Thought Leader & Business Strategist*

This was another interesting year with the Marketing Advisory Council (MAC) as we changed the frequency of the meetings to allow us to achieve more of our Governing Board-approved marketing goals. This allowed us some additional room to play with new ideas to continue to market, plan for multiple events, and attend other events including those we didn't normally attend, all while keeping the LF Networking brand in the community's thoughts. I'm happy to say that this year was a Marketing success.

The MAC's goal is to provide mature and experienced guidance to our internal Marketing team to help them fulfill the mandates determined at the Governing Board level. We plan to continue that mission in 2024 with new vigor. The MAC itself will have new members with new ideas that will help us with the tasks around that work. We invite all LFN member organizations to reach out and provide us with their MAC representatives to help us influence everything from direct marketing efforts to brand evolution, and to provide us with fresh ideas that we haven't thought of before.

Our Marketing efforts themselves helped to increase the brand exposure with podcasts, webinars and industry analyst support; traditional marketing outputs such as articles, blogs, white papers; and events that were held throughout the year. With evolving technology, community, and marketing needs, our Governing Board adopted the Strategic Planning Committee's recommendation to evolve the LFN brand in 2024 to help it embrace newer, stronger messaging that would be more relevant to the times (don't worry, no name changes or logo changes!). So we will be working on that evolution starting in January of next year.

From a LF Networking events perspective, we listened to the community and acted accordingly. ONE Summit was pushed out to April, 2024 due to ongoing travel and corporate budget restrictions. However, this allowed us to experiment with regional events that we called "ONE Summit Regional Days" in North America, Spain, China, and India, all of which enjoyed strong registration numbers. We're optimistic that travel and budget restrictions will loosen in the coming months and that our flagship event will return to its full capacity and flair.

Enthusiasm for our face to face events, particularly at the Developer and Testing Forums, continues to be high. Developers are an important part of the community and, while video calls and remote discussions yield results, I think we can all agree that there's nothing quite like running into someone you haven't seen in a while, or only see on a Zoom call, and talking over a cup of coffee.

We're also very excited that Nephio was inducted into LFN, and that the 5G Super Blueprint continues to be a gem of community and corporate participation and collaboration. The 5G SBP in particular continues to evolve and innovate as new technologies come to light, and new projects come into LFN. OpenDaylight (ODL) turned 10 years old, which is a testament to the longevity of the project and the strength of the support from our members and leaders to continue to evolve and ODL's ability to stand the test of time.

This year was great. Thank you. So, join a project, join a community, and [\*\*join us in making 2024 an even greater success.\*\*](#)



# Industry Impact

## By the Numbers



**8**

PRESS RELEASES



**800**

PRESS CLIPS/  
MENTIONS



**10**

MEDIA/ANALYST  
BRIEFINGS



**2.3B**

POTENTIAL  
AGGREGATE REACH



**360K**

LINKEDIN  
IMPRESSIONS

## Top Quotes

“Open source networking technologies are now leading the way forward for enterprises, cloud and telco.”

— SEAN MICHAEL KERNER, SDXCENTRAL

“Over 100 developers are focusing on developing carrier-grade, intent automation and common automation templates [for Nephio]. The goal is to streamline the deployment and management of multi-cloud infrastructure and network functions across large-scale edge deployments.”

— DAN JONES, SILVERLININGS INFO



## Top Headlines



CNCF, LF Networking Join Forces to Drive Open Source Telecom Cloud Native [Read Now ▶](#)



Google talks up impending project Nephio release [Read Now ▶](#)



Project Nephio announces Release 1 [Read Now ▶](#)



Top 3 Open Source Networking Trends for 2023 [Read Now ▶](#)



Linux Foundation Wants to defragment telecom CNF efforts [Read Now ▶](#)



Project Nephio could really shake things up for network automation [Read Now ▶](#)



Linux Foundation announces new projects to help Telcos innovate with open source [Read Now ▶](#)

## Social Media

2023 brought an increased focus on LinkedIn given declining engagement on X/Twitter

**360K**

Linkedin impressions

**35%**

Growth in LinkedIn followers

**3%**

Growth in X followers

**19K**

YouTube views

**182**

Videos uploaded

**42%**

Growth in channel subscribers

Most viewed content focuses on:

- **5G Super Blue Print**
- **Sister project alignment** (e.g. Nephio, CAMARA, SONiC)

# Follow and Join Linux Foundation Networking

To learn more about LF Networking and membership benefits, please visit the [LF Networking website](#).

Follow us on LinkedIn ([LF Networking LinkedIn](#) and [ONE Summit by LFN LinkedIn](#)) and X/[Twitter](#) so you don't miss out on what's happening in the world of open source networking.

Bookmark and subscribe to the [LF Networking YouTube channel](#) to watch all recorded sessions from LF Networking events.



Thank you all for a successful 2023  
and here's to looking toward  
new horizons in 2024!