THE LINUX FOUNDATION

## Annual Report 2023

# Rising Tides of Open Source

www.linuxfoundation.org

# Contents


**A note about the images in this Annual Report:**

All images in this book are sourced from Linux Foundation Flickr, Unsplash, Pexels, Stocksnap, Adobe Stock, and Getty Images.

All icons used within are from The Noun Project.

# A message from our Executive Director

As 2023 comes to a close, I want to share with you a note on the tremendous progress the Linux Foundation enjoyed in what could otherwise have been a challenging year. Through hard work, perseverance, and the strong ongoing support of the community, we are continuing to grow and thrive.

Despite strong economic headwinds, we are on target for adding 270 new organizational members by the end of 2023. This includes dozens of new additions to the PyTorch Foundation, which has become a fundamental component of the fast-growing AI ecosystem and quickly blossomed into a neutral home for fostering and governing such a critical project. A more subtle membership success story is the growth in cross-foundational memberships. Many of our existing members have chosen to increase their commitment by participating in additional effects. We see this dynamic in crossovers between loosely coupled communities, such as CNCF and the FinOps Foundation.

In 2023, we eliminated any doubt that Linux Foundation in-person events would bounce back after COVID-19. Event registration is up 28.5% from last year. We helped organize and put on 256 events with 3,581 talks delivered by 4,576 speakers gathering 120,000 attendees from 17,764 organizations in 160 countries. The LF Event's team is tireless, incredibly detail-oriented, and, apparently, can be simultaneously in two places at once.

The third leg of our LF stool is LF Training. The future of open source depends on a global, educated workforce that has the required technology skills to create and maintain projects and deploy open source infrastructure.

We know from our surveys that demand for open source technology skills continues to grow. In 2023, cumulative trainee enrollments exceeded 3 million, with over 1,000 people taking an LF Training exam each week on average. Total enrollments grew by 13.8% compared to 2022. We added 11 new free courses, six new paid eLearning courses, two new certification exams, and three new instructor-led courses. LF Training now has 200 courses in the catalog, and we plan to add many more in the coming year. Kudos to the LF Training team.

Our continued strength in membership, events, and training is driving a rock-solid financial performance. Our revenues are growing year over year. This strong performance has enabled us to continue pouring resources back into the community. For example, we handed out $1.64 million in community travel funding and registration scholarships in 2023 to attend career changing events. This included 548 diversity travel scholarships and 362 need-based scholarships. Since its inception, we have paid over $1.5 million to nearly 500 mentees participating in the LFX Mentorship program.

Of course, the proof is in the project count and the ways that major organizations are using the code and standards we foster. We added 79 new projects in 2023 and are approaching 1,000 active projects — by far the largest collection of active projects in any open source foundation today.

All these statistics and milestones lead us to our most important measure: impact. Linux is omnipresent. PyTorch has become the dominant framework for machine-learning applications. Kubernetes continues to grow, and almost every major entity in the space deploys AI infrastructure; OpenAI, HuggingFace, and Adobe all deploy AI on Kubernetes and other cloud native tech. Our years of fostering community efforts in open source standards is bearing fruit: ISO accepted the two standards we sponsored for software security and carbon density measurement, and the CAMARA Project has become the most widely adopted open standard for API design and implementation on telecommunications networks, with strong backing from the GSMA. The LF has achieved all of this while maintaining high standards for diversity and inclusion; over 50% of LF employees are women, and women occupy 29% of executive positions, far exceeding technology industry averages.

The coming year will be perhaps more challenging than the last. Global conflicts and tensions are running high. The economic recovery of the latter half of 2023 appears tenuous. Although AI is the tide lifting many boats, it remains unclear whether the spending boom on AI will continue at the same pace. I have the greatest confidence none of this will slow down the rise of open source. Likewise, I have the greatest confidence that you, our community, will continue to provide tremendous levels of support and resources, without which the growth, expansion, and success of our joint endeavor would never have been possible. Thank you for everything, and here's to a successful coming year.

Sincerely,

**Jim Zemlin**
Executive Director,
The Linux Foundation

# A message from the Chair of the LF Board of Directors

As I write this, it's hard to fathom how much the world of technology has changed since I penned my last letter for the 2022 Linux Foundation Annual Report. Artificial intelligence and machine learning have exploded into our lives. GPUs and TPUs have gone from something only infrastructure geeks appreciated to part of the everyday considerations in building new applications. Each week seems to reveal a slew of new models, both open source and proprietary. In reality, the AI explosion of 2023 is built on decades of steady improvements in cloud computing, algorithms, databases, and many other core elements of open source technology – a perfect storm of years of improvements has resulted in this availability.

Technology is funny that way. We went from a Windows world to Linux servers everywhere in what seemed like a blink of an eye. Smartphones went from novelty to ubiquity in a flash. The same can be said for open source — today, it is the essential technology fabric that binds our world.

Even proprietary AI services like OpenAI's GPT-4 and Google's Bard are built on decades of open

source innovation. With the launch and rapid growth of the Linux Foundation Europe, it feels like we are finally everywhere. Then again, the LF has been on a steady upward trajectory now for decades, meeting customer and industry needs for collaboration to solve difficult problems. Maybe the EU was just that tipping point — but it feels momentous.

Taking a historical perspective is important and particularly relevant for me. With this letter, I mark my 25th anniversary working in open source. The community is my "work family," with so many good friends and wonderful colleagues that every event is something of a reunion. I am incredibly blessed to have this life and these connections; from them, I have boundless optimism for open source.

We are also witnessing a paradigm shift in what open source can achieve. Through the communities that the Linux Foundation works with and supports, open source innovation is expanding well beyond its software roots and pushing the boundaries into entirely new areas and different parts of the industry ecosystem. We face an existential crisis in global warming. The open source community is rising to the challenge by reimagining infrastructure at every level — from power plants and systems to make energy distribution more reliable, to best practices in efficient data center design, to reductions in compute required to power AI, all the way down to making websites greener and less energy intensive. The financial system is our economic glue. The open source community that the LF is working with is making tremendous progress in opening up

and democratizing access to what had been a largely closed system. We are working with diverse stakeholders to create open standards for digital identity, content provenance, carrier services interoperability, and higher capacity communications protocols required for foundational AI model training. The very nature of open source is about reusing, extending, and collaborating to reduce duplication and waste. Its very nature is about sustainability and saving energy.

Of course, none of this matters if we cannot secure the future and train the next generation to continue to innovate on open source. Over the past year, the OpenSSF and the open source community have made remarkable progress in securing our open source supply chain. Numerous tool and framework releases have filled critical gaps in open source security processes. Grant awards to critical open source projects have funded resources and expertise to focus intently on projects that matter, and make them safer. The OpenSSF and the Linux Foundation also continue to partner with governments worldwide to make the public infrastructure we all rely on safer and more resilient. Because of the diversity and scope of players in the software supply chain, the coordination and leadership of organizations like OpenSSF are critical to delivering on the promise of a more secure supply chain.  To deliver on the future promise of open source and foster the next generation, the Linux Foundation has rapidly expanded training programs, adding numerous courses. We aim to be the premiere resource for career and educational training in open source and to make this knowledge accessible to all. Through LFX, our community mentors work with ambitious technologists from around the world — many from disadvantaged backgrounds — to create a new generation of open source contributors and maintainers.  Our focus on the developer and their experience is central to our work across the foundation.

The breadth, depth, and momentum we see across so many fronts is a testament to all of you. Engaged members are what bring communities to life. The Linux Foundation is blessed with some of the most engaged memberships of any organization on the planet. This report is full of innovation and hope and a testament to what we can do together. Thank you for making 2023 a wonderful year and for all your hard work for the cause of open source, and for improving the world around us.

**Nithya Ruff**
Chair of the Board of Directors,
The Linux Foundation

# Linux Foundation Board of Directors

**Suzanne Ambiel**
*VMware*

**Tim Bird**
*Sony – Gold Director*

**Erica Brescia**
*At-Large Director*

**Kimberly Craven**
*Red Hat*

**Eileen Evans**
*At-Large Director*

**Melissa E. Evers**
*Intel*

**Frank Fanzilli**
*At-Large Director / Treasurer*

**Peixin Hou**
*Huawei*

**Takehisa Katayama**
*Renesas—Gold Director*

**Ken Komiyama**
*Fujitsu*

**Xin Liu**
*Tencent*

**David Marr**
*Qualcomm*

**Ben Maurer**
*Meta*

**Yuichi Nakamura**
*Hitachi*

**Shojiro Nakao**
*Panasonic—Gold Director*

**Sarah Novotny**
*Microsoft*

**Daniel Park**
*Samsung*

**Stormy Peters**
*GitHub—Silver Director*

**Phil Robb**
*Ericsson*

**Nithya Ruff**
*Chair*

**Keiichi Seki**
*NEC*

**Dan Williams**
*Intel*

**Jim Wright**
*Oracle*

**Jim Zemlin**
*Linux Foundation*

# Thank you to our members

In 2023, we saw several new challenges emerge. Across the world, governments are crafting or instituting broad-ranging regulations that could negatively impact open source ecosystems. Geopolitical tensions have exacerbated techno-nationalism. Attacks on the open source supply chain increased in frequency, with bad actors targeting package managers, build tools, and popular packages with various exploits.

Despite these challenges, the positives for open source in the past year easily outweigh the negatives. The launch of LF Europe was a rousing success, as measured by a growing number of participants and strong attendance at events. Due to a rebound in attendance, the events team at the LF added new events catering to emerging communities, such as WasmCon and the PyTorch Conference. In China, the LF community has continued to grow, demonstrating the power of open source to supersede political tensions. This story had several high points, including KubeCon + CloudNativeCon + Open Source Summit China.

Even as concern over regulations grew, the LF continued to expand its relationship with government entities and launch new programs fostering cybersecurity and open source software adoption. A great example is our partnership with DARPA in the AI Cyber Challenge. While expanding into new sectors, the LF also made great strides in open source standards and open source data sets; the CAMARA standard, already adopted by most major telecommunications providers, and the first global data release of the Overture Maps Foundation are two prime examples.

We attribute our successes in 2023 to the support of our members and the strength of our community. We are seeing unprecedented levels of engagement, participation, and mentorship activity across our various projects. As we move into the coming year, we look forward to expanding our efforts in AI and data, cloud computing, and many other domains. None of this would be possible without the continued support of our community in the form of membership, event sponsorships, governance participation, maintainer resources, and, of course, the code you commit to our projects.

We enter 2024 in a strong position, reflecting your efforts and hard work and the power of open collaboration. Open source is now the technological foundation of the world, and it's only going to get better.

We wish you the best for the coming year and thank you for your invaluable support.

**The Linux Foundation**

# Linux Foundation members

## Platinum members














## Gold members














## Silver members

### #

0Chain
1Crew
1NCE GmbH
1Nebula
1Password
23 Technologies GmbH
24x7 Geeks Solutions Pvt Ltd.
3-Shake Inc
42on
6WIND S.A.
99Cloud Inc.
A10 Networks

### A

Aarna Networks
Absa Bank Limited
ACC ICT
Accuknox
Acend GmbH
ACKSTORM
Acorn Labs, Inc
Acornsoft
Acumatica Inc.
Ad Hoc LLC
Adaptech Group
Adaptive Financial Consulting Limited
Addresscloud
Adfolks LLC
Adobe Inc.
Adusoft - Adam Nowaczyk
Adva Optical Networking SE
Advanced Driver Information Technology Corporation
Advanced Micro Devices (AMD)
Aembit Inc
aeolabs
Aerospike
Affinidi Pte Ltd
Afi Technologies
Agenda d.o.o.
Agile Lab
Ahana Cloud, Inc.
AIA
AIM (agile-im.de)
Airbnb
Airbyte
Airlock by Ergon Informatik AG
Airwayz
Aisin Corporation
Aiven Inc
Akamai Technologies, Inc.
Akatsuki Games Inc
Akenes SA (Exoscale)
Akuity, Inc.
Alauda, Inc
Alerant Zrt.
Allegro Cloud
Allianz Investment Management
Alluxio, Inc.
Allwinner Technology, Co. Ltd.
Alpha Business Solutions Private Limited
alphawave semi
Alter Way
Amadeus IT Group, S.A.
amazee.io
Amazon Web Services, Inc.
Ambassador Labs (f/k/a Datawire)
Amberflo.io
Ambient IT
American Cloud
American Express Banking Corp.
American Tower Corporation
Amesto Fortytwo
AMI US Holding Inc.
Ampere Computing
amplication
Amundi Asset Management
Anaconda, Inc
Analog Devices, Inc.
Anchore, Inc
Andes Digital
Animal Logic Pty Ltd
Anjuna Security, Inc.
Anodot Inc.
Anonyome Labs, Inc.
Ant Group Co., Ltd.
Antmicro
anynines GmbH
Aokumo Inc.
APE FACTORY
APIIDA AG
Apiiro
Apollo GraphQL
Apono
Appddiction Studio
AppsCode Inc.
Appstellar
Apptio
Appvia Ltd.
Aqua Security Software, Inc.
Archera
ArcherOS Cloud Software Co., Ltd.
Arcontech Group PLC
Arduino
Argonaut

ARIMA
Arista Networks, Inc.
Arm Limited
ARMO (Cyber Armor)
Armory Inc.
Arnica
Arrikto, Inc.
Ascensio System SIA
aserto
Aspen Mesh
Aspen Technology, Inc.
ASRock Rack Incorporation
Asterfusion Data Technologies
Astronomer
ASUS Cloud Corporation
AT&T Services, Inc.
ATB Ventures
Aternos GmbH
ATIX AG
Atlassian US, Inc
Atos SE
Audiokinetic Inc.
Augtera Networks
AuriStor Inc.
AUSY Technologies Germany AG
Authzed
AutoCloud
Autodesk
Automatic Data Processing, Inc. (ADP)
Avanade Inc.
Avanza Innovations IT Solutions LLC
Avesha
AVEVA Group
Avisi Cloud Services B.V.
Aviz Networks
AVL Software and Functions GmbH
AVSystem sp. z o.o.
AXA Group
Axcelinno
Axiado
Axiata Digital Labs
Axis Communications
Axoflow

## B

b-nova Schweiz GmbH
B1 Systems GmbH
Bancolombia
Bank of America Corporation
Bank of Montreal
Bank of New York Mellon
Bankware Global
Banma Information Technology
BasicAI
basysKom GmbH
Baumer Management Services AG
BayLibre Inc.
Beechwoods Software, Inc.
BeekeeperAI
Beijing Baolande Software Corporation
Beijing Big Data Co.,Ltd.
Beijing Datenlord Technology Co., Ltd.
Beijing Dosec Technology Co., Ltd
Beijing Huijun Technology Co. Ltd. (JD Cloud)
Beijing Ji Ke Tian Cheng Technology Co., Ltd (ScaleFlash)
Beijing Primitive Technology Co., Ltd
Beijing Shengxin Network Technology Co., Ltd. (QINGTENG)
Beijing Sup-info Information Technology Co. Ltd
Beijing Tongtech Co., Ltd.
Beijing Truth Technology Co., Ltd.
Beijing VNET Broad Band Data Center Co., Ltd.
Beijing Zhiling Haina Technology Co., Ltd (SmartX)
Bell Canada
BellSoft
BerryBytes
BeyondEdge
Binario Etico
BISDN
Bitrock
BlackRock, Inc.
BlakYaks
Block, Inc.
BlockLabs
Bloombase, Inc.
Bloomberg Finance L.P.
Blue Sentry
BlueArch Group Inc.
Blues Inc.
BMC Software, Inc
BMW
BNP Paribas
Boeing
Bolt Graphics
BONbLOC Inc
Boost Security
Bootlin
Booz Allen Hamilton, Inc.
Bosch
Boston Consulting Group
BoxBoat Technologies
Broadcom Corporation
Brobridge
BS Company Srl
Bull SAS
Buoyant, Inc.
Business-intelligence of Oriental Nations Corporation Ltd
Bytedance Ltd
bytesatwork
ByteSource Technology Consulting GmbH

## C

Cable Television Laboratories Inc.
Calyptia
Camptocamp
CanaryBit
Canonical Group Limited
Cape Inc.
Capgemini
Capital One Services LLC
Carbonated
CasperLabs LLC
CAST
Cast AI Group, Inc.
Catalogic Software
Catalyst Cloud
Caylent Inc
CECloud Computing Technology Co., Ltd
CelerData
Cerbos
Certizen Limited
Cesium
Chainguard
Chainyard
Chaitin Tech
Change Healthcare
Chaos Software LTD
chargebyte
Charter Communications
Checkmarx
Chengdu Yuan Lai Yun Zhi Technologies Inc.
China Mobile Communication Company Ltd
China Systems Holdings Limited
China Telecom Cloud Technology Co., Ltd
China Telecommunications Corporation
China Unicom
Chislitel Lab
Chkk Inc
Chronosphere, Inc.
Ciena Canada, ULC
Cinemo GmbH
CINQ ICT
Cirba d/b/a Densify
Circle Internet Services, Inc
Circonus
Circulor Ltd.
Cirrus Logic
CISEL Informatique SA
Citi
Civo Ltd.
claion
Clastix SRL
Cleartrace
Clockwork.io
Cloud Ace
Cloud Kinetics
Cloudbase Solutions S.R.L
CloudBees, Inc.
CloudBolt Software
CloudControl, Inc.
CloudCover Pte. Ltd.
Cloudera, Inc.
CloudFabrix
CloudFerro Sp. z o.o.
CloudFix
CloudGeometry Inc.
Cloudical
Cloudification
CloudLinux
Cloudmate
CloudMonitor
CloudOps Inc.
Cloudshape Inc
Cloudsmith Ltd
Cloudstratex
Cloudthread
CloudZero
Clussys Inc
Clyso GmbH
CME Group Inc.

Cockroach Labs
Code Intelligence
Codefresh, Inc.
Codethink
CodeWave
Cog Systems
Cognizant Technology Solutions
Coinbase Inc.
Colder Products Co
Collabora Ltd.
Comcast Cable Communications, LLC
comforte AG
Commvault Systems, Inc.
ComplianceCow
Component Soft Kft.
Concourse Labs
Connect 5G, Inc.
Connectifi
Conoa AB
Consensys AG
Container Solutions BV
Continental Automotive Systems
Contrast Security
Control Plane Corporation
ControlMonkey
ControlPlane.io
Convox Opco Inc.
CoolIT Systems Inc.
CORE 24/7 LLP
Coredge.io
CoreHive Computing LLC
CoreStack
CoreWeave, Inc.
Cornelis Networks
Corsha
Cortex
Cosaic, Inc.
Cosmonic
CoSoSys S.R.L.
Crafter CMS
Crayon
Creationline, Inc.
Cribl Inc
CRIF S.p.A
croit GmbH
CrowdStrike
Crunchy Data Solutions, Inc.
Cryptape Technology Co., Ltd.
Cryptosat
CSDN (Beijing) Network Technology Co. Ltd
CSEngineering
CTO.ai
Ctrlstack
cuegee it
Cuemby Inc.
CVS Health
CyberArk Software Ltd
Cybertrust Japan Co., Ltd.
Cybozu, Inc.
Cycode, Inc.
CYSEC SA

## D

d-Fine GmbH
D2iQ, Inc.
DABCo Ltd
DAEKYO CNS
DaoCloud Network Technology Co., Ltd.
Data Storage Research, LLC d/b/a DSR Corporation
Databricks Inc.
Datachain, Inc.
DataCore Software
Datadog, Inc
Datadrivers
DataStax, Inc.
Datastrato
Dataverse
Datree.io
Daugherty Business Solutions
Daynix Computing LTD
DB Systel GmbH
De Novo LLC
Deepfactor
Deepfence, Inc
Deepshore GmbH
Defense Unicorns
Dellfer, Inc.
Deloitte Consulting LLP
Delta Electronics Worldwide
Dembach Goo Informatik GmbH & Co. KG
Denodo Technologies
DENSO CORPORATION
DENX Software Engineering GmbH (DENX)
DeployHub, Inc.
Depository Trust and Clearing Corporation (DTCC)
Depot
Desay SV Automotive
Design Barn Inc
Desotech srl
Deutsche Bank AG
Deutsche Telekom AG
DevsOperative
Devtron Inc.
Dhiway Networks Private Limited
Diagrid
Diamanti, Inc.
Dianomic
Didim365
DigiCert, Inc.
Digital Asset Holdings, LLC
Digital China Macao Commercial Offshore Limited
Digital Impact LLC
DigitalOcean
Direktiv
Discover Financial Services
DLT Global Inc.
DMetaSoul
DNEG
Docker, Inc.
DoiT International
Dorado Software
DornerWorks, Ltd.
dq technologies AG
Dragonflydb
DreamBig Semiconductor Inc.
DrimAES
DriveNets
Dynatrace LLC

## E

EasyStack Inc.
eBay, Inc.
Edge Delta
Edgecore Network Corporation
Edgeless Systems
Edgenesis
EdgeRay Technologies Co., Ltd
efabless Corporation
Elasticsearch, Inc.
Elastisys AB
Elastx AB
Electricity Maps
Electronics and Telecommunications Research Institute
Elektrobit Automotive GmbH
Elementl
Elotl, Inc
Emagine IT, Inc.
emlix GmbH
Enakta Labs
enclaive
Endor Labs
Energy Web Foundation
Enfabrica
Ensignia
Enterprise DB Corporation
Entigo OÜ
EntServ UK Limited
env0
Enveil
Environmental Systems Research Institute, Inc. (ESRI)
Envisor
envite
EPAM Systems, Inc
Epic Games, Inc
Equifax Inc.
Equinix Services, Inc.
Ernst & Young Global Limited
esatus AG
Escala24x7
Escape
Espeo Software
Esperanto Technologies Inc.
Ethernity CLOUD
Evolutio
Evolvere Technologies
Evonem LLC
Exein
Exivity
Exotanium Inc.
Expert Thinking
Extreme Networks, Inc.

## F

F5, Inc.
Fabrick S.p.A
Facets Cloud Inc.
Fairwinds Ops, Inc
Far-Galaxy Networks, Inh. Sebastian Fohler
Federal National Mortgage Association (Fannie Mae)
Fermyon Technologies
Fidelity Investments
Filecoin Foundation
Finout

Firecell
FireHydrant
Firetail
Fisher-Rosemount Systems, Inc., an Emerson Company
Flanksource
FLANT EUROPE OÜ
Flexera
FlexiDAO
Flexnode
FluxNinja Inc
FogHorn Systems
Fortanix
FOSSA
FossID
Foundries.io LTD
Fournine Cloud Solutions
Framestore
FreedomFi
ftrack AB
FUGA BV
FullStackS
Fullstaq
FuriosaAI, Inc.
Futurewei Technologies, Inc.

## G

Gaia Information Technology
Galois, Inc
Garden Technologies Inc.
Gatsby Inc
GEICO
Gen Digital
General Electric Company
Genesis Global Technology Limited
genezio
Genvid Technologies Inc
GenXcomm Inc
GENXT
German Edge Cloud GmbH
Giant Swarm GmbH
GienTech
GitGuardian
GitHub, Inc.
GitLab Inc.
Gitpod GmbH
Globant LLC
Globo
GoDaddy Operating Company, LLC
Goldman Sachs & Co. LLC
GoLedger
Golioth
Grafbase
GramLabs, Inc. (d/b/a StormForge)
Granulate Cloud Solutions, Inc.
Grape Up Sp. z.o.o.
Graphcore
Gravitational, Inc
Green Hills Software LLC
Greptime HK Limited
greymatter.io
groundcover Ltd.
GSBN
Guangdong OPPO Mobile Telecommunications Corp., Ltd.
Guida

## H

HackerOne
Hadean Supercomputing Ltd
Hammerspace
Hangzhou EMQ Technologies
Hangzhou Harmony Cloud Technology Co., Ltd.
Hangzhou Langhe Technology Co. Ltd. (Netease)
Hangzhou MoreSec Technology Co., Ltd.
Hangzhou WOQU Technology Co., Ltd.
Hanover Insurance Group
HAProxy Technologies
Harness Inc.
Harpoon Corp
Hartford Financial Services Group Inc.
HashiCorp Inc
Hasura, Inc.
HCL Technologies Ltd.
Hedera Hashgraph LLC
Hedgehog
Helios
Helium Systems, Inc.
HENSOLDT Cyber GmbH
HERE Global B.V.
Heroic Labs
Hewlett Packard Enterprise Development LP
Hexagon AB
Highlight
Highway9 Networks
Honda Motor Co., Ltd.
Honor Device Co. Ltd
Horizon Robotics
Hostersi sp. z o.o.
Hound Technology Inc. dba Honeycomb
HP Inc.
HSA Foundation
HSBC
Hugging Face Inc
Humanitec
Hushmesh
Hygraph
Hyland Software, Inc.
Hyundai Mobis Co., Ltd.
Hyundai Motor Group

## I

Iauro Systems
iCubed
Identity Technologies Inc
IDnow GmbH
iExec Blockchain Tech
IFS World Operations AB
Igalia, S.L.
IGNW
IHS Markit
IITS Consulting
IKEA Marketing & Communication AB
ILKI FRANCE
Imagination Technologies Group Ltd.
Imperas Software Ltd
Indeed, Inc.
Indicio
IndyKite Inc.
Infineon Technologies AG
InfinyOn Inc
InfluxData Inc
Infoblox Inc.
InfoCert
Information Data Systems
Infosys Limited
Infra Technologies, Inc.
Infracloud Technologies INC
Infracost
infraeo
Inframappa
ING Group
Inigo
initializ™
Innogrid
inovex GmbH
Inspur Group
Instnt Inc.
Instruqt B.V.
Integra Ledger
IntellectEU
Intelligent Systems Services
Intensivate, Inc.
InterCloud
Interdynamix
Intesi Group SpA
Intuit, Inc.
Intuitive Technology Partners, Inc.
Invia
IO Builders Blockchain Technologies & Ventures
IOG Singapore Pte. Ltd
IOTech Systems Limited
IPwe
Iquall Networks
IRNAS
iSoftStone Information Technology (Group) Co., Ltd
Isovalent Inc.
ITAU BBA USA SECURITIES, INC.

## J

Japan Securities Clearing Corporation (JSCC)
Jetstack Ltd
JFrog, Inc
Jina AI Limited
Joby Aero
Joisto Group Oy
JPMorgan Chase
Jump Operations, LLC
Juniper Networks, Inc.
JVC KENWOOD Corporation

## K

Kaleido
Kasten, Inc.
KBSYS Inc
KDDI Corporation
Kentik
kering
Keyfactor
Keyless technologies LTD
Keysight Technologies Inc.
Kinetix Trading Solutions
KINX
Kion
Kioxia Corporation
Kiratech SpA

KitBash3D
Kloia Software and Consulting Ltd
Kloudfuse, Inc.
KodeKloud
Kodem Security
Komodor Inc.
Kong Inc.
Konsulko Group
Koor Technologies, Inc.
KPIT Technologies Limited
KPMG LLP
Kry10 Limited
Krypc Corporation
KSOC
kt NexR
Kubeark
KubeOps GmbH
Kuberix
Kubermatic GmbH
Kubernetes Innovation Labs LLC (Kubeshop)
Kubevisor
Kubiya Inc
Kublr
KUKA Deutschland GmbH
Kumina B.V.
Kumoco limited
Kusari Inc
Kyndryl
Kythera AI

## L

L4B Software GmbH
Lablup Inc.
Lacework
Laird Connectivity, Inc
Lantronix Inc.
Larsen & Toubro Infotech Ltd
Last9 Inc
Lawrence Livermore National Laboratory (LLNL)
Leading Point
LeanIX GmbH
Legit Security
Leica Camera
Lenovo (Beijing) Co., Ltd
LG Electronics Inc.
Lightbend Inc
Lightning AI
Lightrun Ltd
Lightstep, Inc.
Linaro Limited
LINBIT
Lineo Solutions, Inc.
LinkedIn Corporation
Linutronix GmbH
Liquid Reply
Lloyds Banking Group
LMAX Exchange Ltd
Lockheed Martin
Loft Labs, Inc.
Logiq.ai Inc.
Logshero Ltd.
Loongson Technology Corporation Limited
Loophole Labs, Inc.
LPI.org
LSD OPEN
LTIMindtree Limited
Lucidity.cloud
Lumigo Ltd
Lutech Advanced Solutions S.p.A.
Luxoft Global Operations GmbH
LY Corporation

## M

MacStadium
MagicOrange Group Limited
MakinaRocks
Man Technology
Marvell Semiconductors Ltd
Maryville Consulting Group
MasterCard Incorporated
Materna Information & Communications SE
MATRIXX Software
Mattermost, Inc.
Mavenir Systems, Inc.
Maxon Computer GmbH
Mazda Motor Corporation
MBDA Italia S.p.A
McKinsey & Company, Inc
MediaTek USA Inc.
MediConCen Limited
MegaEase, Inc.
MegazoneCloud
Meinberg Funkuhren GmbH & Co KG
Memfault Inc
Memphis.dev dba Stretch, Inc.
Mend.io
Mercedes-Benz Tech Innovation GmbH
Merly Inc
Metis Data
MetroStar Systems
Mezmo
MIA s.r.l.
Micas Networks
Micro Focus International plc
Microchip Technology Inc.
Micron Technology
Micware Co. Ltd.
Midokura Japan K.K.
Milligan Partners
MIIIPont
mimik Technology Inc
Minio, Inc
Mirantis, Inc.
Miraxia Edge Technology Corporation
Mithril Security
Mitsubishi Electric Corporation
Mitsubishi Motors Corporation
Mod Tech Labs
mogenius
Moment Technologies, Inc.
Mondoo
Monokee
Monostream AG
MontaVista Software, LLC
Morgan Stanley
Morpheus Data
Moxa Inc.
MSys Technologies
Mycelial
MyFitnessPal LLC

## N

N3XGEN Smart Information Technology EST
Namespace Labs
NAMUTECH Co., Ltd.
Nanjing eCloud Technology Co., Ltd.
Nanjing Pengyun Network Technology Co., Ltd.
Napptive
National Instruments Corporation
NatWest
Navimentum Information System Co., LTD.
NCC Group
ndustrial
Nearmap Australia Pty Ltd
NEC Networks & System Integration Corp.
Neo4j, Inc.
NEOS
NetApp, Inc
Netdata
Netflix, Inc.
NetFoundry
Netgate
Nethopper LLC
Netris, INC.
Netweb Technologies
NeuReality Ltd
Neuroglia
Nevexis
New H3C Technologies Co., Ltd
nexB Inc.
NextBillion.ai
NGINX International Limited
ngrok
NHN Corporation
Niantic
Nikon Corporation
Ningbo Lotus Robotics Co., Ltd.
NIO
NIPA
Nippon Seiki Co. Ltd.
Nirmata, Inc.
Nokia Corporation
Nomoko
Nomura Holding America
nops.io
Nordic Semiconductor ASA
Northflank Ltd
NTT Corporation
NTT DATA MSE CORPORATION
Numbers
Nutanix, Inc.
Nuvitek
Nuvotex Solutions GmbH & Co. KG
NVIDIA Corporation
NXP Semiconductors Netherlands B.V.

## O

OBSS
Occentus Network
Octo Consulting Group
Octopus Deploy PTY Ltd.
OGIS-RI Co., Ltd.
OKESTRO
Okta Inc.

Okteto
Ondat
OnGres
Opaque Systems Inc.
Open Source Automation Development Lab (OSADL) eG
Open Source Consensus(Shanghai) Network Technology Co., Ltd
Open Source Consulting Inc.
OPENFLAME INC.
OpenNebula
OpenSynergy GmbH
Operant
opscruise
OpsLevel
OpsMx
Optim Cloud
Opus Security
Orange SA
ORCASIO, INC
Origoss Solutions Ltd
Orkes Inc
Ortec Finance
Osaka NDS Co., Ltd.
OSNEXUS
OSSO B.V.
Oteemo Inc.
Oticon A/S
OTOY, Inc.
Otterize
OVH SAS
Ozone Cloud Inc.

## P

P0 Security
Paladin Cloud
Palark GmbH
PalCNetworks
Palo Alto Networks
PantaRei Design
PANTHEON.tech s.r.o
Paramount Software Solutions Inc.
Parasoft
PayPal Holdings, Inc.
PBG Consulting
Peloton Interactive
Penten
PepperData
Percepio AB
Percona
PerfectScale
Permit.io
phala network
Phoenix Software International
PHYTEC Technologie Holding AG
Pier Cloud
Ping An Technology (Shenzhen) Co., Ltd
PingCAP
Pionative
Pioneer Corporation
Pionix GmbH
Pipekit Inc
PlanetScale, Inc.
Plat'Home Co., Ltd
Platform9 Systems, Inc.
Platformatic
plural
plusserver
PLVision Corporation
Point72, L.P.
Polar Signals Inc
Polar Squad
Port
Portainer.io
Posedio - Professional Cloud Consulting
Posit
Poste Italiane SPA
Postman
Precisely Holdings, LLC
Precision Innovations Inc
Prefect
Preferred Networks, Inc.
Prisma Data, Inc
Privado
Prodigy Education
Prodvana
PRODYNA SE
Profisea
Progressive Insurance
Proofcraft Pty Ltd
ProsperOps
proteanTecs
PTV Group
Publicis Groupe
Pulumi
Puppet, Inc.
Pure Storage
Puzzle ITC GmbH

## Q

QAware GmbH
Qiming Information Technology Co., Ltd.
QingCloud Technologies Corp.
Qleet - The Application Orchestration Platform
Quali
QualitySoft Corporation

## R

R3 LLC
Rackner
Rackspace US, Inc.
Radisys Corporation
RADTONICS
Rafay Systems, Inc.
Raft
Raintank, Inc. – Grafana Labs
Randoli
RapidAPI
RapidFort, Inc.
RBC Capital Markets, LLC
re:cinq
ReadMe
REALTO GROUP INC
Reblaze
Recurve
Red Date (Hong Kong) Technology Limited
Red Kubes BV
Redeploy
Redocly Inc
Redpanda Data
REGnosys Limited
Rego Consulting
Release Technologies, Inc.
Reliance Jio Infocomm Limited
Replicated, Inc.
ReversingLabs
Revolgy
Ribbon Communications Operating Company, Inc.
Ricoh Company, Ltd.
Ripple Labs Inc.
Rivos Inc
RNG Technology
Roadie
Robin Systems, Inc
Robotec.ai sp. z o. o.
Robusta.dev
Rocket Software, Inc.
RodeoFX
Rookout Ltd.
Rootly, Inc.
RTE (Reseau de Transport dElectricite)
Ruijie Networks Co., Ltd
RX-M, LLC

## S

S&P Global Inc.
SADA Systems
SAIC Motor Corporation Ltd
Salad Technologies
Saleor Commerce
Salesforce.com, Inc.
Salience Labs
Salsify
Saltware
Sanborn
SANCLOUD LTD
SAP
Sartura
SAS Institute Inc.
Sateliot
Sauce Labs Inc
Savoir-faire Linux
ScaleOps
Scaleway
Scantist Pte. Ltd.
Scarf Systems, Inc
Scenera Inc
Schellman & Company, LLC
Schneider Electric
Schwarz IT GmbH & Co. KG
Science Applications International Corporation
Scotiabank
Scott Logic Ltd
ScoutAPM
Scribe Security
Seagate Technology LLC
Seal Software (Shenzhen) Co.,Ltd.
Searce
Second State
Secondfront
section.io Inc
Selective Insurance Group
Senofi

Sense Reply
Sentry Software
ServeTheWorld AS
servicememe
Services4-IT
Shabodi
Shanghai Guance Information Technology Ltd.
Shanghai HFtech Co. LTD
Shanghai Mandao Technology Co., LTD
Shanghai Qiany Technology
Shanghai Sectrend Information Technology Co.,Ltd
Shanghai Vonechain Information Technology Co., Ltd
Shanghai Yunzhou Information Technology Co. Ltd (ZStack)
SHE BASH
Shenzhen Forms Syntron Information Co. Ltd
Shenzhen Wise2C Technology Co.,Ltd
ShiftLeft
ShineSoft Co. Ltd.
Shopify Inc.
Shoreline
SICPA SA
SideFX (Side Effects Software Inc)
Sidero Labs
Siemens AG
sifamo
SiFive
SIGHUP s.r.l.
Signadot
SigScalr
Silicon Studio Corporation
SIMBA Chain
Simba Innovation
SingleStore, Inc.
Sirius XM Radio Inc.
Skyloud
Slim.AI
Smallstep
Smart Cloud Solutions
SmartBear Software, Inc.
Smartiful, Inc.
Snapper Future Tech Pvt Ltd
Snow Software Inc
Snowflake Inc.
Snyk Limited
Société Générale
Socket
SoftBank Corp.
Softchoice LP and Softchoice Corporation
Software Mind
SoftwareONE AG
SoKube
Solace
SolidRun Ltd
SOLIZE Corporation
Solo.io, Inc.
Sonar
Sonatus, Inc.
Sonatype, Inc.
SORAMITSU CO., LTD.
Sosivio
Spacelift, Inc.
Sparkfabrik srl
Spatial
Spectro Cloud, Inc.
SpeedScale
SphereEx
Spirent Communications Inc
Splunk Inc.
Spotify AB
Springer Nature
Sprint Corporation
Spyderbat
Spydra Technologies Pvt Ltd
Squarespace, Inc.
SQUER Holding GmbH
stack.io
stackgenie
StackHawk
Stacklet
Stacklok
Stackwatch Inc
Stateful
Staubli Corporation
Steamhaus
Stellate
Sterlite Technologies Limited
Sternum
Stigg.io
STMicroelectronics International N.V.
Storm Reply
StorPool Storage AD
Stratascale
Strategic Blue
Stratox Cloud Native
Strava
StreamNative
Structsure, LLC
Styra Inc
Sue B.V.
Sumitomo Electric Industry, Ltd.
Sumo Logic, Inc.
Super Micro Computer, Inc.
Supercritical
SuperOrbital, LLC.
Surveil
SUSE LLC
Suzhou Beyondcent & Software Co., Ltd. (BoCloud)
Suzuki Motor Corporation
SVA System Vertrieb Alexander GmbH
Swisscom
Symbotic
Symphony Communication Services LLC
Synax GmbH
Synechron, Inc.
Synopsys, Inc
Synyega
Sysdig, Inc.
SysEleven GmbH
SYSGO GmbH

## T

taikun.cloud a.s.
Tangoe US , Inc.
Target Corporation
Tata Communications Limited
TDT AG
Tech Mahindra Limited
technative
Technology Innovation Institute
Tectonic Labs Ltd.
Telechips, Inc.
Telecom Italia Mobile (TIM) S.p.A.
Telefonica, S.A.
TELUS Corporation
Temenos
Temporal Technologies Inc
Tenable, Inc.
TenneT
TensorSecurity Technology Ltd
TenxCloud
TeraSky
Terramate
TestifySec
Testkube
Tetrate.io
Teuto.net Netzdienste GmbH
Texas Instruments Incorporated
Thales SA
The 4th Paradigm Technology Co., Ltd
The Constant Company, LLC / Vultr
The Foundry Visionmongers Limited
The Guild
The Qt Company Oy
The Scale Factory Limited
The Walt Disney Studios
Thebes Cloud Management Limited
Thnk Big
Thought Machine Group Limited
ThoughtWorks, Inc
Thunder Software Technology Co. Ltd.
Tick42 AD
Tidelift, Inc.
Tietoevry
Tigera, Inc.
Timescale
Timesys Corporation
Timspirit
TL Consulting Group
TmaxCloud
TO THE NEW
Tokentrust AG
TomTom International B.V.
ToposWare Inc.
Traceroute42
Traefik Labs SAS
Trail of Bits
Transposit Corporation
Transwarp Technology (Shanghai) Co., Ltd
Travelers
Travelping GmbH
Trenchant Limited (trading as G-Research)
Trend Micro Incorporated
True B.V.
Truepic, Inc.
turntabl

Tuxera Inc.
Tyk Technologies Ltd.
tykelab srl

## U

U.S. Bank
Uber Technologies Inc.
Ubiquitous AI Corporation
UBS AG
Uffizzi
Ultraviolet Consult DOO
UMB AG
UNIBERG
Unikraft GmbH
Union.ai
Unisys
Unity Technologies
Unlocked Networks Inc.
Unravel
unSkript, Inc.
Upbound, Inc.
UpCloud Ltd
Upsider
Uptycs, Inc.
Utilidata
UtilityAPI
Uturn Data Solutions
UWS Inc.

## V

VA Linux Systems Japan K.K.
Validation Cloud
Valve Corporation
Vates
Vaxowave
Veea Inc.
Vega Cloud Inc
Velocity
Ventana Micro Systems
Veriken, Inc.
VeriSilicon, Inc.
veritone
Verizon Corporate Services
Vertice
Vertiv
VES LLC
VEXXHOST, Inc.
Vicom Infinity, Inc.
VicOne Inc.
VictoriaMetrics
Videndum Media Solutions Spa
Virtasant
vivo Mobile Communication Co., Ltd.
VNC Automotive Limited
Vodafone Group Plc.
Volkswagen Aktiengesellschaft
VSHN AG

## W

Wanclouds Inc.
Wargaming.net Limited
WattCarbon
Wavecon GmbH
Wavelabs
Wayfair
Weaveworks Inc.
Web3 Labs
Wegmans Food Markets
Wellington Management Company, LLP
WeScale SAS
Western Digital Corporation
Weta Digital Limited
Wevr
WhaTap Labs Inc
Whitestack LLC
WhizUs GmbH
Wind River Systems, Inc.
Wing Programming Language
Wipro Limited
Wistron Corporation
Witekio Holding
Wowjoy Technology
WSO2 LLC.

## X

x-cellent technologies GmbH
x-ion GmbH
Xcalibyte
Xenit AB
Xevo Inc.
xFlow Research.com
Xi'an Tieke Jingwei Information Technology Co.,Ltd. (CARS)
XigXog
Xosphere
Xsight Labs

## Y

YäRKEN
Yazaki Corporation
Yellowbrick Data
YLD! Limited
Yotascale
Yusur Technology Co., Ltd.

## Z

ZEDEDA, Inc.
Zeeve Inc
Zelarsoft LLC
Zenduty
Zesty Tech Ltd.
Zettabytes, Inc.
Zilliz
Zoi
Zoss Team, LLC
ZTE Corporation
ZutaCore
进迭时空（杭州）科技有限公司 SpacemiT (Hangzhou) Technology Co. Ltd

# Remembering Dr. Shuli Goodman

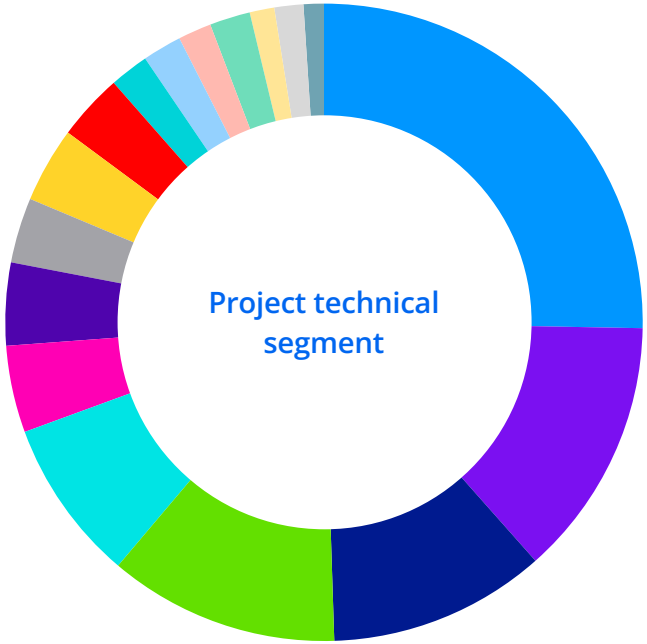
This year, the Linux Foundation lost a dear friend, colleague, and true open source and energy community champion, **LF Energy** Founder and Executive Director Shuli Goodman, who lost her battle with cancer on January 3rd. Shuli will be fondly remembered and sorely missed by all in our community, especially her wife Karen, her son Dakota, her soul-sister Lucy, and the many young people she helped nurture and grow. Our hearts go out to them all at this difficult time.

From its inception, Shuli worked tirelessly to build LF Energy into the thriving community it is today. Even throughout her illness, Shuli remained deeply committed to seeing the mission of LF Energy through. She was a well-respected leader and colleague, and those who worked closely with her will remember her unwavering passion for achieving urgent decarbonization targets through open source.

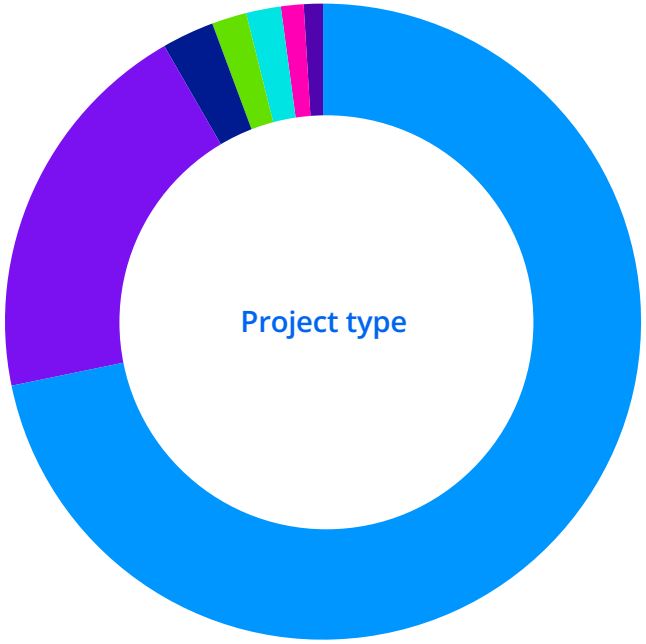
Throughout her successful career, Shuli was admired by all who knew her. She was especially proud of the community she founded and grew and appreciative of the team members across the Linux Foundation and LF Energy who supported her in her mission.

In Shuli's memory, the Linux Foundation remains fully committed to the ongoing success of LF Energy as a community, recognizing its critical role in the future of our planet. With the support of Linux Foundation Executive Director Jim Zemlin, General Manager and SVP of Projects Mike Dolan, and the dedicated LF Energy team, we will continue to advocate for the advancement of energy sector digitalization by implementing open source technologies and encouraging stakeholders at all levels to join us in this impactful work.

# Serving over 1,133 open source project communities




- Cloud, Containers, & Virtualization **25%**
- Networking & Edge **13%**
- AI, ML, Data & Analytics **12%**
- Web & Application Development **11%**
- Cross-Technology **8%**
- Privacy & Security **4%**
- IoT & Embedded **4%**
- Blockchain **4%**
- DevOps, CI/CD, & Site Reliability **3%**
- Open Source & Compliance Best Practices **3%**
- System Administration **2%**
- Linux Kernel **2%**
- System Engineering **2%**
- Storage **2%**
- Open Hardware **1%**
- Safety-Critical Systems **1%**
- Visual Effects **1%**




- Open Source Software **72%**
- Open Standard / Specification **20%**
- Open Data **3%**
- Community Initiative **2%**
- Open Hardware **2%**
- Peer Network **1%**
- Open Governance Network **1%**

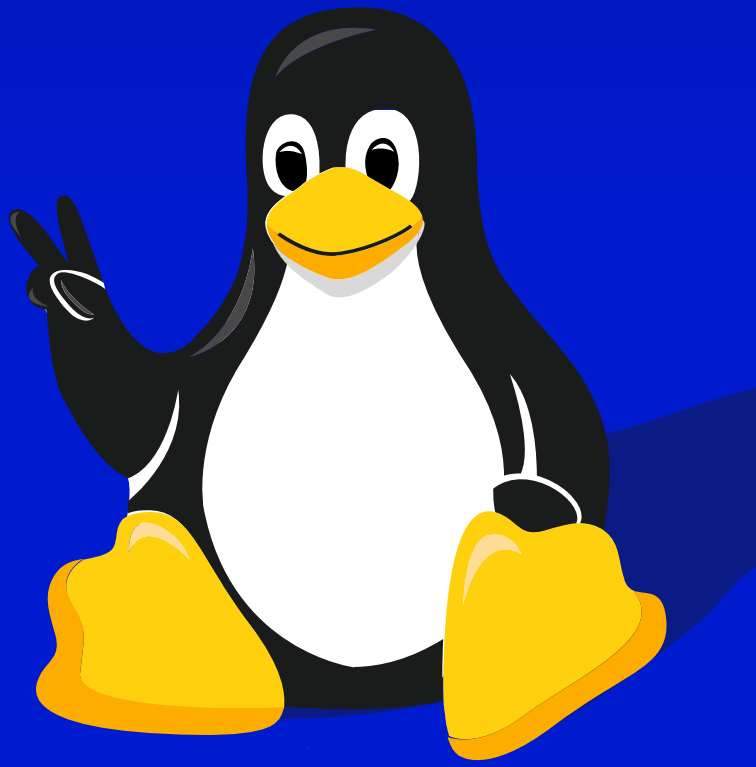
# Linux kernel update

In tandem with security, nurturing open source innovation to create a better world is at the heart of the Linux Foundation's activities. In 2021, we celebrated the Linux kernel's 30th birthday. Two years later, Linux remains among the top three global open source projects in terms of development velocity. Each release results from the work of thousands of contributors worldwide and many organizations. The kernel community actively maintains a steady flow of innovative improvements to expand the footprint of Linux and improve its capabilities.

The Linux kernel allows proprietary modules to be loaded if they adhere to the rules and stay within the bounds. However, the kernel community cannot debug or fix proprietary modules. As a result, they don't see the same level of improvements and enhancements as kernel modules. There is an ongoing game of proprietary module creators trying to push the boundaries to find loopholes and kernel developers trying to close them that plays out every few years. A recent change prevents a proprietary module from getting access to GPL-only symbols through a nominally GPL-licensed module, thereby gaining access to kernel features that are available to GPL-only modules. This new restriction closes this loophole. This is one of the many features and changes that went into the kernel this year, including disabling SELinux's runtime disable feature to prevent accidentally and/or intentionally making systems insecure.

Linux kernel maintainers and developers discussed technical and community health topics as they prepare for the annual **Linux Plumbers conference** in November 2023. The trust and maintenance of the file systems is one such discussion surrounding untrusted and unmaintained file systems and how to address these issues in the future. This is a very active thread with suggestions and ideas leading up to the Maintainer Summit, where decisions could be made on the next steps.

Maintainer stress and burnout due to the role's demands are a central conversation related to community health. Discussions and planning are underway regarding a session with a trained professional to provide guidance and help maintainers and developers cope with stress and burnout.



# LF Charities

LF Charities, Inc. (LF Charities) is a Delaware nonprofit corporation and Section 509(a)(3) supporting organization that is tax exempt under Section 501(c)(3) of the Internal Revenue Code of the United States (the Code). LF Charities supports The Linux Foundation, an Oregon mutual benefit corporation tax-exempt under Section 501(c)(6) of the Code.

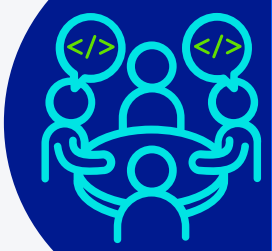
LF Charities facilitates charitable and philanthropic donations of funds and projects in support of the fulfillment of open collaboration. LF Charities actively supports the Linux Foundation in providing a neutral, trusted hub for developers and organizations to code, manage, and scale the numerous open technology projects and ecosystems underpinning the digital infrastructure upon which our world greatly depends. LF Charities projects focus on a range of activities, including scientific, educational, and sustainable development.

Through LF Charities, organizations and donors alike can ensure the sustainability and security of critical open source projects in software, hardware, standards, and data, creating higher levels of trust in the digital commons and making our communities stronger.

# By the numbers: The Linux Foundation

**1.7 billion lines of code** generated.

**13.5K organizations** contributed to Linux Foundation open source projects.



LF Training & Certification enrolled **143K** learners.

**65,081 developers actively contributing**

**13.6K active member contributions**

**LFX Security detected 13,222** code vulnerabilities.

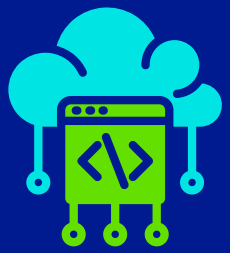
**1,709 members** supported the Linux Foundation.

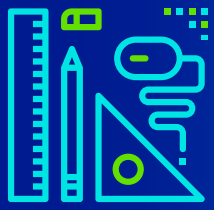
The Linux Foundation hosted **234 events** with **75K attendees**.

LF Training & Certification: **33K certifications,** representing a **26% increase**.

The Linux Foundation hosted **78 webinars** with **10,142 attendees.**

The Linux Foundation hosts over **1000 open source projects**.





The Linux Foundation open source community contributed to over **4.2 million project builds**.

# Cutting-edge innovation: Welcoming new projects

At the Linux Foundation (LF), we're pushing the boundaries of what open source can achieve, welcoming a range of projects that are setting new industry benchmarks. From pioneering advancements in artificial intelligence (AI) and shaping the future of cloud computing to introducing groundbreaking standards in 3D file formats and revolutionizing telecommunications networks, we're transforming industries and enabling them to become more innovative, one project at a time.

# LF AI & DATA

## AI & Data commemorates five years at the Linux Foundation

In 2023, the LF AI & Data Foundation commemorates five years as an LF project. Collaborating closely with the community, it focuses on three pivotal goals to tackle industry challenges: enhancing open source innovation in AI and data; nurturing a dynamic, collaborative community; and generating fresh opportunities for all members. This strategy fosters innovation, collaboration, and value across the AI and data domains.

Key trends are shaping the AI landscape. Trusted and responsible AI is a significant focus as global initiatives strive to ensure fairness, explainability, and security. LF AI & Data supplies tools to support these efforts. Given the digitalization's abundance of data, extracting value from data is another trend. The focus shifts to quality data selection, efficient mining for insights, and converting these insights into business value.

Real-time decision-making drives edge AI advancements, reducing latency and enhancing analytics and scalability. AI chip R&D surges, embedding AI into hardware for greater market opportunities. The demand for more intelligent, efficient algorithms is also rising, with academia and industry propelling innovation in these areas.

### GENERATIVE AI COMMONS

A significant addition in 2023 is the formation of the Generative AI (GAI) Committee. It promotes open source collaboration for GAI development and adoption. We prioritize the transparent co-creation of datasets, models, algorithms, and tools and aim to host key GAI projects, unify open source models, and provide essential elements for a complete open source experience. Through community engagement, best practice sharing, and AI governance guidance, we work to ensure efficient, secure, responsible, and equitable advancement of GAI for the whole ecosystem.

LF AI & Data's open source software and collaborative communities are vital for the flourishing AI industry. By integrating projects seamlessly, the Foundation propels open source AI. It continues to be a driving force in the AI and data landscape through member companies and projects.

### Additional project highlights:

- AI & Data celebrated five years at the LF Foundation.
- Total commits equaled 218k+.
- New contributors increased by 1,036%.
- New contributors increased by 800%.
- New contributors accounted for 930% of all contributions in 2023.

**Ibrahim Haddad, Executive Director of LF AI & Data Foundation**

FINOS

# FINOS Common Domain Model and Cloud Controls projects

This year, FINOS set the stage for a resilient, efficient, and collaborative financial services industry underpinned by open source development and standardization principles by addressing two of the most pressing challenges in the financial services industry. Launched in February and July, these groundbreaking initiatives exemplify FINOS's unwavering commitment to fostering open collaboration, standardization, and innovation.

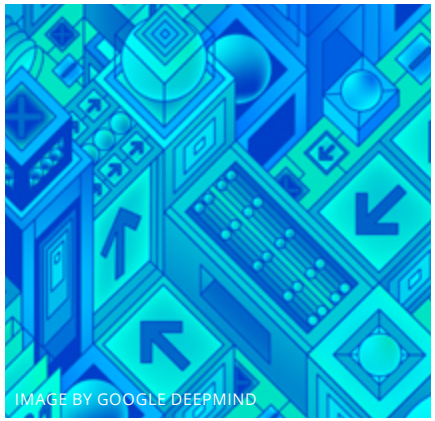


IMAGE BY GOOGLE DEEPMIND

## CDM: Setting the standard for financial transactions

FINOS welcomed the Common Domain Model (CDM) project into its governance framework in February. Supported by three industry trade associations and a broad community of FINOS members, the CDM is more than just a model; it's a machine-readable and machine-executable blueprint that standardizes financial products, trades, and their lifecycle events. The CDM is available as code in multiple languages, facilitating easy implementation across various technologies and covering a wide range of transactions—derivatives, securities lending, and bond and repo transactions. The project has made significant strides in areas such as regulatory compliance and trade life cycle management. The CDM has proven to be a catalyst for digital regulatory reporting efforts and has seen robust contributions, including models for repo securities, securities lending, and collateral, as well as Python-based model representations.

## Common Cloud Controls: unified approach to cybersecurity

In July, FINOS, in collaboration with Platinum member Citi and a legion of over 100 contributors from 10 global financial firms and numerous technology vendors, announced the Common Cloud Controls Project. This initiative was timely and critical, aiming to establish a harmonized set of controls for compliant public cloud deployments in the financial sector. The project addresses the financial industry's growing reliance on a limited number of cloud service providers, posing significant systemic risks. Citi has been at the forefront, leading crucial industry conversations and emphasizing the collective action to mitigate these risks through open collaboration.

## A synchronized vision for a resilient future

A common goal unites the CDM and Common Cloud Controls projects: to enhance interoperability and operational efficiency by mutualizing development costs. While the CDM focuses on creating a standardized framework for financial products and workflows, the Common Cloud Controls project aims to develop a unified and globally applied cybersecurity standard.

AOUSD
Alliance for OpenUSD

## Interoperability standards come to the 3D ecosystem

When Pixar first announced its Universal Scene Description (USD) technology at SIGGRAPH in 2013, no one knew that the 3D ecosystem was on the brink of an evolutionary shift. USD quickly became a ground-breaking technology that enabled Pixar to achieve previously impossible visuals more efficiently, and was open sourced, under the moniker OpenUSD in 2016. Adobe, Apple, Autodesk, NVIDIA, and others implemented OpenUSD in their software products, bringing further cross compatibility benefits to a growing industry of creative visual effects and 3D rendering professionals. Ten years later, those organizations joined Pixar onstage at SIGGRAPH 2023 to announce the **Alliance for OpenUSD (AOUSD)** and a shared vision for a standard, interoperable language and format for 3D content and asset management. Based on OpenUSD, the specification will be a building block for an ever-widening range of 3D-enabled products and services. Developing the project as an open standard further drives innovation in the 3D ecosystem, enabling developers and content creators to describe, compose, and simulate large-scale 3D projects for various use cases. Beginning with the USD core spec, the group plans to standardize a common approach—think of it as the HTML of 3D rendering—that fosters innovation in content, tooling, and applications. Since its launch, AOUSD has grown its membership base to include retailers, systems integrators, and organizations who see the potential of applying 3D technologies beyond the big screen and entertainment media. AOUSD will also align closely with the open source community and partners such as ASWF to enable an open source ecosystem around the standard. The project's open forum encourages content creators and developers to share their demos, ask questions, and grow a sense of community.

**Image of iconic OpenUSD scene 'the Pixar kitchen' from clay render (left) to full render (right).**

## TLA+ FOUNDATION

In April, the LF unveiled the **TLA+ Foundation**. This initiative aims to revolutionize how we think about software reliability and robustness. The TLA+ Foundation has garnered initial support from tech giants such as Amazon Web Services (), Oracle, and Microsoft, signifying the industry's collective commitment to elevating software quality.
TLA+ isn't just another programming language; it's a paradigm shift. Created by the visionary computer scientist Leslie Lamport, TLA+ specializes in modeling complex, concurrent, and distributed systems. It has proven its worth by helping companies identify and rectify design flaws at the earliest stages, saving invaluable time and resources. As Jim Zemlin, the executive director at the LF, puts it, "In an age where distributed systems are becoming the norm, TLA+ is not just useful but essential."

The TLA+ Foundation has a comprehensive roadmap that includes promoting the language's adoption, offering educational resources, and funding cutting-edge research. It will act as the steward for the language, ensuring its continuous improvement based on user feedback and emerging needs. Companies already invested in TLA+ have shared their success stories. AWS uses TLA+ to ensure the highest quality in their services, while Microsoft has found it invaluable for validating system designs before the writing of a single line of code. Oracle, too, has integrated TLA+ into the core of its cloud infrastructure, using it to verify complex scenarios in more than 25 critical services.

As we look to the future, the TLA+ Foundation invites technology companies to join its mission. It aims to democratize access to this transformative language, ensuring that the benefits of TLA+ extend across the software industry. The Foundation is not just a milestone but a beacon, guiding us toward a future where software is as reliable as the laws of physics.

## OpenTofu

In a landmark move that marks a new era in infrastructure as code, the LF unveiled **OpenTofu** on September 20, 2023, at Open Source Summit Europe in Bilbao, Spain. This open source initiative responds to Terraform's recent shift from a Mozilla Public License to a Business Source License, which stirred concerns within the open source community. OpenTofu emerges as a community-driven, neutral, modular alternative committed to backward compatibility.

The initiative has garnered overwhelming support from industry giants and developers alike.

Companies such as Harness, Gruntwork, and Spacelift have formally pledged their support alongside more than 600 individual contributors.

OpenTofu is not just a project; it's a collective commitment to open collaboration and innovation. With a starting commitment of at least 18 full-time developers for the next five years, OpenTofu promises to be a stable and reliable tool for the tech community.

Looking ahead, OpenTofu is committed to driving open and collaborative development, promising a future where infrastructure as code is a tool and a community-driven ethos.

# UXL FOUNDATION
Unified Acceleration

In 2023, the technology landscape witnessed a significant milestone with the formation of the Unified Acceleration (UXL) Foundation, announced at Open Source Summit Europe in Bilbao, Spain, on September 19. Hosted under the LF's Joint Development Foundation umbrella, the UXL Foundation emerged as a transformative force aimed at reshaping the future of accelerated computing. The initiative focuses on heterogeneous computing, a paradigm that leverages a variety of processors such as CPUs, GPUs, FPGAs, and other specialized accelerators, particularly for AI and data-intensive applications.

The UXL Foundation extends the oneAPI initiative, which has already gained traction as an open programming model covering multiple architectures. Guided by a steering committee, the Foundation has garnered the support of industry leaders such as Arm, Fujitsu, Google Cloud, Imagination Technologies, Intel, Qualcomm Technologies, and Samsung. United by a common vision, these organizations aim to create the most extensive open ecosystem for accelerated computing, grounded in open standards and inclusive of multiple vendors.

The ethos of the UXL Foundation is rooted in collaboration and the open source approach. By bringing together top technology companies and fostering a collaborative environment for cross-platform development, the Foundation aims to unlock unprecedented levels of performance and productivity in data-centric solutions. The foundation's goal to establish a programming platform that is both multi-architecture and multi-vendor, offering a vendor-neutral approach to software development for heterogeneous architectures, emphasizes this collaborative spirit.


**UXL Foundation launch**

As a cornerstone event of 2023, the formation of the UXL Foundation has set the stage for a new era in accelerated computing. It promises to provide a standardized, unified, and accessible pathway for developing computationally and data-intensive applications, giving customers the flexibility to choose the hardware that best suits their specific needs. The foundation's inception marks a pivotal step toward a more integrated and standardized future in the rapidly evolving field of accelerated computing.

CAMARA
THE TELCO GLOBAL API ALLIANCE

In February 2022, the LF, in collaboration with the GSMA, launched CAMARA—The Telco Global API Alliance. This groundbreaking initiative addresses the industry's API interoperability challenges and offers a unified, global API solution. The project facilitates seamless application deployment across various telecom networks and countries, thereby preventing fragmentation and accelerating the global adoption of new features and capabilities. Supported by industry giants such as AT&T, Deutsche Telekom, and Microsoft, CAMARA began its journey with a focus on creating an open, global, and accessible API solution.

By September 2023, CAMARA met and exceeded its initial objectives. The project has flourished, boasting over 250 participating organizations and more than 750 contributors. This rapid growth prompted the transition to a fully funded model, introducing a structured governance framework consisting of a governing board, technical steering committee, and end user council. This new model aims to manage collaboration at scale and ensure the project's long-term sustainability.

CAMARA's work has been instrumental in fostering collaboration between telecoms, GSMA, TMForum, and other cloud-based service industries. The project has successfully developed an API solution that provides consistent and user-friendly access to network capabilities, enabling developers to deploy applications that run uniformly across telecom networks worldwide. With premier and general sponsors such as Accenture, Deutsche Telekom, and Microsoft backing the project, CAMARA is well-positioned to continue its mission of empowering developers and advancing the telecom industry.

# LF CONNECTIVITY

LF Connectivity, launched in May of this year, is a new open source project umbrella focused on advancing technologies to accelerate emerging network and connectivity applications. Formed in collaboration with member organization Meta, LF Connectivity will create a robust and sustainable open ecosystem to enable a wide range of communication service providers to leverage open source tools and technologies to help with the end-to-end performance and quality-of-experience requirements of emerging applications.

LF Connectivity will comprise a broad set of subprojects within the connectivity space to address different challenges in high-bandwidth fixed and mobile networks. To get the project started, Meta contributed a rich set of technologies, developed in collaboration with industry partners, including three initial sub-projects:

- **Terragraph** is a wireless technology solution that helps Internet service providers deliver gigabit-speed last-mile access to subscriber homes, enterprises, and multi-dwelling buildings easily and cost-effectively.
- **Open M-Plane** is a software component of Meta's Evenstar hardware design for the configuration and management of the RAN. It is interoperable, hardware-independent, and aligned with O-RAN specifications to help enable mobile wireless connectivity. It allows operators to source hardware from different vendors as they deploy their own RAN solutions.

Arpit Joshipura at OSS Europe

- **Maveric** enables the development and evaluation of cellular network optimization algorithms before their deployment on the network. It is a developer platform that leverages AI/ML approaches to provide realistic cellular network representations and examples demonstrating its use.

The goal is to seed a wider community of developers and companies to leverage those technologies and participate in other future projects within this community.

The community published a deep-dive webinar to share its vision and goals broadly and will work closely with adjacent networking projects at the Linux Foundation (including Magma, LF Networking, and CAMARA). It expects to see strong progress in 2024.

# OpenPubkey

On October 4, 2023, the Linux Foundation, BastionZero, and Docker announced the launch of **OpenPubkey**, an open source project aimed at enhancing security in the open source software ecosystem through zero-trust passwordless authentication. Developed as part of BastionZero's secure infrastructure, OpenPubkey allows users to bind cryptographic keys securely by transforming an OpenID Connect Identity Provider into a Certificate Authority. This integration enables Docker users to improve software supply chain security. The initiative aims to strengthen digital signatures, secure remote access, and enhance features like signed builds and code commits. Want to get involved? Check out **OpenPubkey's reference implementation GitHub repository** and read the specification.

In November, the Linux Foundation celebrated the launch of the DAOS Foundation, a collaborative effort by industry giants to enhance the governance and development of the Distributed Asynchronous Object Storage (DAOS) project. With founding members including Argonne National Laboratory, Enakta Labs, Google Cloud, Hewlett Packard Enterprise, and Intel, the Foundation is set to propel high performance computing (HPC) and artificial intelligence/machine learning (AI/ML) workloads into a new stratum.

The DAOS project itself is a marvel of modern data storage technology. Originating at Intel, which contributed and open sourced the DAOS code, it departs from traditional POSIX-based systems with its distributed key-value storage architecture, optimizing performance by capitalizing on commodity hardware's capabilities. The project supports a vast range of application interfaces such as TensorFlow, HDF5, and MPI-IO, situating DAOS at the vanguard of storage solutions. This broad compatibility enables it to handle diverse and demanding I/O workloads with unprecedented efficiency.

Currently, the DAOS project shines in its deployment within the Argonne National Laboratory's Aurora supercomputer, delivering performance twenty times that of previous file systems. This accomplishment is just a hint of its potential. As the DAOS Foundation strengthens the project's framework, DAOS continues to evolve, carving its place as an essential tool for researchers and various industries, spearheading the future of data storage and high performance computing.


**Argonne National Laboratory's Aurora supercomputer**

In November 2023, the Linux Foundation announced its intention to form the High Performance Software Foundation (HPSF), marking a significant development in the high performance computing (HPC) arena. This initiative was conceived to address the growing need for a unified and robust software stack that could cater to the demanding requirements of scientific computing, digital engineering, and AI.

HPSF aims to make life easier for high performance software developers through several focused initiatives, including:

- Continuous Integration resources tailored for HPC projects
- Continuously built, turnkey software stacks
- Architecture support
- Performance regression testing and benchmarking

## Inaugural technical projects

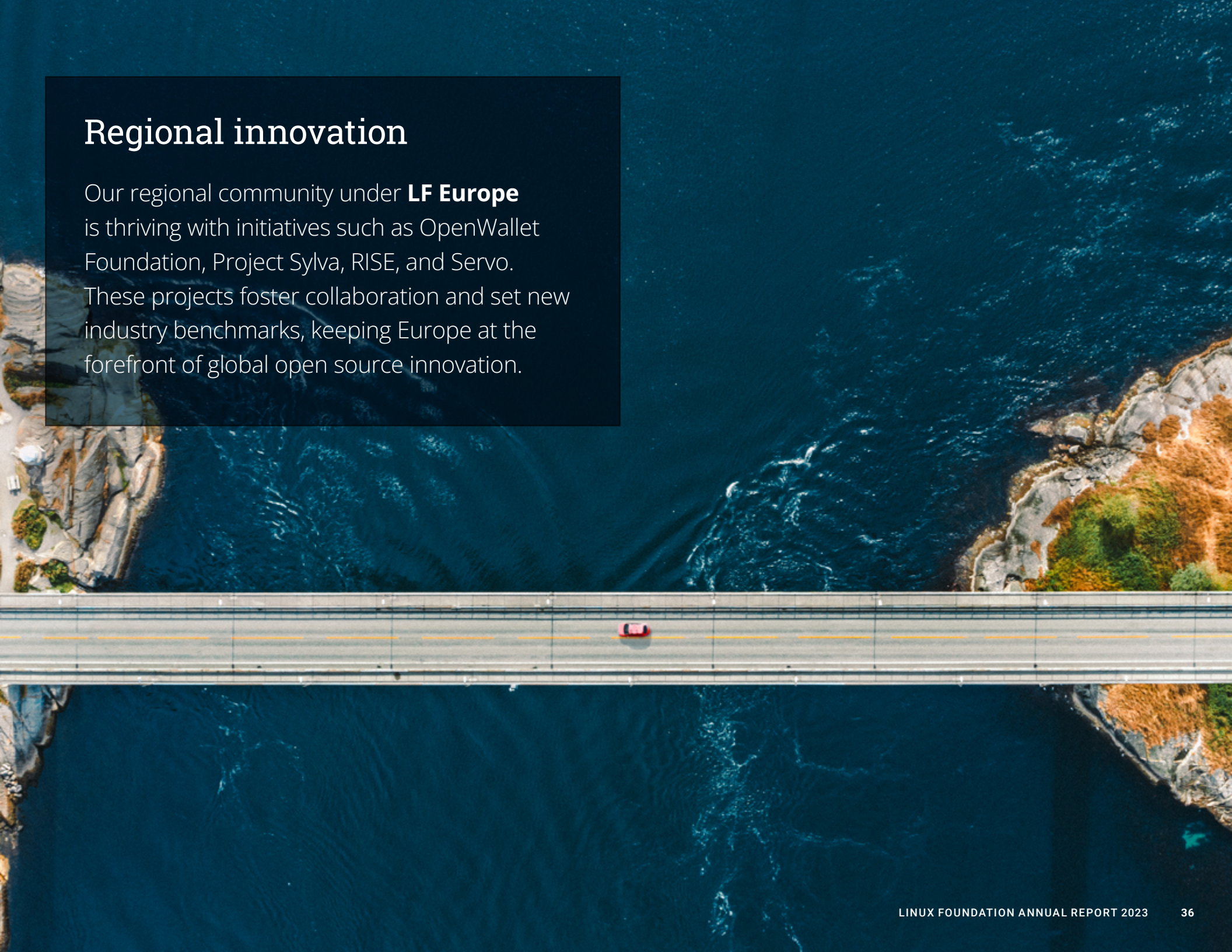
With the formation of the HPSF, the Linux Foundation hosts a suite of open source technical projects poised to underpin the foundation's objectives:

- **Spack:** Redefines HPC package management by simplifying the installation and management of complex software packages.
- **Kokkos:** Provides a performance-portable programming model for developers to write modern C++ applications adaptable to various hardware environments.
- **E4S:** Offers an extreme-scale scientific software stack, bolstering scientific research capabilities.
- **AMReX:** A performance-portable framework designed to accelerate the solution of partial differential equations on advanced mesh structures.
- **WarpX:** Recognized with the 2022 Gordon Bell Prize and contributes its Particle-in-Cell coding expertise to the HPSF's mission.
- **Apptainer:** Introduces a secure, high-performance computing container system and image format.
- **VTK-m:** Provides a suite of scientific visualization algorithms specially designed for accelerated computing architectures.
- **HPCToolkit:** Offers a suite of performance measurement and analysis tools suitable for a wide range of computing systems.
- **Charliecloud (incubating)**: Presents an HPC-tailored, lightweight container solution that emphasizes simplicity and security.

These lay the groundwork for the HPSF's ambitious goal to streamline the HPC software ecosystem, making high-performance tools accessible and manageable.

# Regional innovation

Our regional community under **LF Europe** is thriving with initiatives such as OpenWallet Foundation, Project Sylva, RISE, and Servo. These projects foster collaboration and set new industry benchmarks, keeping Europe at the forefront of global open source innovation.



In a year marked by unprecedented challenges and opportunities, **Project Sylva** stands out as a beacon of innovation and collaboration in the telecommunications sector. Launched in 2022 under the auspices of LF Europe, Project Sylva aims to revolutionize the Telco Cloud ecosystem by creating an open source, production-grade Telco Cloud Stack that aligns with the European Union's stringent privacy, security, and energy efficiency standards.

The project has garnered significant attention and support from industry giants, including Deutsche Telekom, Orange, Telefonica, Vodafone, and key vendors such as Ericsson and Nokia. This year, the project took a monumental step forward with the launch of the Sylva Directed Fund. This dedicated funding initiative has received first-round subscriptions from various industry leaders, further bolstering the project's resource pool and accelerating its mission.

Building on existing open source projects such as LF Networking's Anuket and CNCF's Kubernetes, Project Sylva focuses on three key areas: development, validation, and market adoption. The Directed Fund will specifically support the development team in procuring licenses, resources, and continuous integration capabilities. It will also back the Validation Program by acquiring the hardware and services needed for Sylva Validation Centers.

The fund also aims to enhance market awareness and community participation by investing in marketing and communication capabilities.

The impact of Project Sylva extends beyond the European landscape. While it addresses the E.U.'s unique challenges, its open source framework has global applicability, making it a vital player in the worldwide Telco Cloud ecosystem. As we look ahead, Project Sylva can become a cornerstone in the digital transformation journey, reducing operational complexities and fostering a more unified, efficient, and secure telecommunications infrastructure.

MARKUS SPISKE: UNSPLASH

In 2023, the OpenWallet Foundation (OWF) experienced a transformative year, achieving significant milestones that have fortified its mission to foster a secure and interoperable digital wallet ecosystem. Hosted under the aegis of LF Europe, OWF has emerged as a collaborative hub, uniting companies, nonprofits, and governmental bodies to advance open source software solutions for digital wallets.

The year's momentum increased notably in August when Google became a premier member of OWF. This partnership elevated the Foundation's credibility but also enriched its pool of expertise in digital wallet technology. Google's alignment with OWF's commitment to open and interoperable solutions set the stage for a fruitful collaboration.

In September, Google made a significant code contribution from its identity credential library.

**Keynote: Fireside chat with Ola Ben Har, Global Head of Developer Relations, Google Pay and Wallet & Marie Austenaa, Head of Digital Identity, Visa and Governing Board Chair, OpenWallet Foundation**

This library, open source since 2020, simplifies the construction of secure applications for digital identity and is a standard test bench in the industry. This contribution was a pivotal moment, adding substantial value to OWF's community-driven projects.

Earlier in the year, the modular open source identity platform (MOSIP) had already contributed code focusing on verifiable credentials and BLE-based credential sharing. This was crucial in developing essential components for secure and portable digital wallets.

September also saw additional code contributions from Ping Identity, esatus, and Lissi by neosfer. Ping Identity provided components for various credential formats and protocols, while esatus and Lissi contributed their multi-platform Wallet Framework .NET, enhancing the versatility of OWF's offerings.

OWF's Government Advisory Council has been a cornerstone in bridging the public and private sectors, aiming to create digital wallets that are secure, private, and user-friendly. With an expanding roster of members and supporters, OWF is well-positioned to realize its vision.

Reflecting on the year, it's evident that OWF has expanded its membership and impact. Contributions from industry giants such as Google, MOSIP, Ping Identity, esatus, and neosfer have accelerated the Foundation's progress, making 2023 a landmark year for both OWF and the broader digital wallet ecosystem.

RISE
RISC-V Software Ecosystem

## Launch of the RISE Project

Launched in May and hosted by LF Europe, RISE is a collaborative endeavor that unites global industry leaders such as Google, Intel, NVIDIA, Qualcomm, and Samsung. The initiative aims to accelerate the development of high-performance, secure, and commercial-ready software for RISC-V cores, targeting a myriad of market segments, including mobile, consumer electronics, data centers, and automotive.

The RISE Governing Board reflects a diverse coalition of tech giants and innovators committed to a shared mission: to fast-track the RISC-V software ecosystem's readiness. The project members contribute financially and provide invaluable engineering talent to address specific software deliverables. The RISE Technical Steering Committee (TSC) prioritizes these deliverables, which range from software development tools and virtualization support to Linux distribution integration and system firmware.

As RISC-V continues to gain traction, the need for a robust software ecosystem has never been more critical. RISE commits to filling this gap by working upstream first with existing open source communities in line with best practices. The project is already making strides in enabling RISC-V in open source tools and libraries such as LLVM and GCC, thereby reducing time-to-market for RISC-V-based solutions.

RISE is not just an initiative; it's a global collaborative effort that promises to catalyze the RISC-V software ecosystem, making it more performant and reliable. We are honored to provide a neutral, trusted home for RISE under LF Europe and look forward to the transformative impact it will have on the open source community.

servo

## Servo joins LF Europe

Originally incubated by Mozilla Research in 2012, Servo was the first major Rust codebase and has since been a cornerstone for experimental web engine design. The engine transitioned to the LF in 2020 and has experienced renewed vigor in 2023, thanks to Igalia, an LF Europe member. This year, Servo officially joined LF Europe, marking a pivotal moment in its journey.

The move aims to bolster Servo's visibility within Europe's robust open source community, increasing its market penetration and long-term sustainability. Manuel Rego, chair of the Servo TSC, emphasized the project's goal to build a stronger community with more organizations and contributors participating in its development. Servo's integration into LF Europe aligns perfectly with this vision, offering a cross-industry collaboration and innovation platform.

Written in Rust, Servo takes full advantage of the language's memory safety and concurrency features, offering faster and more energy-efficient rendering with fewer vulnerabilities. The engine is modular and embeddable, making it ideal for many applications beyond web browsers, such as kiosk interfaces and digital signage. With robust support for WebGL and WebGPU, Servo is particularly well-suited for applications requiring interactive or immersive experiences.

As we look forward to the future, Servo's team is actively working on expanding platform support, including Android, and is keen on porting to new platforms and embedded devices. The project continues to be a shining example of what open source collaboration can achieve, and we are excited to support and sustain this important work in the years to come.


**Servo experiments: "Dogemania Benchmark" (demo.servo.org)**

**Servo experiments: "Mosaic effect using DIV"" (demo.servo.org)**

# The EU Cyber Resilience Act

Open source software has become integral to global innovation, offering a secure and democratized way to build digital solutions. Organizations such as the Open Source Security Foundation (OpenSSF) have been pioneers in enhancing cybersecurity from the software's origin. The security gaps often lie downstream in the product implementations that frequently ship with outdated or insecure configurations.

The E.U.'s Cyber Resilience Act (CRA) threatens to upset this ecosystem. Unlike most governments that opt for collaboration to improve software security, the EU is taking a regulation-heavy approach, which could destabilize the global open source supply chain and disproportionately benefit large tech companies, primarily outside the E.U., who have the resources to comply.

Current drafts of the CRA make compliance nearly impossible for global open source projects, especially charitable or nonprofit-oriented ones. The likely outcomes are either a block on distributing such software within the EU or public access with disclaimers stating the software's inappropriateness for the European market.

A collaborative effort between the EU and the open source community could have yielded better security outcomes. As the EU approaches the adoption of the CRA, time for constructive dialogue is running out.

The LF continues to offer information and collaboration around the CRA legislative process. During Open Source Summit Europe 2023, Gabriele Columbro, GM of LF Europe, contextualized the issues with the CRA draft in the **opening keynote** address, and it was part of a **panel discussion on the impact of the CRA on the open source ecosystem** with members from the Python Software Foundation, the Linux kernel community, Red Hat, GitHub, and Ericsson. Additional analysis by the LF is available in three blog posts: **Understanding the Cyber Resilience Act: What Everyone Involved in Open Source Development Should Know**, **Will the Cyber Resilience Act help the European ICT sector compete?**, and **Open Source and the CRA: It Will Not Work**.

We urge all stakeholders to voice their concerns. Contact your MEPs and government officials to express that the CRA will neither improve security nor benefit small and medium enterprises in the EU The time to act is now.

ENGIN AKYURT: UNSPLASH

# Open Source Summit Europe

The Open Source Summit Bilbao 2023 emerged as a significant milestone in the world of open source technology, drawing a diverse and dynamic community of 2,700 attendees. There were 1,200 participants who attended this hybrid event in person, with an additional 1,500 joining online, reflecting the summit's commitment to inclusivity and global reach.

The summit was successful because of its enthusiastic attendees and the unwavering support of 34 sponsors, including industry titans such as Fujitsu, Google, AWS, and Huawei. The presence of these sponsors underscored the pivotal role that open source plays in the broader technology landscape and highlighted their dedication to nurturing the open source ecosystem.

A robust schedule featuring over 175 sessions was the heart of the event, providing attendees with a wealth of knowledge and insights. These sessions spanned a spectrum of open source domains, catering to newcomers and seasoned experts. A standout feature was the inclusion of 12 micro-conferences, each delving deep into specific aspects of open source technology:

- **LinuxCon** served as a forum for Linux enthusiasts, exploring the latest developments and trends in the Linux ecosystem
- **SupplyChainSecurityCon** addressed the pressing issue of supply chain security in open source software, a topic of growing concern in the digital age.
- **Open AI + Data Forum** delved into the intersection of artificial intelligence and open source technologies, offering valuable perspectives on innovation and collaboration.
- **SustainabilityCon** provided a platform for discussions on sustainable practices within open source projects, acknowledging the importance of environmental responsibility.
- **OSPOCon** brought together leaders from Open Source Program Offices (OSPOs) to share strategies and best practices for effective open source management.
- **OpenSSF Day** was a highlight, focusing on advancing the security of open source software, crucial in an era of increasing cyber threats.

The summit also hosted 11 co-located events, each dedicated to specific areas of interest, including Linux security, digital wallets, continuous delivery, and regional perspectives on open source software security. These co-located events enriched the summit experience by fostering in-depth discussions, networking, and collaboration among like-minded individuals.

The Open Source Summit Bilbao 2023 was not just a conference but a celebration of the open source ethos. It provided a platform for global collaboration, knowledge sharing, and innovation. With the generous support of sponsors, a rich schedule of events, and a diverse community of attendees, the summit reaffirmed the critical role of open source in shaping the future of technology. Attendees left inspired with insights and connections, ready to drive positive change within the open source ecosystem and beyond.

**Gabriele Columbro, General Manager of Linux Foundation Europe**

# Planetary innovation

Of great importance to our community is aligning innovation with global sustainability. We're broadening our understanding of how our projects accelerate sustainable development goals, and we're revolutionizing energy systems by implementing "green" infrastructure. Further, we're catalyzing positive change by hosting projects dedicated to animal well-being, human health, greener software, and advanced agricultural technology. By reducing waste and making critical infrastructure available to all who need it, LF projects and communities embody the rising tide that lifts all boats. By supporting open source software, open hardware, open standards, open data, open AI models, and open content, the LF plays an important part in shaping a future that upholds innovation alongside sustainability.

DAMIR: PEXELS

# LF Sustainability

In 2015, the United Nations introduced 17 Sustainable Development Goals (SDGs) in its "2030 Agenda for Sustainable Development," representing a plan of action for organizations and institutions to progress toward economic, social, and environmental sustainability. The relevance of open source in this endeavor was clear: the U.N. Global Compact stated that digital technology—particularly open source—would be instrumental in achieving the U.N. SDGs.

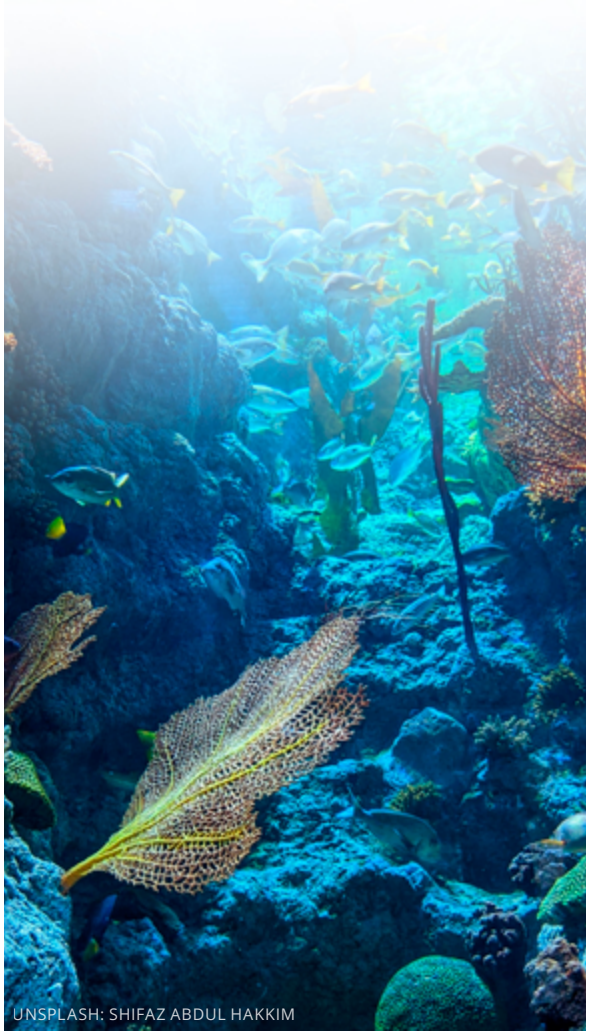

We created LF Sustainability as a digital gateway to help broaden the understanding of our community's impact at the intersection of open source and sustainable development, using the SDGs framework to map LF projects to the 17 impact areas, from hunger and well-being to city infrastructure and energy. Notable projects include:

Zephyr: Contributors to the Zephyr project are building out small, scalable, real-time operating systems optimized for resource-constrained networks of devices. These connected embedded devices—sensors, wearables, modems, and small wireless gateways—work to improve health, create decent jobs and equal opportunities, support diverse business models and markets, and monitor and strengthen institutions.

AgStack: Accessible digital infrastructure tailored to agriculture, including open data, artificial intelligence (AI) modeling, and software applications, means farmers can manage such resources as water and field workers more effectively and make data-driven decisions to balance supply and demand. This infrastructure helps reduce poverty, hunger, and economic inequalities; increase the resilience of communities and business models; and reduce their impact on the climate and the land.

C2PA: The Coalition for Content Provenance and Authenticity (C2PA) combats the ubiquity of fake news and other misleading information online by developing open standards for certifying the source and provenance of media content. A project of the Joint Development

The Linux Foundation supports the Sustainable Development Goals

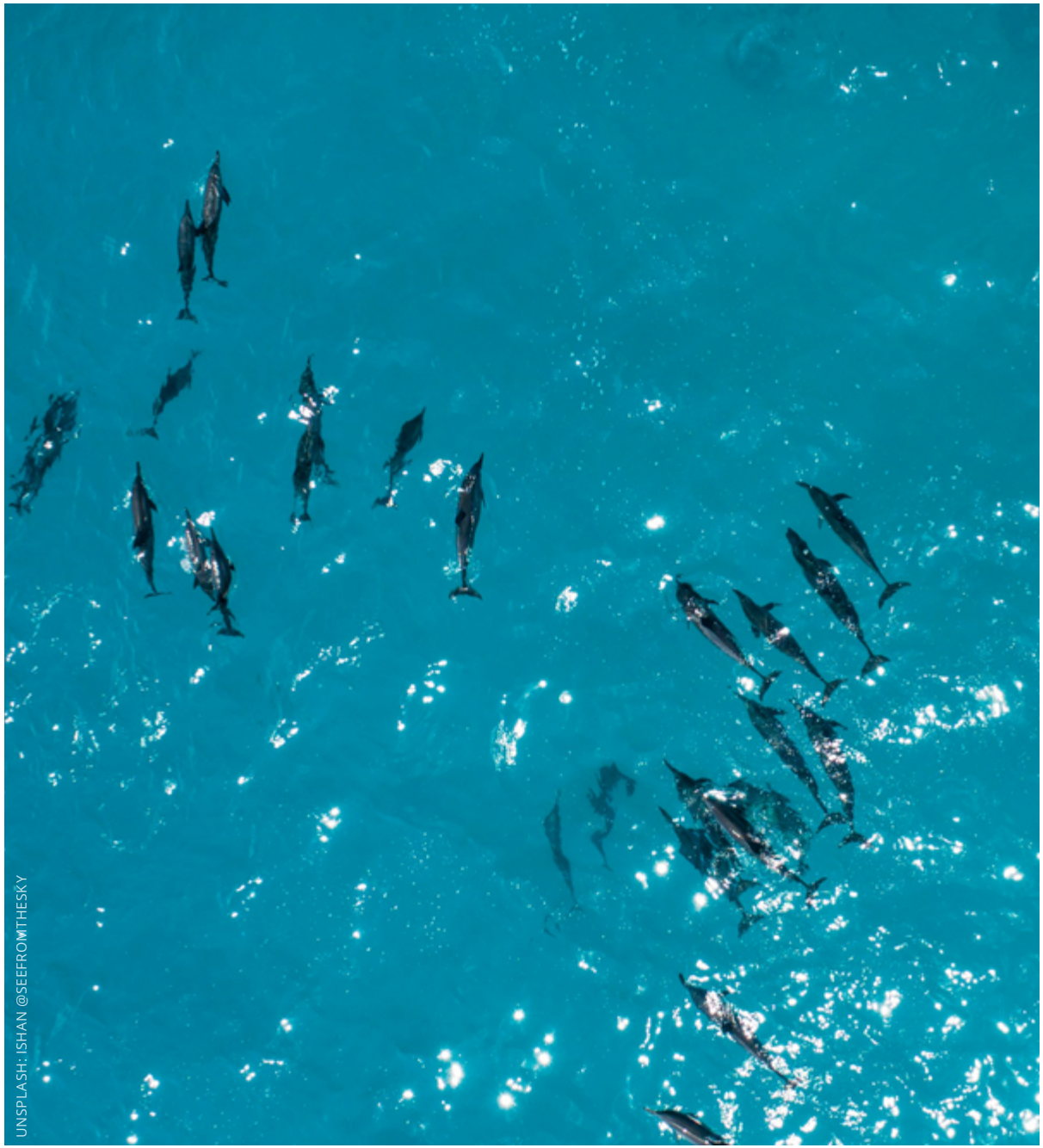


UNSPLASH: SHIFAZ ABDUL HAKKIM

Foundation, C2PA gives consumers and publishers tools for understanding whether different types of media are authentic and their sources genuine, whether it's coverage of climate science, election results, healthcare, or labor practices.

**OS-Climate**: OS-Climate (OS-C) is developing a software platform to boost funding for climate change mitigation and resilience initiatives that will make a measurable difference across the SDGs. The platform integrates open data, models, computing, and data science into a physical-economic model. Enhanced by AI, this model will function like an operating system, helping to match investment capital with financial products to manage and mitigate climate-related risk.

Also central to LF Sustainability is an in-depth report from LF Research, **Open Source for Sustainability**, that explores the extent to which the open source community, in the development of open source software, open hardware, open standards, open data, open AI models, and open content, sustains the very digital public goods that advance the mandate of the SDGs, with LF projects featured as specific examples of this impact. The research demonstrates the LF's commitment beyond the technological, illustrating how collaborative, community-level initiatives play a vital role in sustainable innovation.



UNSPLASH: ISHAN @SEEFROMTHESKY

# LF ENERGY

LF Energy, a driving force in the energy sector's transformation, focuses on innovative solutions to decarbonize and address climate change challenges. Converging information technology and operational technology while embracing open source solutions is essential to expedite this transition. The LF Energy community has made large strides in the past year. Topline progress has included:

- A 1.25x increase in hosted projects compared to the end of 2022
- A 23% jump in unique contributors across LF Energy hosted projects in the past 12 months
- An increase of 15% for commits made across LF Energy repositories
- An 8% increase in one year for the lines of code added across unique commits, which grew to 114 million


**LF Energy Summit**

- The release of three highly detailed research reports, providing insight into the progress made in the energy transition, how open source is assisting, and the remaining challenges
- Hosting four in-person events and significantly increasing the number of industry events where LF Energy projects have presented

Further details of the progress made are as follows:

## Growing the ecosystem

Aspen Technology, Atos, chargebyte, CRESYM, d-fine, EDSN, Open Climate Fix, Trusted Computing Group, and WattTime Corporation joined LF Energy, bringing the foundation's membership to nearly 75, including electrical utilities, academic and research institutions, technology vendors, consulting firms, and government agencies.

With the addition of Arras, Dynaωo, Power Grid Model, and RTDIP, the number of LF Energy projects has increased to 25, with each contributing to grid simulation, power system decision-making, a high-performance distribution grid calculation model, and high volume, historical, and real-time process data for analytics applications.

The release of a **revised landscape** showing the total available suite of open source projects focused on energy and sustainability provided a convenient way to identify projects of interest and visualize gaps that the community should work to fill.

There were three papers published in 2023 in partnership with LF Research: Energy Transformation Readiness, Open Source Sustainability, and Open Source Microgrids (below).

## Increasing collaboration

To raise awareness of open source solutions for the energy sector and create more opportunities for collaboration, the LF Energy Summit returned in person, focusing on the theme of "Deep Decarbonization."

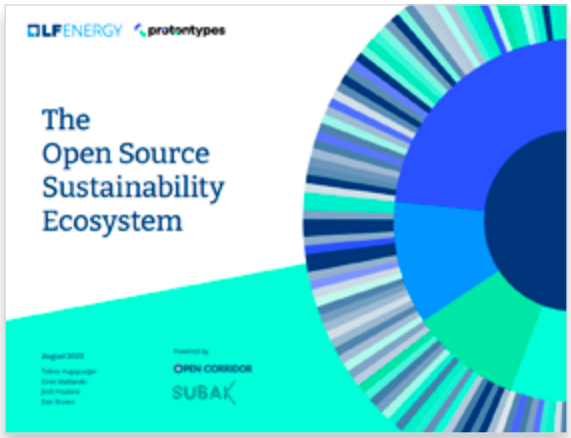
The foundation also hosted the LF Energy Embedded Summit and helped launch SustainabilityCon in North America and Europe, emphasizing open source's role in energy and sustainability across various industries.

LF Energy projects also presented at numerous third-party events to raise awareness of the challenges and opportunities for open source in energy, including State of Open Con, Smart Grid Tech Week, CIRED, MOVE, Canadian Open Data Summit, Enlit Europe, and EETimes PowerUp.

Digitalizing energy systems streamlines processes, enhances visibility, and improves decision-making. Real-time data collection and analysis enable rapid adjustments to supply and demand, supporting the integration of renewable sources. Digital technologies also aid in monitoring progress toward decarbonization


**LF Energy Summit**

goals, providing insights to refine strategies and policies. LF Energy is leading the charge to develop open source software, hardware, standards, and specifications to drive this transformation forward to create a reliable energy system that ensures a cleaner future for everyone.



**LF Energy published three reports at the intersection of energy and open source in 2023. For more information, see the "Data-Driven Innovation" section of this report.**

# OS-C

In 2023, OS-C made great progress in accelerating the adoption of open source technologies for climate action. OS-C's projects have added new features and functionality and are maturing along these core themes:

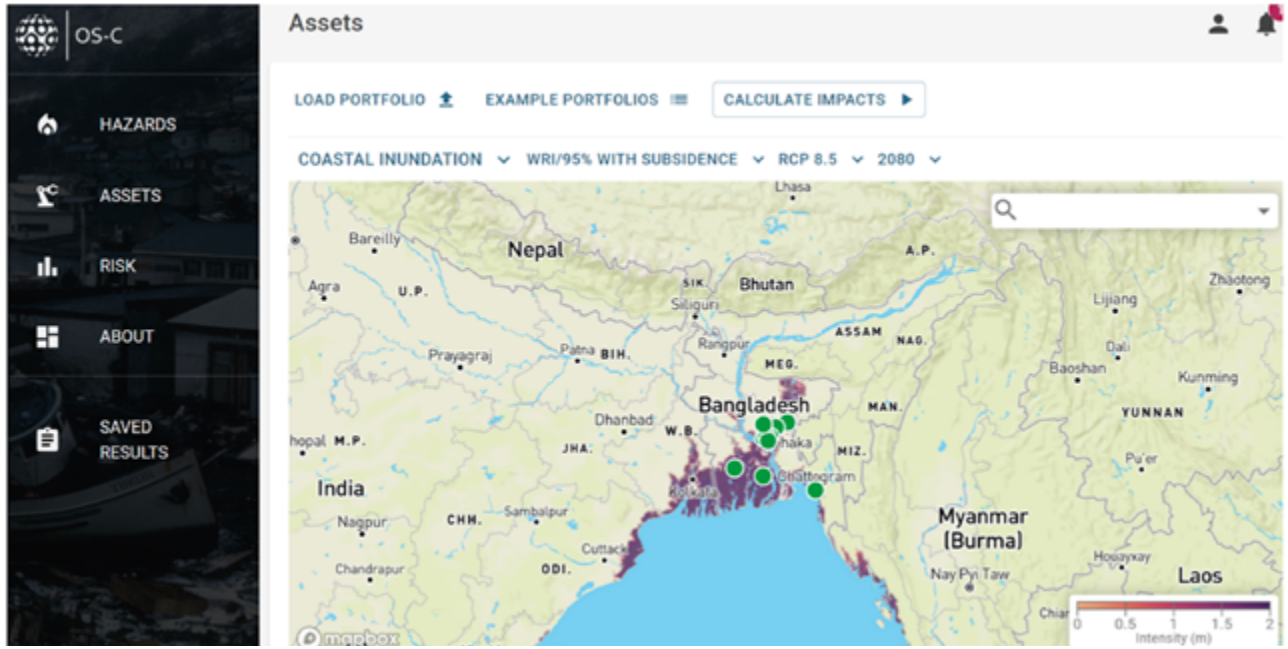
## Transition Scenario Analysis

- The open source Transition Scenario Analysis (TSA) tool is a game-changer. It can spur commercial innovations worth hundreds of billions of dollars while significantly reducing greenhouse gas emissions. The tool allows users to model and assess transition strategies across various sectors and scenarios, catering to diverse stakeholders, including asset owners, banks, policymakers, and researchers. In this video, OS-C's Executive Director Truman Semans and Capgemini EVP Cyril Garcia discuss how open source involvement benefits businesses and the environment.

- In September, OS-C reached a significant milestone with the debut of Capgemini's Business to Planet, a product built on an OS-C project. Launched during Climate Week and the U.N. General Assembly in New York, the event attracted a diverse audience from Fortune 500 companies and the public sector.

## Physical Risk & Resilience

- The Physical Risk & Resilience (PRR) community has made significant strides in integrating open climate models to help financial institutions assess climate-related risks such as drought, flooding, and heat on their portfolios. These tools are crucial for making informed investment and lending decisions, such as loans for properties at risk from rising sea




**Example showing analysis of the exposure of bank counterparties' assets (buildings, factories) to coastal inundation, one of the many climate impacts modeled in the PRR Tool.**

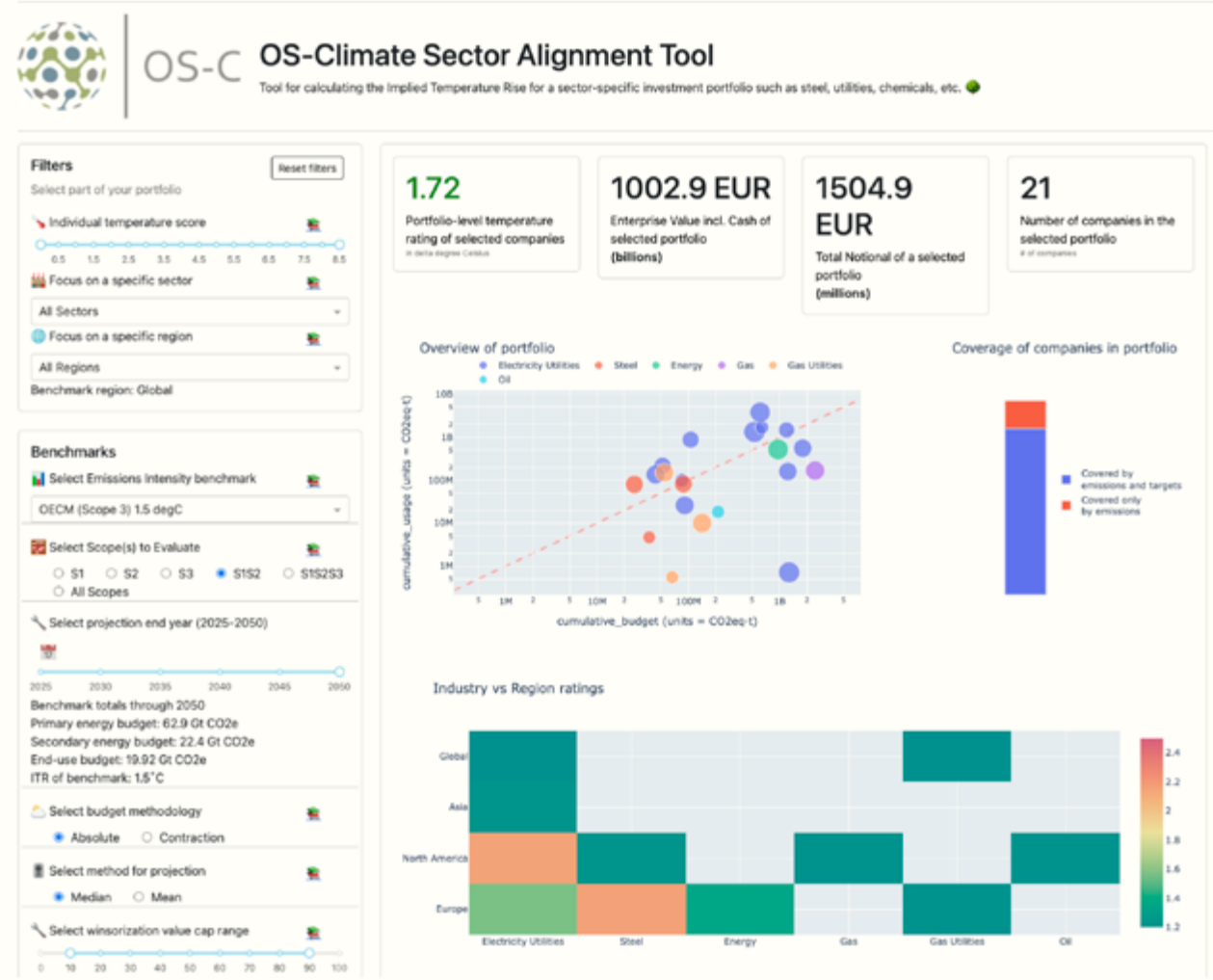
levels. The PRR Tool can analyze how vulnerable bank assets are to coastal flooding.

- This collaborative effort in risk modeling involves researchers, non-governmental organizations (NGOs), and industry players. It can also have a broader environmental and social impact, particularly in areas such as the Global South that require investment in resilience and adaptation. These broader applications can adapt the same tools financial firms use.
- Public projects such as the Sustainable Africa Initiative and Climate Risk Research Challenge in Nigeria use OS-C's PRR tool, showcasing our commitment to global climate solutions.


**Sustainable Africa Initiative Outreach Lead Azeez Abubakar (bottom left) with data science faculty and students at the University of Ibadan.**

## Investment portfolio decarbonization

- OS-C continues to add functionality to its Sector Alignment tool, which allows investment firms to measure and set targets on forward-looking carbon emission pathways. In this regard, OS-C has strengthened relations with GFANZ / NZAOA / UNEP-FI as a regular invitee to their working groups.
- **The UN-Convened Net Zero Asset Owner Alliance (NZAOA)** manages over €10 trillion and aims to transition its portfolios to net-zero greenhouse gas emissions by 2050. It's part of the GFANZ, representing over $80 trillion in assets, including $70 trillion in banking and $700 billion in insurance premiums.
- Two years ago, GFANZ introduced a methodology for calculating "Implied Temperature Rise" (ITR). OS-C has since developed the first open source tool for ITR calculations.




**A sample portfolio of companies in different regions and sectors. Companies at or below the dashed red line (or rendered in green in the heatmap) have an alignment with 1.5°C 2050 targets.**

It helps stakeholders, from asset managers to NGOs, understand how corporate carbon goals align with 1.5°C temperature targets.

Transparency in these metrics is a powerful way to direct the capital investments needed for a net-zero transition.

## Data mesh architecture

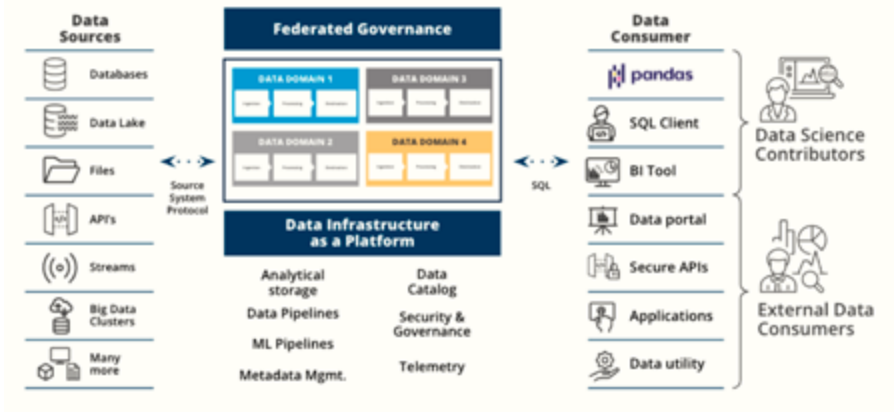
This project, led by Red Hat, has attracted the attention of biodiversity stakeholders, and one of the World Wildlife Federation's working groups is evaluating ways to leverage the architecture for their use cases. As an interface to the Data Mesh, the Data Exchange project (a marketplace for climate data, making it easy to find, consume, trust, and share) has matured such that it is under consideration as a commercial entity.

OS-C's Data Mesh architecture and components address pain points associated with managing large, complex climate datasets by "managing data as code." By managing data as code, we ensure that changes in data sources, the schema, and the data pipeline logic have mandatory reviewers who sign off before they implement changes. Data artifacts have associated tests and undergo continuous testing, such as those used in software code versioning and management.

We aim to build a "**Climate Data Product Factory**" with repeatable templates and processes that will make it easy to build, secure, deploy, and manage data products as public goods.

## OS-Climate events

- OS-C made a strong impact at ChangeNOW and Vivatech, Europe's major tech events, with high booth traffic and stakeholder engagement.
- The project contributed to Open Source Summit conferences in Vancouver and Bilbao with key talks from industry experts, highlighting the role of open source in sustainability.
- OS-C partnered with BNP Paribas and Capgemini during NYC's Climate Week to launch "Business for Planet," an initiative based on OS-C's Transition Analysis tool.




**Climate Data Product Factory**

**OS-C Board Member Valerie Perhirin and OS-C Transition Scenario Analysis Technical Steering Committee Chair Matthieu Meaux of Capgemini present the project at BNP Paribas during New York Climate Week 2023.**

# Green Software Foundation

In 2023, the Green Software Foundation (GSF) made remarkable strides in its mission to accelerate the development and adoption of green software. Several key milestones occurred this year, setting the stage for a more sustainable future in software development.

## Launching the State of Green Software report


In May, the GSF released the State of Green Software report, providing critical global insights and data for decarbonizing software at scale. The report offers "insight bytes" on green software adoption, recent research, decarbonization tools, and policy changes. It emphasizes the importance of green software for a net-zero future and presents a compelling business case for investing in green software projects.

## Green Software certification program

The GSF launched its first Green Software Practitioners course to support developers in enhancing their carbon awareness. This course provides a framework to educate software practitioners on topics related to green software. Learners will explore green principles, understand and use shared language and standardized terms, and apply green software principles to the design and development of their software applications.

## Workshops and events

The GSF promotes community engagement and awareness through a series of workshops and events, including the GSF Decarbonize Software. This event showcases projects that positively contribute to a low-emission and climate-resilient world. At COP28, world leaders will discuss ways to reduce global greenhouse gas emissions by 43% by 2030. The Decarbonize Software event aims to position software as a leading factor in climate action, aligning with this ambitious goal.

## Tools and resources

The GSF has been proactive in developing tools and resources to facilitate the adoption of green software practices. The GSF is working on several projects, including the open source Impact Engine Framework (IEF) Project, enabling practitioners to calculate software emissions across all runtime environments. In establishing the SCI Specification, the GSF has set the standard, and the IEF provides the methodology. This standardized approach will enable thousands of professionals to collaborate on decarbonizing software.

## Community building

The GSF Community Meetup program boasts a global membership of over 6,000 individuals and is steadily expanding. It aims to promote sustainable software practices globally and attract fresh faces by fostering a passion for environmentally friendly software development and cultivating strong bonds founded on a shared vision.

The GSF has become an indispensable resource for organizations aiming to minimize the environmental impact of their software development practices. Through its initiatives, tools, and community support, the GSF is a leader in making software development more sustainable.


In 2023, the AgStack Project marked a transformative year, achieving several pivotal milestones that have significantly advanced its mission to make open source software the cornerstone of sustainable agriculture globally.

## Release for Asset-Registry v1.0

In June 2023, AgStack launched its first "smart-geoid" registry hosted to provide a unique geospatial "key" for land-based stationary assets in agriculture (e.g., field boundaries). The project aims to solve a fundamental "indexing" challenge in AgTech, without which data interoperability is elusive. Asset-Registry 1.0 allows registered AgStack users to create a geoid for their field. The geoid is addressable and not discoverable, i.e., a user must share the geoid with another user whose geoids are not discoverable. Over 1,000 active users across thousands of fields across more than 40 countries have adopted the seest registry.

## Launch of incubation for Asset-Registry v2.0

Using work by Dr. Sherrie Wang (MIT), asset-registry 2.0 will "auto-draw" the polygon for a user using machine-learned decision tools leveraging satellite data. The functionality will allow asset-registry 2.0 to scale across geographies at a very low (or no) cost, which can have a massive positive impact on farmers using these services in the Global South.

## Launch of incubation for AgStack Field Carbon Model

In March 2023, AgStack launched the "field carbon model" sub-project incubation to improve the cost and transparency of traditional MRV techniques for the agriculture "carbon" space. Early model validations use a remotely sensed dataset and the NASA L4C model to estimate carbon flux on a given agriculture field (provided by the geoid). Early estimates look quite encouraging, with >80 correlation with reference data.

Launch of Incubation for a System Solution Using AgStack for EUDR
In June 2023, the EU announced a major regulation to reduce the impact of deforestation on food production by passing the EUDR legislation. AgStack has received several grants from the EU and partners to participate and co-create the pre-competitive stack for EUDR.

## Development of a global ecosystem with CGIAR as a partner

In Feb 2023, AGStack and CGIAR signed a memorandum of understanding to partner with one another to co-create digital tools and services that will transform the agriculture ecosystem globally by providing these as a "global digital public good." With its vast array of "on-the-ground" scientists around the globe (especially the Global South), CGIAR needed a tech-first partner who could build communities around their largest projects. CGIAR is becoming a premier member of AgStack to help join and compel AgStack's community to build and offer these digital infrastructure components to CGIAR internally and to the large agriculture ecosystem for farmers to maximize yields while minimizing pesticide use. They also released a new farm management and decision support tool, offering cost tracking and crop rotation planning features.

# Security and trust in innovation

Our ongoing commitment to fortifying the digital landscape is unwavering. By spearheading software security, digital trust, and data integrity initiatives, LF projects set new standards for secure coding, transparent supply chains, and trustworthy content. We're creating a safer, more reliable digital world by fostering collaboration across industries and sectors.

## Open Source Security Foundation

The Open Open Source Security Foundation (OSSF) is a cross-industry collaboration that brings leaders together to improve open source software (OSS) security through targeted initiatives, education, and best practices. Over the course of 2023, OpenSSF membership grew to more than 100 members across North America (77), Europe (13), Asia (15), and the Middle East (1). Premier members include AWS, Apple, Atlassian, Capital One, Cisco, Citi, Dell Technologies, Ericsson, GitHub, Google, Huawei, Intel, IBM, JPMorgan Chase, Meta, Microsoft, Morgan Stanley, Oracle, Red Hat, Sonatype, VMware, and Wipro.

## Educational milestones

Education has been a cornerstone of OpenSSF's 2023 agenda. Over 20,000 developers enrolled in courses to teach the fundamentals of secure software development. The diversity, equity, and inclusion group launched an "office hours" program, providing invaluable mentorship to newcomers in the field of OSS security.

## Guiding the way: Security guides

OpenSSF has been a prolific publisher of security guides this year. These guides, such as the Concise Guide for Developing More Secure Software, have become essential resources for developers, consumers, and the security community at large. Other publications included the Concise Guide for Evaluating OSS


**Omkhar Arasaratnam, General Manager, OpenSSF**

**OpenSSF Day Europe**


**Above images OpenSSF Day North America 2023**

and Source Code Management Platform Configuration Best Practices.

## Evaluating OSS security

The OpenSSF Scorecard has been a game-changer, offering automated assessments of OSS projects based on various security criteria. This year, the Scorecard expanded its reach to scan over a million OSS projects weekly. Complementary efforts such as Allstar have made it easier for organizations to integrate the Scorecard into their development processes.

## Setting the standards: Best practices and frameworks

OpenSSF introduced the Best Practices Badge, a set of security and sustainment criteria for OSS projects. Over 6,000 projects participated, showcasing their commitment to security. The Supply-chain Levels for Software Artifacts framework was another milestone, focusing on preventing tampering and securing packages and infrastructure, and the Security reviews collection is a published set of known security evaluations of OSS, enabling others to find and review this information quickly.

## Infrastructure and tooling

From Sigstore's digital signing and verification to the Package Manager Security Landscape Survey, OpenSSF has been at the forefront of improving OSS infrastructure and tooling. Initiatives such as Fuzz Introspector and spdx/tools-python have further enriched the ecosystem.

- Sigstore provides digital signing and verification for artifacts. Sigstore serves as a signing release for CPython, Kubernetes Artifacts, and npm package provenance. We also have a free course on how to use sigstore. There have been over 32 million recorded entries for signatures within sigstore's public signature transparency log, spanning over 17,000 unique OSS projects, including Kubernetes, CPython, LLVM, KNative, Istio, and ArgoCD.

- We conducted a Package Manager Security Landscape Survey to contrast their security capabilities and then developed the Build Provenance for All Package Registries to encourage improvements across all repositories.
- OpenSSF funded spdx/tools-python to improve SBOM handling led to the 0.7.0 release of the Python SPDX-Tools package. Fuzz Introspector, designed to improve fuzz testing and fuzz testing tools to enable the detection of vulnerabilities before attackers discover them, now has unified support for C, C++, Java, and Python.

## Finding and fixing vulnerabilities

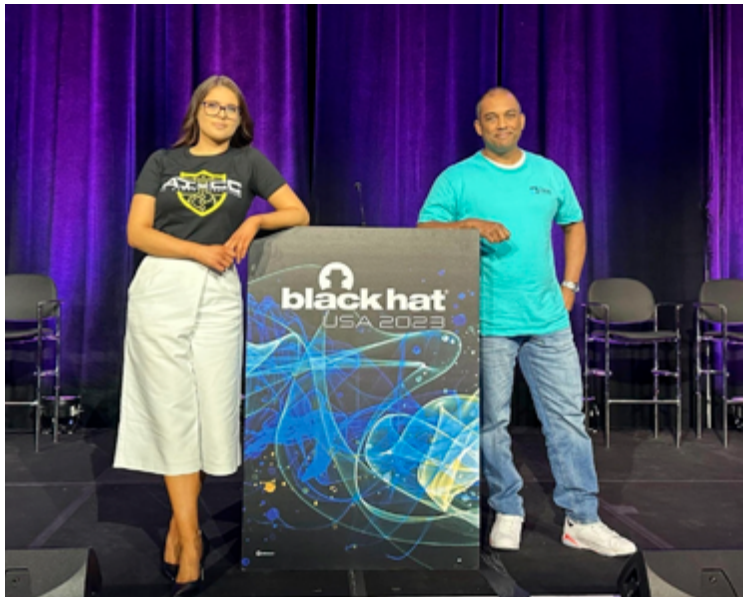
The Alpha-Omega initiative, which $12.5 million in corporate sponsorship backs, has been a monumental effort in discovering and fixing vulnerabilities in widely used OSS. Partnerships with the Python Software Foundation and OpenJS have had a ripple effect, enhancing security across the board.

- Alpha-Omega, with $12.5 million in corporate sponsorship, collaborates with OSS maintainers to systematically find and fix undiscovered vulnerabilities and improve their overall processes. Current partners include the Python Software Foundation (including funding a Python security developer in residence), ISRG's Prossimo, the OpenJS Foundation and jQuery, the Eclipse Foundation, Node.js, and the Rust Foundation. These partners manage important, widely used OSS, so the security improvements substantially improve security for all.
- We've supported in-depth security audits of some widely used OSS, often via Alpha-Omega and a partnership with OSTIF. These include OpenSSL 3.1.0 and various Eclipse projects (p2, Mosquitto, Jetty, and jKube). Some audits are still in progress.
- Open Source Vulnerability Schema is a machine-readable format that precisely maps vulnerabilities to open source package versions or commit hashes. Currently, 18 ecosystems use them, including AlmaLinux, Rocky Linux, and the Haskell programming language, which are recent additions.

**Jennifer Bly of OpenSSF with Rebecca Rumbul of Rust Foundation, at OpenSSF Day Bilbao**

**OpenSSF Day North America**


**OpenSSF at CloudNative Security Con**




**DEF CON**

## Research and government engagement

OpenSSF has been an industry leader as well as a thought leader. Partnerships with Linux Foundation (LF) Research and advisory roles in DARPA's AI Cyber Challenge are testaments to OpenSSF's influence in shaping the future of OSS security. Meetings with U.S. government officials have further solidified OpenSSF's role in national cybersecurity efforts.

- We partnered with LF Research on an OpenSSF software security awareness survey, and we continue to refine a set of critical OSS projects.
- OpenSSF is serving as a challenge advisor on the DARPA AI Cyber Challenge (AIxCC) to guide teams in creating AI systems capable of addressing vital cybersecurity issues, such as the security of our critical infrastructure and software supply chains.
- We gathered U.S. government officials from the National Security Council, the Office of the National Cyber Director, and the Cybersecurity and Infrastructure Security Agency with industry leaders at Secure OSS Summit in September to collaborate on securing critical infrastructure.

## Community and outreach

OpenSSF Days held in North America, Europe, and Japan have been pivotal in bringing the community together. Local meetups and extensive media coverage have amplified OpenSSF's reach and impact.

- We held OpenSSF Day North America in Vancouver, Canada; OpenSSF Day Europe in Bilbao, Spain; and OpenSSF Day Japan, in Tokyo, Japan. These brought together the open source community to discuss the challenges, big-picture solutions, ongoing work, and successes in securing the OSS supply chain.
- We have held local meetups in the global OSS community to encourage the use of OpenSSF resources.
- There have been numerous OpenSSF initiatives featured in news articles, webinars, podcasts, and industry conferences.

# THE LINUX FOUNDATION DigitalTrust

Digital trust is critical in today's interconnected world, affecting everything from asset management to identity verification. LF Digital Trust is an information hub for identifying key open source projects under the LF umbrella, aiming to bolster digital trust and enable discovery.

The initiative features a blend of technology-focused and industry-specific projects, each contributing unique solutions to the challenge of digital asset interoperability. Noteworthy among these is the OpenWallet Foundation, a recent but significant addition that underscores the importance of open source in the growth of decentralized systems.

The LF Digital Trust is an information hub for LF-hosted projects and communities that develop standards, tools, governance, and infrastructure in support of digital assets, credentials, relationships, and ecosystems for use by people, governments, enterprises, non-profits, academic institutions, and society at large.

## Communities and their contributions

Several communities within the LF are making impactful contributions to the realm of digital trust:

- **The Coalition for Content Provenance and Authenticity (C2PA)** sets the standard for tracing the origin and history of digital assets.
- **The Confidential Computing Consortium** boosts data security through hardware-based trusted execution environments.
- **The Decentralized Identity Foundation** pioneers open standards for decentralized identity.
- **The Hyperledger Foundation** focuses on the open development of enterprise-gradel distributed ledgers.
- **The OpenWallet Foundation** works on open source elements for interoperable digital wallets.
- **The Trust Over IP Foundation** establishes a comprehensive set of standards for scalable digital trust.

## Industry-specific projects

- **The AgStack Foundation** concentrates on secure and trusted identity solutions for the global food and agriculture sectors.
- **FINOS** promotes the adoption of trusted Web3 technologies within the financial industry.

LF Digital Trust projects encourage participation from a broad audience, including individuals, governments, and corporations. Please get involved to ensure a thriving and more trustworthy digital ecosystem.

SPDX®

SPDX 3.0 has reached two significant milestones with the launch of the two release candidates announced in June 2023 and September 2023. The SPDX community is delivering the most adopted SPDX communication format to meet the increasing demands the White House and the EU have requested from the software industry. It represents a significant achievement in the historic standardization of the software bill of materials (SBOM) communication format. With its enhanced capabilities and improved interoperability, SPDX 3.0 enables more efficient and accurate tracking of software components throughout the development lifecycle, from design to deployment, and includes support for a myriad of use cases that were not part of its original charter, such as building software, supply chain security, or AI and training data sets. These new features (called profiles in SPDX lingo) improve visibility and traceability, which can dramatically help organizations better manage their software assets, reduce security risks, and comply with regulatory requirements more effectively.

SPDX 3.0 provides several benefits for SBOM adoption and usage. Firstly, it enables the creation of comprehensive and accurate SBOMs that different stakeholders can share, reducing misunderstandings and errors. Secondly, it provides a common language and structure for describing software components, making it easier for developers, integrators, and auditors to work together on software supply chain security. Finally, SPDX 3.0's improved support for complex software systems and architectures means that organizations can now create more detailed and accurate SBOMs, which is critical for ensuring the security and reliability of modern software-intensive systems.

Innovation Insight for SBOMs, published February 14, 2022, by Gartner: “Among the three SBOM standards, SPDX has gained the most industry traction. It is supported by software composition analysis (SCA) vendors such as Snyk (FossID), Sonatype, Synopsys, and WhiteSource. The SPDX specification is now an ISO standard. The SPDX version 2.2 includes an ‘SPDX Lite’ profile that defines a subset of the specification to tailor it to vertical-specific use cases. SPDX Lite is developed by Pioneer, Sony, Hitachi, Renesas, and Fujitsu, among others.”

In 2023, the C2PA project marked a year of remarkable achievements, setting the stage for a future where cloud native application protection conforms to a standard, is robust, and, perhaps most importantly, is verifiable. One of the most pivotal accomplishments was unveiling the C2PA Reference Architecture. This comprehensive guide serves as a foundational blueprint for organizations aiming to implement C2PA systems. The architecture has had widespread approval and adoption, solidifying its role as an industry standard.

Complementing the Reference Architecture, the launch of the C2PA Conformance Testing Program provided a rigorous evaluation framework. Organizations can now validate their C2PA systems against established specifications, ensuring compliance and interoperability.


**The CR "Content Credential" icon was developed by Adobe with other companies as one of the many initiatives of the C2PA.**

This has been a game-changer in setting quality benchmarks and fostering stakeholder trust.

On the tooling front, the project released a slew of open in source resources to simplify the implementation process. Noteworthy among these are the C2PA compliance scanner and the C2PA test harness, which have been instrumental in streamlining the compliance journey for many organizations.

Beyond technical deliverables, the C2PA project has successfully cultivated a vibrant community. Events such as the C2PA Workshop and the C2PA Summit have driven knowledge sharing and collaboration. The launch of a dedicated website and social media channels has further amplified the project's reach and impact.

Looking ahead to 2024, the project has outlined ambitious goals, which include the ongoing refinement of the C2PA Reference Architecture and Conformance Testing Program and collaboration with industry partners to develop new tools. Additionally, the focus is on expanding the C2PA community and driving adoption. Research initiatives are also underway to explore the implications of C2PA on privacy and security.

# App Defense Alliance

In November 2023, Google, Microsoft, and Meta announced they were formally partnering as the founding steering committee to improve app security through a newly restructured **App Defense Alliance**, under the Joint Development Foundation, part of the Linux Foundation family. The collaboration brings together the best open source principles and industry-leading cybersecurity expertise to establish standards, conformance criteria, and certifications for mobile application security.

Founded in 2019, the alliance's primary objective has been to identify and neutralize potentially harmful applications before mobile app marketplaces such as Google Play disseminate them. Through initiatives such as mobile application security assessment, cloud application security assessment, and malware mitigation, the Alliance has been at the forefront of combating cybersecurity threats targeting mobile applications.

Joining the Joint Development Foundation amplifies the App Defense Alliance's capabilities, first by integrating it into a broader network of open source projects and communities, then by supporting a range of standards development activities that will benefit and protect mobile app developers and users. This partnership will accelerate the development of robust security standards and facilitate the sharing of critical threat intelligence across various platforms. It will also enable the Alliance to tap into the LF's extensive resources, including its global community of developers and industry experts.

USHUBHAM DHAGE: UNSPLASH

# Skills-driven innovation

Empowering talent through learning opportunities that fuel innovation is like a lighthouse marking a safe harbor. As the demand for skilled open source professionals continues to soar, we're committed to providing the necessary training and certification to meet this challenge. We've designed our courseware to equip individuals and organizations with the skills to bring secure, innovative solutions to market, bridging the talent gap and ensuring a sustainable future for open source innovation.

# New courseware

## Expanding approaches to knowledge and skill development

Upskilling remains essential to retaining IT talent and growing organizational capabilities despite changing economic conditions. While most organizations are taking a more cautious approach to hiring new talent, the demand for technology professionals remains very high.

Emerging technologies such as artificial intelligence and machine learning account for some of the demand; however, the continuing, consistent growth of established technologies, particularly cloud and open source, ensures a shortage of tech talent for at least another decade.

Today's employers need to know that new hires have the skills they need now and a willingness to learn as technology evolves.

The result has been the most significant shift in the market in a long time: a reliance on verifiable certifications that rivals employers' desire to hire candidates with a traditional university education.

Upskilling also serves as a hedge against resource constraints. Rather than hire new talent to fill skills gaps, organizations are embracing the wisdom of offering their best talent the opportunity to learn new skills and take on new challenges, increasing their IT team retention.

## New subscription offerings

We continued to respond to shifts in the market with new courses, certifications, and learning approaches. This year, we introduced THRIVE for enterprise, an innovative approach to the traditional learning subscription that focuses on learning


JASON GOODMAN; UNSPLASH

investment ROI rather than learning activity. Pricing reflects a target number of certifications for an IT team to achieve and provides full access to a curated library of e-learning courses. We also launched THRIVE-ONE for individuals, which combines certification exams with traditional e-learning course offerings.

In addition to our standard courses, we introduced a new e-learning course structure that features highly focused content that participants can complete in a single 60- to 90-minute session.

## New courses, certifications, and SkillCreds in 2023

- Security and the Linux Kernel
- Introduction to Quantum Circuits
- Cybersecurity Essentials
- Introduction to Cilium
- RISC-V Fundamentals
- Introduction to Cilium
- Quantum Computing Essentials for Senior Leaders
- Computer Architecture with an Industrial RISC-V Core [RVfpga]
- PyTorch in Practice: An Applications-First Approach
- Ethical Principles for Conversational AI

- Programming in RUST
- Installing, Configuring, and Managing SPIFFE and SPIRE
- Forest Monitoring with AgStack
- Modern Air Gap Software Delivery
- OWASP Top 10 Security Threats for Web Application Developers
- Documenting Supply Chain Security for Open Source Projects
- PyTorch Essentials: An Applications-First Approach
- Open Source Contribution in Finance
- Open Source Technical Documentation Essentials
- Cloud Native Fuzzing Fundamentals
- Developing Solutions with FDC3
- Detecting Cloud Runtime Threats with Falco

## Express learning

The first set of Express Learning courses include:

- Interacting with REST and HTTP-based APIs
- Creating Edge IoT Solutions with EdgeX Foundry
- Introduction to FDC3
- Automating Supply Chain Security: SBOMs and Signatures
- Securing Projects with OpenSSF Scorecard
- Security Self-Assessments for Open Source Projects

## New certs/SkillCreds

- RISC-V Foundational Associate (RVFA)
- Hyperledger Fabric Certified Practitioner (HFCP)
- Istio Certified Associate (ICA)
- Certified GitOps Associate (CGOA)
- Kubernetes and Cloud Native Security Associate (KCSA)
- FINOS Certified FDC3 Practitioner (FCFP)
- SkillCreds
  - JavaScript (JSON)
  - Tekton
  - Regex

## Scholarships

In 2023, The Linux Foundation awarded 500 scholarships for training and certification to individuals from 80 countries in memory of Shubhra Kar, Linux Foundation's CTO. Hundreds more received awards via partnerships with nonprofits, including Blacks in Technology, TransTech Social Enterprises, and Women Who Code.

We also collaborated with the Republic of Trinidad and Tobago's Ministry of Digital Transformation to provide access to more than 40 e-learning courses and IT certifications as part of the Ministry's Developers' Hub Initiative.

MIZUNO K: UNSPLASH

# 2023 State of Tech Talent report

We published our **2023 State of Tech Talent Report** in May 2023, which offers insights into the current and future technology staffing needs and skills that organizations require. Linux Foundation Training & Certification and Linux Foundation Research conducted a global survey in February and March 2023 of over 400 hiring managers and staffing professionals, addressing the needs of end-user organizations and technology providers.

## Impact of economic concerns

One of the report's key findings is the impact of economic concerns on technical hiring plans. More than 50% of organizations surveyed reported revising their hiring plans by freezing new positions. This result is likely due to the ongoing global economic uncertainty caused by the COVID-19 pandemic and other factors, including inflation and geopolitical conflicts.

## Demand for skilled technical talent

More organizations plan to increase their technical staff than decrease. This is a positive sign for those seeking employment in the tech industry. The demand for skilled tech talent remains strong, particularly in newer areas such as cloud / containers, cybersecurity, and AI / ML. Respondents identified these areas as the primary focus for hiring in 2023.


## A shift in technical roles

Another interesting finding is the shift in hiring practices for technical roles. While senior technical positions have seen the most job cuts, new hiring focuses more on developers and IT management. This suggests organizations seek skilled individuals who can contribute to project implementation, management, and technical development.

## Training and upskilling

Training and upskilling are strategies that are becoming more important for organizations to address the changing hiring landscape. The report highlights that 70% of organizations surveyed provide training opportunities for their existing technical staff on new technologies. This is a positive sign, as it indicates a commitment by organizations to continual employee development and keeping their workforce up to date with the latest technologies and practices.

## Recruitment and upskilling

Upskilling is also becoming increasingly important for recruitment. Organizations train existing employees more often than hiring consultants when suitable technical candidates are unavailable, recognizing the value of investing in their current staff and the challenges of finding the appropriate external applicants.

## Certification and pre-employment testing

Respondents felt that certification and pre-employment testing are necessary to verify skills to address the challenges of finding the proper candidate. This tool ensures organizations hire the appropriate people for the job. It also gives candidates a clear understanding of the skills they must demonstrate to succeed in the role.

# Community-led innovation

In 2023, we redoubled our efforts to foster an inclusive and connected open source community. Through mentorship programs, we're empowering the next generation of innovators. Our focus on diversity, equity, and inclusion makes our ecosystem more robust and sustainable. The return to in-person events has rekindled the invaluable power of face-to-face connections, strengthening our collective resolve.

# THE LINUX FOUNDATION | Events

At the end of 2022, we looked toward 2023 with cautious optimism. The waning of the COVID-19 pandemic allowed us to remove mask mandates and left more people feeling comfortable with face-to-face gatherings. We envisioned a return to the bustling ambiance of pre-pandemic meetings. Yet, the year had other plans. By late 2022, layoffs signaled the onset of economic challenges, leading us to anticipate reduced event participation throughout the year. While we initially hoped this downturn would be short-lived, it stretched throughout 2023.

However, every cloud has a silver lining. While in-person registration numbers remained reduced, the quality of interactions flourished. Heartening feedback from participants continued to remind us of the value and impact of our events, irrespective of their scale.

"Participating as a speaker at **#KubeCon #CloudNativeCon #OSSummit** China 2023 in Shanghai has been by far the best experience in my IT professional career." ***—Lo Bu Hi***

In many ways, 2023 was a landmark year. We re-established our in-person event presence in China and India, introduced a first-time event in Israel and Singapore, and successfully launched several new events, including CloudNativeSecurityCon, GraphQL Summit, WasmCon, and AI.dev, a new open source AI developer conference. We supported the seL4 community's annual summit for the first time, produced the first PyTorch Summit organized under the PyTorch Foundation, and held the pioneering Open Source Congress in Geneva, gathering global open source foundation leaders for profound dialogues around timely topics affecting us all.

We amplified remarkable project launches, such as the OpenTofu Foundation and Generative AI Commons, at our events, and we made a strategic pivot from virtual platforms to live streaming, offering all conference session recordings on YouTube to democratize access. This enhances the reach and longevity of the knowledge shared, leading to wider dissemination of outstanding educational content that has witnessed, to date, over 100,000 views of 2023 event content.


"WasmCon 2023 was a jam-packed affair boasting four separate tracks and well over 30 talks, so any attempt to capture its essence is doomed to come up short."

***—Dominique Saulet & Chris Dickinson***

"Open Source has redefined the concept of reaching larger communities for education. I am glad that this is just the beginning."

***—Rashmi Acharyya***

## TRAVEL FUNDING

In our continued efforts to broaden accessibility to in-person events, especially in a year that saw, we provided over:

**$1.6M** in travel funding and registration scholarships

**60%** increase from 2019

**548** Diversity Travel Scholarships

**71** Diversity Registration Scholarships

**362** Need-Based Travel Scholarships

**25** Need-Based Registration Scholarships

## ATTENDANCE ACROSS 2023 EVENTS

**100k+** attendees

**XX** countries

**250** events

**12k** organizations

Despite the lower registration numbers referenced earlier, we did enjoy the largest in-person European KubeCon + CouldNativeCon to date in April, with more than 10,500 joining us in Amsterdam—a 48% increase in in-person attendees from our 2022 European event.

In conclusion, 2023, while riddled with challenges, brought forth resilience, innovation, and a reaffirmed commitment to our mission. Despite the obstacles, it was a commendable year.

**GraphQLConf 2023, San Francisco Bay Area**


**Mary Hardy, Sr. Corporate Counsel for Microsoft Open Source on the job at LF Member Summit 2023 in Monterey.**

"Inspiring talks, impressive projects, and great people #GraphQLConf Thank you all behind @GraphQL for organizing this conference and a wonderful ecosystem."

***—Hyeseong Kim***

# Diversity, equity, and inclusion

## Our events

Our commitment to diversity, equity, and inclusion (DEI) continued across the organization in 2023, beginning with our events, which we proudly use to **create diverse and inclusive spaces in open source that we hope foster more diversity**.

Our existing event initiatives continued in 2023, including:

- An adherence to the LF Event Code of Conduct at all events, which all event participants must agree to follow in the registration process
- Policies against all-male panels and speaker lineups
- Free childcare at LF and many project events
- Nursing rooms, pronoun stickers, all-gender restrooms, zen zones, and prayer rooms across LF and most project events
- Hosting the Diversity Empowerment Summit at Open Source Summit North America (OSSNA) and Europe
- Closed captioning and multilingual captioning across most event recording sessions for expanded accessibility
- DEI special event activities, including women and non-binary networking lunches, diversity lunches, and receptions that include Ally guests
- Meeting CHAOSS badging requirements for events
- Ongoing outreach to invite and encourage more diverse speakers at events—we're excited to share a great example of how these efforts can pay off, **as this year, our flagship OSSNA & Europe each had more than 30% of speakers identifying as women or non-binary**.

We also expanded on several efforts this year and will continue to do so in 2024, including:

- Making outreach for more diverse program committees a priority (as in the example where 37% of the OSSNA program committees identified as women or non-binary)
- Increasing accessibility efforts at in-person events, including bringing in guide dogs, ASL interpreters, and conference "guides" for attendees who need them to be able to fully participate
- Partnering with the LF TAB to offer wellness and burnout counsel to the kernel maintainer community, who are indicating that maintainer burnout is becoming a real crisis, and launching these initiatives with a session at the Linux Plumbers Conference / Kernel Maintainer Summit
- Expanding opportunities for kids with a new Kid's Day at KubeCon + CloudNativeCon Europe and North America, with the European event offering workshops in both Dutch and English

"As a first-time in-person attendee, I felt welcomed and encouraged to learn and to share in every session and interaction I had. The community is so welcoming, and I really felt that during the conference.

***—Aisha Gautreau***

# Meeting diverse communities where they are

Beyond our events, this year the LF and Cloud Native Computing Foundation jointly sponsored the Grace Hopper Conference, Black is Tech, and the Society of Hispanic Professional Engineers Annual Conference (SHPE). We decided to expand our presence at diversity tech events after receiving valuable advice from community members that "meeting diversity in tech where they are will help show your commitment to diversity."

At Black is Tech, we hosted a technical workshop (presented by Randall T. Vazquez from LF) and a conference session where LF TAB Board Chair and Linux Kernel Developer Dan Williams shared his personal story of being Black in tech and counseled attendees on learning how to be comfortable with being uncomfortable and influencing a global community to be more inclusive. Community members Jasmine James (Square), Cassandra Cross (Amazon), and Stephen Augustus (Cisco) were also present and hosted lighting talks and spoke to conference attendees at our booths. Although SHPE had not yet taken place at the time of this writing, we were delighted with the response to our presence at these events thus far, which we plan to continue in 2024.

"As a person with disability, [this] was my first time at OSS NA and also my first time as a speaker at suchNo a large international event. I loved every single moment at this conference. Be it the keynote, or the co-located events, the lightning talks, the diversity lunch, first-time attendee breakfast, the sponsor booth crawl to the aquarium visit, and the wonderful Vancouver bus tour, I loved, loved, and loved being part of this beautiful, inclusive, diverse conference."

## Open Mainframe Project diversity efforts

Open Mainframe Project aims to ensure that diversity is an important part of the project as well as the technology landscape. Through the "Making Our Strong Community Stronger (MSCS)" collaborative initiative, Open Mainframe has hosted several webinars, presentations, and blogs focused on DEI. This year, MSCS hosted webinars about how to foster inclusive work environments for the LGBTQIA+ community, how to create a multi-generational workforce, and how to close the knowledge gap.

Open Mainframe also featured project and community leaders in a series of personal blog posts in honor of Black History Month, Asian American & Pacific Islander Month, Women's History Month, International Day of Women and Girls in Science, and National Hispanic Heritage Month:

- Closing the Knowledge Gap: How to Attract and Retain Next-Gen Mainframe Talent
- Building Dreams in Binary: A Latino Software Engineer's Story
- My 360 Journey into the Mainframe World
- Hope for the Future: A View on Progress for Inclusion with AAPI Communities
- Fostering Inclusive Work Environments for the LGBTQIA+ Community
- AAPI Spotlight: Dong Ma, Software Engineer at IBM
- 3 Ways to Celebrate AAPI Heritage Month

- It Starts with Us
- Life Comes Full Circle with COBOL
- My Journey: A Mentorship with Zero Linux Knowledge
- Black History Month Spotlight: Byron Smith
- Black History Month Spotlight: Dr. Cameron Seay
- International Day of Women and Girls in Science 2023
- Mental Wellness Month

Additionally, Open Mainframe Project smashed the image of what a "typical" developer or engineer in this space looks like with its popular "I am a Mainframer" podcast. The podcast showcases the unique career paths of people in the mainframe ecosystem as well as the related technologies that surround it. This year, the podcast has featured a wide range of guests, including university students studying COBOL, a director of infrastructure, software development engineers, an inventor, an Open Mainframe Project mentee, a cloud solutions engineer, and more. Watch the videos on the podcast playlist on the Open Mainframe Project YouTube Channel or anywhere you listen to podcasts.

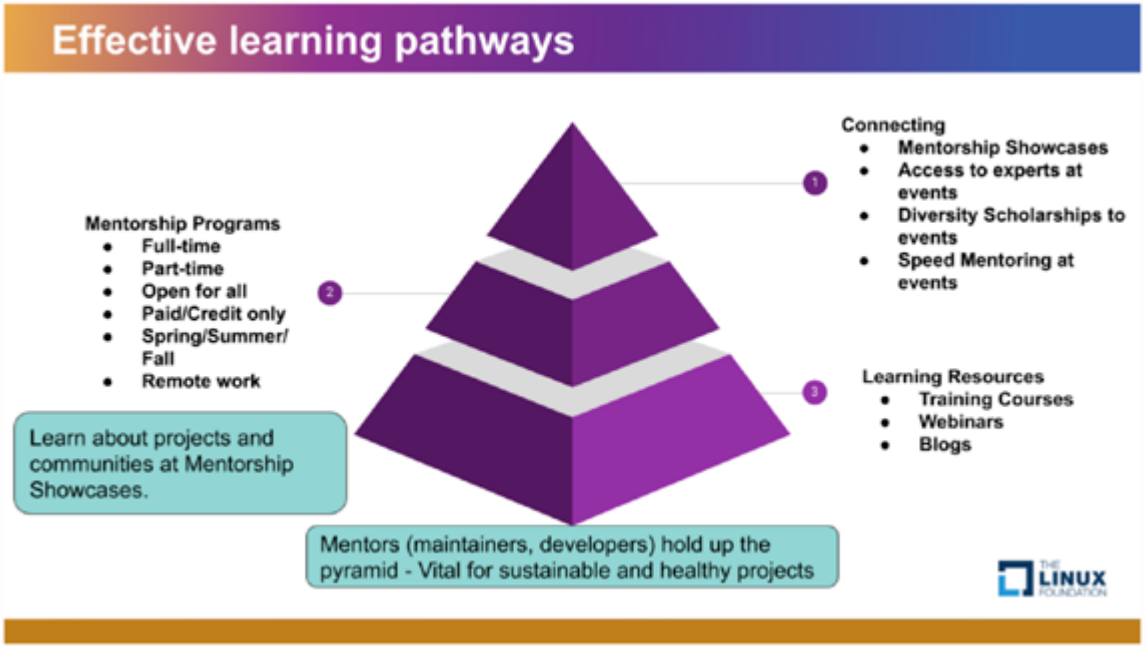

**The podcast showcases the unique career paths of people in the mainframe ecosystem as well as the related technologies that surround it.**


**Open Mainframe Project YouTube channel**


**A graphic from the Open MainFrame Project website supporting Mental Wellness Month.**

"The women / non-binary lunch and the DEI lunch were GREAT. I met so many great people here, and the energy was so much more inclusive."

# Mentorship




Open source software is the backbone of our world infrastructure in financial, healthcare, and telecommunications sectors and critical internet infrastructure. As a result, ensuring these communities are healthy and sustainable for the long term is paramount to keeping this infrastructure working. Our responsibility as maintainers and contributors is to invest in the future by empowering the next generation of open source developers. It is difficult for stretched-thin experts to take on mentoring roles; however, it is important to the continued success and health of the communities.

Equitable access to learning resources is a barrier for many new developers. Making access to learning equitable is essential to attract and retain new open source talent to keep communities healthy. Empowering aspiring open source developers to have agency over their learning and skill development is important.

We at the LF have recognized access to resources is a barrier and designed our programs with that in mind. Our all-remote, open to all full-time and part-time mentorships, webinars, and training resources enable women and people with work-life balance challenges to overcome the barriers to learning. We see participation from various global regions. Every term, there is a new country and region added.

The LF Mentorship program embarked on its fifth year with a humble beginning in 2019. The LFX Mentorship programs, spanning a wide range of LF projects and technologies, have been training the next generation of open source developers. As of this writing, we have received 10.7K applications, accepted close to 850 candidates, and had 575 participants graduate from the programs. We have paid $2M in stipend payments. Except for a small number of unpaid programs, most of our programs pay a stipend to learn. Our mentorship programs are open to all, allowing students and developers to advance their careers and expand their skills in technical areas of interest.

We have learned that our applicants widely regard our mentorship program as one of the top choices for engaging with the open source community and practicing skills related to Linux, kernel development, CNCF, HyperLeadge, RISC-V, and many other open source technologies.

## Empowered learning

We look at mentoring from a broader perspective. In addition to structured mentorship programs, we provide several learning resources through interactive webinars. These webinars offer opportunities for new developers to learn from experts in various technical areas. An example of one such webinar offering is our virtual mentoring series entitled LF Live: Mentorship Series. These webinars are free for anyone to attend, and we offer them to support the development of skills and further empowerment of the community. We archive past webinars, and they are available as a self-learning resource for developers.

## Making connections

We recognize connecting our graduates with prospective employers is important. Our LFX Mentorship Showcases connect graduates with people looking for talent. Our graduates share their experiences in their talks at the showcases, in blogs published on LF blog sites, and in other publications such as The New Stack.


**Shuah Khan, LFX Mentorship Program Lead and Linux Foundation Fellow at Diversity Empowerment Summit North America 2023.**

## Highlights:

- LFX Mentorship Showcase 2023: We connected our 2022 graduates with prospective employers. Our graduates showcased their projects and the skills they learned during their mentorship sessions. This is a work in collaboration with the LF Events.
- It was a successful year, with several spring, summer, and fall LFX Mentorship programs offered. Visit our LFX Mentorship Dashboard for details.
- Work in collaboration with the LF Research Mentorship in Open Source report: This work explored succession and diversity challenges across open source projects; the

history of mentorships within academia and open source organizations; and the origin of the LFX Mentorship program within the LF Mentorship program and its challenges and benefits. It concludes with a set of actionable insights for the community to help scale mentorship programs at the LF and throughout the industry.

- Work in collaboration with LF Research: We published blogs by experts on LF blog sites and in other publications such as The Newstack. These blogs strengthen the self-learning resources we make available to developers.
- Work in collaboration with LF Research: We published mentee blogs on LF blog sites and in other publications such as The Newstack.
- We reached out at Black Is Tech, Grace Hopper, and SHPE Annual Conferences,

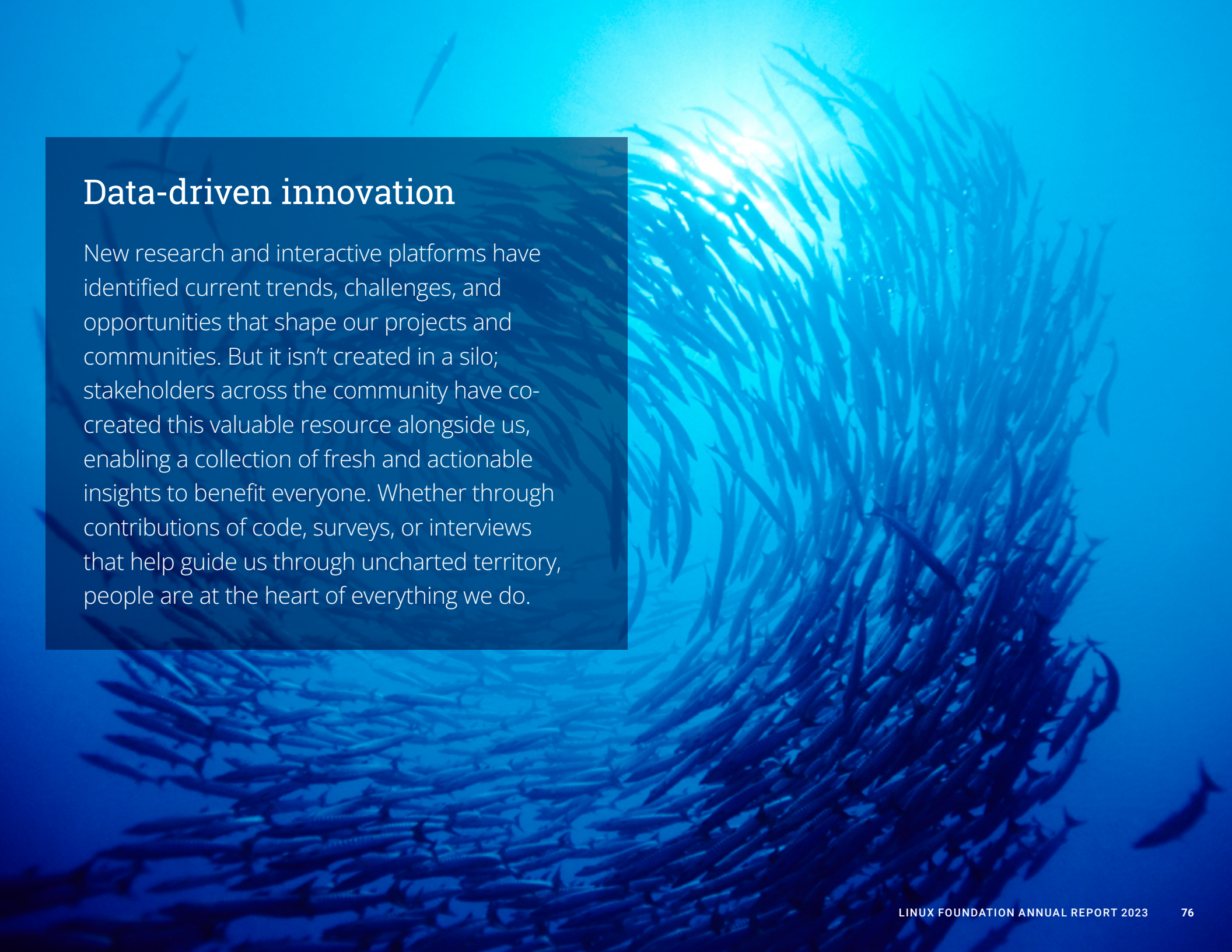

sharing information regarding the LFX Mentorship programs and learning resources.

- Applications came from all corners of the globe, spanning all the continents. The LFX Mentorship applicant self-identified demographic data comprised:
  - 17+% women, 73% men
  - 1% White, 72% Asian, 8% Black / African American, 1% multi-racial, <1% Hispanic
  - 45% lower middle income, 13% upper middle income, 17% working class
  - A majority of mentees from Asia and Southeast Asia

## Outreach

As we approach the fifth anniversary of our mentorship programs and other efforts to empower the next generation of open source developers, these programs have matured and become stronger. Hence, our outreach focus has shifted from promoting mentorship programs to educating open source communities on the importance of active mentoring for the continued health of their communities. Here is a summary of our outreach efforts:

- BoF: Empowering the Next Generation of Open Source Developers—Shuah Khan, The LF at the Diversity Empowerment Summit at the OSSNA 2023: The presenter speaks about the importance of keeping the open source communities healthy and sustainable for the long term and our responsibility as maintainers and contributors toward investing in the future by empowering the next generation of open source developers.
- Behind the Scenes of Running Linux Kernel Mentorship Programs: This is a behind-the-scenes view, beginning with the project creation, application screening, mentee selection, running the session, and then guiding mentees to the finish line.
- Getting a start in open source at Opportunity Open Source: The presenter speaks about overcoming the beginner's problem and marching toward becoming an open source contributor.
- Empowering the Next Generation of Open Source Developers—Shuah Khan, The LF at The LF Member Summit 2023: The presenter speaks about the importance of keeping the open source communities healthy and sustainable for the long term and our responsibility as maintainers and contributors toward investing in the future by empowering the next generation of open source developers.



## Data-driven innovation

New research and interactive platforms have identified current trends, challenges, and opportunities that shape our projects and communities. But it isn't created in a silo; stakeholders across the community have co-created this valuable resource alongside us, enabling a collection of fresh and actionable insights to benefit everyone. Whether through contributions of code, surveys, or interviews that help guide us through uncharted territory, people are at the heart of everything we do.

# THE LINUX FOUNDATION | Research

Now in its third year, LF Research continues to bring together developers and maintainers, business and community leaders, and a cross-section of open source stakeholders to explore a diverse set of research questions. Within and outside the Linux Foundation community, our mandate is to study the latest challenges and opportunities for open source and its impact on industry, government, and all facets of society. In 2023, we published more than 20 in-depth research reports in various industry verticals, across ecosystem-wide trends and practices, on different emerging technologies, and within different regions around the world, generating actionable insights for all.

## Core research projects

An important part of our portfolio represents priority challenges and opportunities that members face across open source. Below are highlights from the core research agenda.

## Open source perspectives and best practices

### A Road Map to Improve the Effectiveness and Impact of Enterprise Open Source Development

As open source continues to grow at the enterprise level, there is increasing recognition of the challenges inherent to enterprise open source consumption and contribution. This report covers several practices that enterprises can adopt to effectively participate in open source.

### Measuring the Economic Value of Open Source

Open source technologies are free to use, making them challenging to value in economic terms. Professor Henry Chesbrough, a pioneer in open innovation, aggregates survey findings and describes the perceived economic benefits of open source software, including cost savings, faster development, open standards, and interoperability.

### Recommended Practices for Hosting and Managing Open Source Projects on GitHub

This report is a reflection on the power of GitHub to manage open source projects, based on a compilation of best practices to help developers enhance project engagement, understandability, and organization. Recommendations range from documentation and communication practices to embedding open source principles into the foundations of project development.

### Open Source Maintainers: Exploring the People, Practices, and Constraints Facing the World's Most Critical Open Source Software Projects

The software that powers so much of our technology infrastructure would not be possible without the individuals who maintain it. To understand more about this group of individuals, we interviewed some of the community's most influential maintainers. Interviewees shared their best practices to balance the growth of a healthy software community with their own lives. We collected 41 practices throughout the interviews, including using inclusive language; providing radical transparency; prioritizing and formalizing the documentation processes; ensuring there are regular funding sources; and pairing mentoring with diversity efforts.

### The 2023 State of Open Standards

Standards are a part of the fabric of our digital systems and have an important influence over decision-making and innovation. This report synthesizes findings from a survey that asked the Linux Foundation and survey partner communities about their involvement in standards, the value of and growth in standards, and what challenges they have experienced in this practice.

### The Business Value of the OSPO

This report, conducted in partnership with the TODO Group, explored the question: Why are Open Source Program Offices (OSPOs) valuable from a business perspective? This qualitative study takes the reader through different value propositions to connect OSPOs to business objectives and identifies the challenges to expect on an OSPO's journey.

### 2023 State of Tech Talent Report

LF Research partnered with LF Training and Certification for its annual talent report, this time from the perspective of hiring managers. A resource for organizations, developers, and hiring managers, this report highlights the priorities, challenges, and changes experienced by the tech industry and the tech workforce in 2023.

### Open Source for the Mobile Sector

Currently, siloed companies dominate our mobile phone industry, resulting in vendor lock-in, inflexible terms, higher costs, and ultimately stunted growth. This negatively impacts consumers, app developers, manufacturers, and regulators. This research report, sponsored by Futurewei and in partnership with numerous open source projects, features interviews from subject matter experts to understand the current state of the mobile industry, the challenges this industry faces, and how open sourcing the mobile technology stack can address these challenges. Critical to this shift are open standards, which provide cross-industry consensus for the development of the stack.

## Spotlight on sustainability

This year, our research portfolio published several reports on the relationship between open source and sustainability.

### Open Source for Sustainability: How Projects Under the Linux Foundation Are Helping to Advance the UN Sustainable Development Goals

As part of the LF Sustainability initiative, this report analyzed use cases as well as documented efforts of project communities across the Linux Foundation, its curators and contributors, and its working groups to map efforts to the different dimensions of sustainability represented by the 17 United Nations Sustainable Development Goals (SDGs). This research identified hundreds of digital public goods, from open content and standards to software and hardware, that advance at least one of the goals. By capturing where and how our projects are making an impact, the report helps the Linux Foundation community to further direct resources to broaden and deepen these efforts.


### The Open Source Opportunity for Microgrids

Conducted in partnership with Futurewei, LF Energy, and Intentional Futures, this research explores the state of open source in the microgrids market. This qualitative report uncovers the significance of microgrids to renewable energy access and how open source is a vital element to microgrid proliferation. It describes current opportunities and gaps and how greater open source collaboration could potentially address market barriers by encouraging innovation, modularity, interoperability, and access.

### Web3 and Sustainability: How We Can Reduce the Climate Impact of Blockchain, How Blockchain Can Help Reduce Our Own

In the summer of 2022, Intel and LF Research hosted a roundtable of stakeholders from across the Web3 ecosystem to discuss how various communities define and practice sustainability. This report, sponsored by Intel, captures the discussions across different dimensions, such as more computationally efficient blockchains, the use of green energy, and implementing technical and accounting standards, and identifies three areas of action: governance of ecosystems, cultivation of knowledge, and greater advocacy for infrastructure innovation.

## World of Open Source series

Following the success of the 2022 Europe Spotlight survey and report, we launched a worldwide project this year to expand our view of open source participation in different regions. The research investigates open source trends, including the size and scope of open source programs across organizations and industries; the opportunities and challenges in

private and public sector engagement in open source; the value proposition of open source; and the use and adoption of open source technologies and best practices.

### Europe Spotlight 2023

The Europe Spotlight represents a segmentation of the worldwide report to take a closer look at the trends, challenges, and opportunities that this specific region faces.

### Japan Spotlight 2023

The Japan Spotlight similarly focuses on findings specific to the country and how they may differ from other regions.


### Global Spotlight 2023

The worldwide report compares findings from the entire survey to develop a snapshot of variations in trends across geographic regions.

### Enabling Global Collaboration: How Open Source Leaders Are Confronting the Challenges of Fragmentation

Today's open source community comprises millions of projects and contributors. While open source allows many different approaches to solving problems, it also can lead to fragmented communities that duplicate efforts, create extra costs, and add complexity. This report takes an in-depth look at these benefits and costs from the perspective of open source leaders around the world, both from a theoretical and practical standpoint.

### The European Public Sector Open Source Opportunity: Challenges and Recommendations for Europe's Open Source Future

While the EU increasingly recognizes the value of open source, the public sector is still behind in embracing open source software, with little contribution to the ecosystem and policymaking that inhibits its potential. This report examines the present-day trends, challenges, and opportunities for open source software adoption in this sector, emphasizing the need for a cultural shift for open source to reach its full potential in Europe. Synthesizing case studies and interviews with subject matter experts, the report identifies resources to encourage public sector engagement.

### Open Source Congress

Following the January 2023 publication Enabling Global Collaboration: How Open Source Leaders Are Confronting the Challenges of Fragmentation, the Linux Foundation hosted a Chatham House roundtable discussion with many leaders from the open source community to explore how to enhance ecosystem-wide collaboration on important topics. Sponsored by Futurewei, this report captures the meeting's takeaways for improving collaboration on common issues such as regulation, cybersecurity, sustainability, diversity, equity, and inclusion.

## Research from Linux Foundation projects

Our research, in partnership with Linux Foundation projects, captures priority areas for project communities, including emerging technologies, new products, developing trends, challenges, and future planning.

### 2023 Energy Transformation Readiness Study

This survey-based research explores the state of adoption of open source technology stacks vital to achieving climate targets. It finds that

energy stakeholders are on the path of digital transformation and are keen to adopt open source technology. Although intentions and first steps are visible in the sector, we are yet to see industry-wide full adoption and magnified contribution to open source. The training and upskilling of the energy sector workforce will play a crucial role in this effort.

### 2023 Hyperledger Foundation Brand Study

In 2021, LF Research and Hyperledger Foundation partnered to study the perceptions, awareness, and adoption of enterprise-grade blockchain technology and Hyperledger Foundation's specific projects. Based on a survey and interviews, this year's report captures public perceptions of the technology and the Hyperledger brand, the ways that they differ from the 2021 report, and what might be causing these perceptions today. This research provides evidence for the Hyperledger Foundation to make strategic decisions around its brand, direction, and community.

### 2023 State of Open Source in Financial Services

The annual FINOS research report, now in its third year, provides empirical and qualitative data to understand industry-wide trends in open source adoption, ranging from banking to asset management to hedge funds. In comparison to the 2021 and 2022 reports, this analysis illustrates directional shifts in the use and contribution of open source software and acts as a resource for industry leaders to create or refine their open source strategy.

### Why the World Needs an Open Source Digital Wallet Right Now

Coinciding with the launch of OpenWallet Foundation, this report identifies key challenges with current digital wallets, including vendor lock-in, security vulnerabilities, data privacy concerns, lack of transparency, and limited functionality. It argues that open source digital wallets can provide solutions by offering flexibility, security through code transparency, user-centric business models, and the ability to perform multiple functions in a single wallet. It makes the case that open source wallets have the potential to revolutionize financial and personal data management, addressing the shortcomings of existing solutions.


In 2023, LFX has emerged as a cornerstone of the Linux Foundation's commitment to fostering open source communities. Our focus has been creating a seamless, efficient, and insightful experience for members and maintainers.

## LFX: Key performance indicators

### User growth

- Achieved a **20% growth** in user base, reaching **1.3 million** active users.
- Averaged **14,000 LFID signups** per month.
- Increased the number of monthly active users to **62,000 in 2023**, up from **44,000 in 2022**.

### Meeting management

- In 2023, 19 projects hosted board meetings using the new meeting management tool.
- Weekly hosted meetings rose from **40 in 2022** to **120 in 2023**.
- Weekly meeting participant count surged from **200 in 2022** to **1,400 in 2023**.

## Key milestones

### Operational excellence

- Prioritized member and community satisfaction: We've prevented maintainer burnout and provided projects with valuable insights, ensuring a thriving community.
- Streamlined internal operations: Automation has been our ally in managing tasks like member management, committees, surveys, and meeting attendance, making our operations more efficient.
- Aligned employee productivity and efficiency: Our internal focus has been on aligning employee efforts with higher-order organizational values.
- Standardized development activities: We've established a "day in the life" view across projects to bring uniformity to development activities.
- Enhanced research capabilities: Our engagement-based research now offers deeper insights into technology trends and developer satisfaction.
- Focused on data management: We've replaced data silos with a queryable data lake, reducing data duplication and increasing data accuracy.

## Product development

- Automation and integration: Automated meeting attendees, recordings, and transcripts. Integrated committees, mailing lists, and meetings to reduce manual data entries.
- Survey support: Introduced features to measure and enhance stakeholder satisfaction.
- Executive dashboards: Launched Foundation-based executive dashboards for comprehensive health metric insights.

## Dashboards

- Org dashboard: Released an improved version featuring new leaderboards, project contributions, and employee management tools.
- Individual dashboard: Introduced a simplified dashboard for contributors, including email preference settings.

## Community management

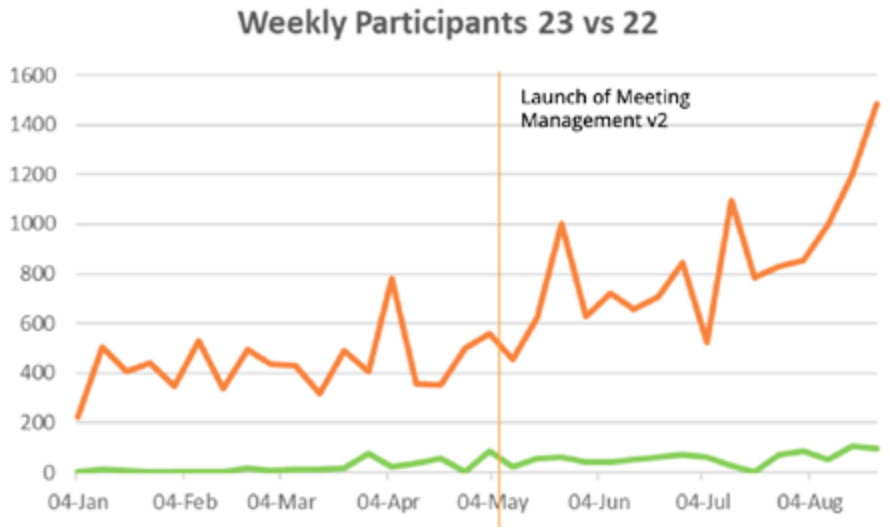
- Released the first version of Community Management to help projects build healthy and engaged communities.
- Stakeholder Engagement Metrics: Measured activity across various platforms and engagements.

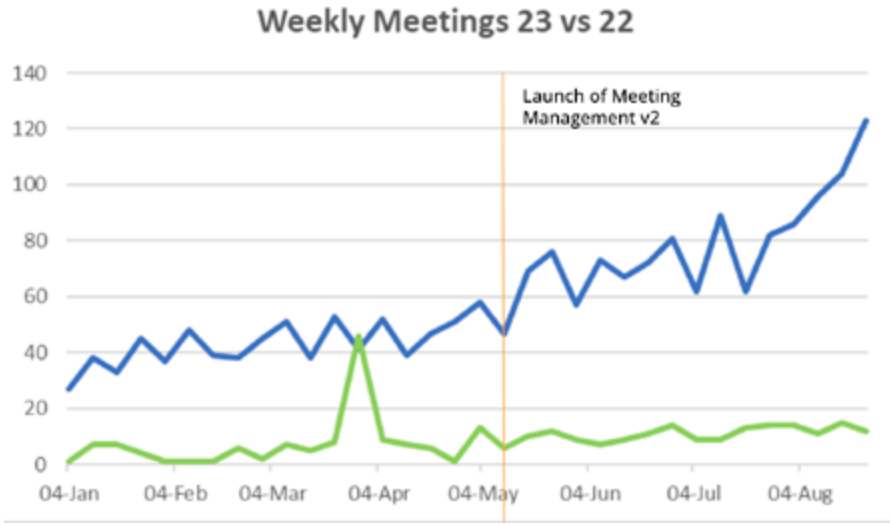
## Insights 3.0

- Introduced a comprehensive view of project ecosystems, including contribution trends, analytics, productivity, velocity, and best practices.

## CRM

- Redesigned CRM System: Improved sales engagement through better tools and data insights.



# Innovation in open standards

Our commitment to open standards remains a cornerstone of our strategy. While we're renowned for our open source software projects, we recognize that open standards are vital for maximizing the impact of these implementations. LF initiatives encompass various projects engaged in standards and specification development. This multifaceted approach extends the reach of open source and fosters interoperability and innovation across industries.

# Standards and specification development at the LF

Nearly 20% of Linux Foundation (LF) projects are standards and specifications. Some, such as FINOS's CDM, Common Cloud Controls, and FDC3, or OpenSSF's SLSA Framework, S2C2F, and OpenVEX, leverage the Community Specification License (CSL), which is an innovative approach that incorporates open source tooling and software development approaches with the governance, policy, and due process necessary to develop a standard. The CSL has grown in popularity as open source developers increase their engagement in standards development, looking for methods that enable an understanding of how they can leverage standards to bolster their projects.

ANNIE SPRATT; UNSPLASH

# Ultra Ethernet Consortium

The LF officially launched the **Ultra Ethernet Consortium (UEC)** on July 19, 2023, which aims to revolutionize Ethernet-based communication stack architecture, catering to the burgeoning demands of artificial intelligence (AI) and high-performance computing (HPC) at scale. The initiative is a collaborative effort involving industry giants such as AMD, Arista, Broadcom, Cisco, Eviden (an Atos Business), HPE, Intel, Meta, and Microsoft.

The UEC is not about reinventing the wheel but fine-tuning Ethernet to meet specific performance needs. Dr. J Metz, chair of the UEC, emphasized that the consortium would scrutinize every layer—from the physical to the software—to enhance efficiency and performance at scale. The focus is on creating an open, interoperable, and high-performance full-communications stack that is scalable and cost-effective.

The technical roadmap for the UEC is ambitious. It aims to develop specifications, APIs, and source code to define protocols, signaling characteristics, and data structures for Ethernet communications. The consortium will also work on link-level and end-to-end network transport protocols, telemetry, and signaling mechanisms suitable for AI, machine learning, and HPC environments. Four working groups will spearhead these efforts—physical, link, transport, and software layer.

Industry analysts have lauded this initiative and see it as a significant step toward addressing HPC and AI users' performance and interoperability challenges.

By leveraging Ethernet's ubiquity and flexibility, the UEC aims to set new s tandards that will meet the complex demands of modern data center workloads. The consortium will become a cornerstone in developing next-generation AI and HPC networks, offering a scalable and cost-effective solution for the industry.

URIEL SC: UNSPLASH

# Sustainable & Scalable Infrastructure Alliance (SSIA—formerly Open19)

In 2023, the **Sustainable & Scalable Infrastructure Alliance (SSIA)**, formerly known as Open19, made remarkable strides in its mission to accelerate the adoption of sustainable and scalable data center and edge infrastructure technologies. Highlights included pivotal milestones, new leadership, and groundbreaking initiatives that have set the stage for the industry's future.

## Milestones

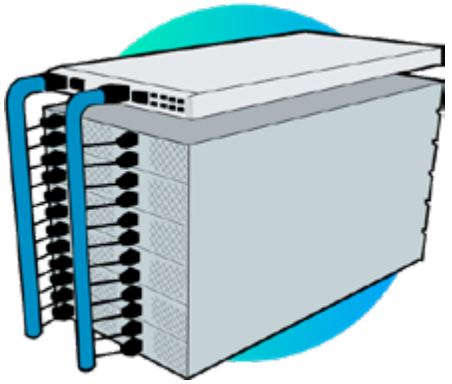
- Rebrand to SSIA: Open19 transitioned to SSIA in September 2023, signaling an expanded focus on sustainability across data center and edge infrastructure.
- New Leadership: My Truong, field CTO at Equinix, took charge as chair of the SSIA board of directors, bringing a wealth of experience and a commitment to sustainability.
- Growing Membership: SSIA's membership expanded rapidly, welcoming stakeholders from cloud providers to equipment manufacturers.
- Technical Progress: Key releases included the Open19 V2 specification, data center sustainability best practices, and edge infrastructure guidelines, each contributing to more sustainable and scalable solutions.

## Initiatives

- SSIA Workgroups: Newly launched specialized workgroups focused on the Open19 V3 specifications, data center circular economy, and edge infrastructure sustainability.

## Additional Activities

- Educational Events: SSIA hosted a series of webinars, workshops, and conferences to foster industry knowledge.
- Community Building: Regular member meetings and collaborative platforms took place to facilitate idea sharing.
- Advocacy: SSIA actively engaged with policymakers to promote its standards and technologies.

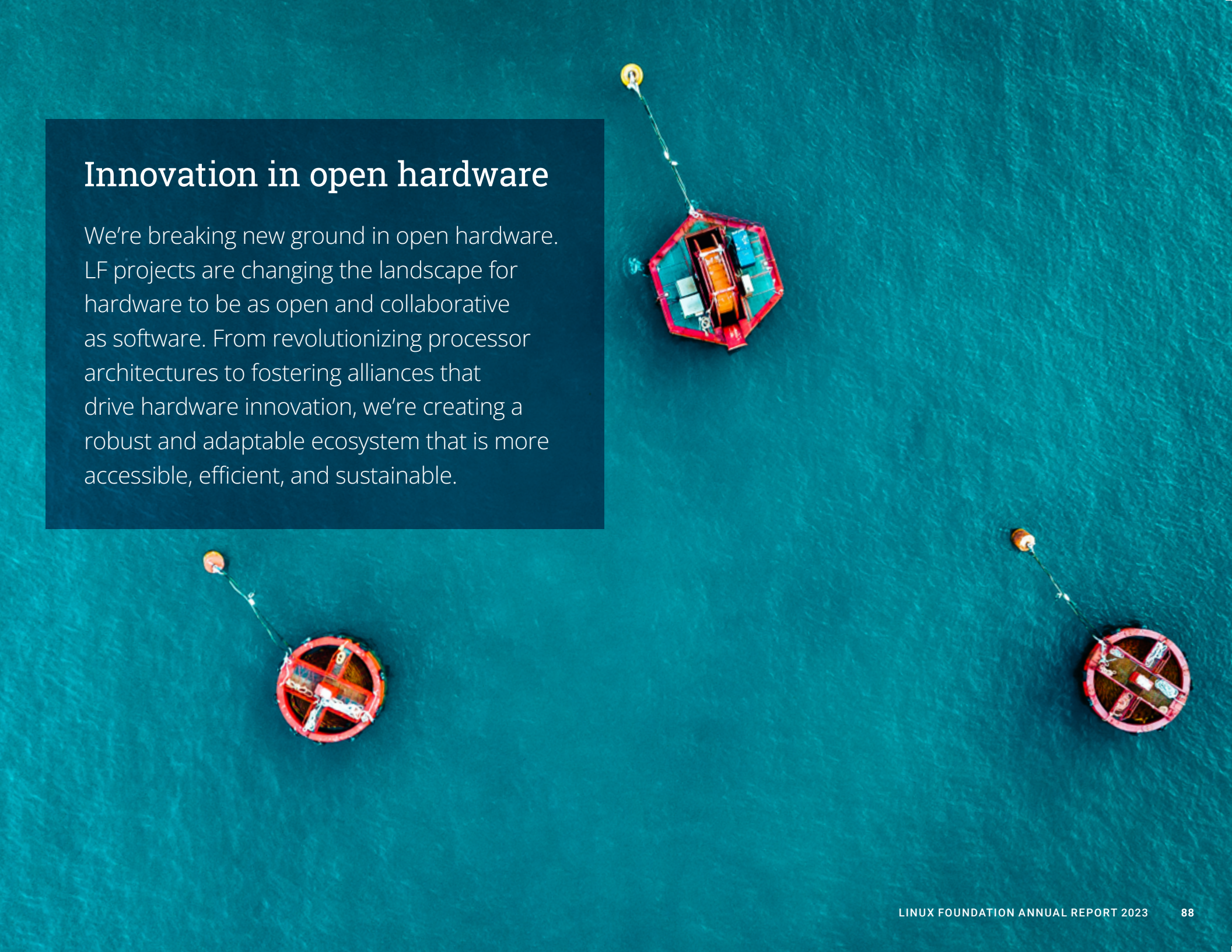


## Conclusion

SSIA's achievements in 2023 have positioned it as a leader in driving the industry toward a more sustainable and scalable future. Its work is pivotal for technological advancement and integral to achieving the industry's net-zero carbon goals. With its growing community and forward-looking initiatives, SSIA can continue its impactful work in the coming years.

# Innovation in open hardware

We're breaking new ground in open hardware. LF projects are changing the landscape for hardware to be as open and collaborative as software. From revolutionizing processor architectures to fostering alliances that drive hardware innovation, we're creating a robust and adaptable ecosystem that is more accessible, efficient, and sustainable.



Over 10 billion cores shipped. Four thousand members in the RISC-V community. Billions of collective RISC-V investments. RISC-V is not in the future; it's now.

With Semico Research forecasting that 62.4 billion RISC-V chips will ship by 2024, there are no signs of slowing down.

There have been efforts around RISC-V to accelerate the ecosystem, including the RISE Project (Software) and collaborations initiated in Germany and China.

In 2023, several new products came to market, including:

- Meta's RISC-V AI inference accelerator: There are two core processors in each PE (one of them equipped with the vector extension).
- Ubuntu on StarFive's VisionFive 2 RISC-V single-board computer, which Canonical enabled.


The Roma laptop

- The world's first RISC-V laptop Roma: The laptop has 8GB RAM and comes pre-installed with domestic OS.
- Milk-V Vega, the world's first RISC-V open source 10 gigabit Ethernet switch.

Through the creation of Market Development Groups, 2024 will see a focused push into new verticals and targeted attempts around existing efforts. The first is a new Automotive Market Development Committee, established to advance the awareness and adoption of the RISC-V ISA and member technologies in the automotive supply chain.

Additional technical, marketing, and community highlights follow below.

## 2023 RISC-V technical progress

- Specifications ratified year-to-date: seven ISA (four Fast Track), two Non-ISA, three Profiles
- Specifications in public review (3Q): Counter Mode Filtering (August 2), Hardware Update of PTE A/D Bits (August 29)
- Specifications preparing for ratification: Vector Crypto, Additional Scalar FP, Conditional Ops
- The progression of several security initiatives this year, including the AP-TEE interface proposal, SPMP extension, shadow stacks, and landing pads extension


**RISC-V Summit Europe, Barcelona**

- RISC-V Platform standardization, which is moving to ratify Boot Runtime Services to provide software requirements for OS vendors and promote OS-level interoperability
- Recent call for candidates (3Q): Server SOC specification TG, post-quantum computing TG, TSC chair & vice-chair, 3x TSC elected members
- Recently approved TGs (3Q): RAS Error-record Register Interface (RERI), Application Processor Trusted Execution Environment I/O (AP-TEE-IO)
- Developer boards: 130 boards purchased and 112 shipped
- Launch of RISC-V technical session webinars program, with 1,400 attendees so far
- Launch of a technical newsletter in 3Q 2023

## 2023 RISC-V marketing progress

- Marketing progress
  - Utilized RISC-V Exchange to continue to add new solutions, hardware, software, etc., with a growth of 26% since the beginning of 2023
  - Launched RISC-V Ecosystem Landscape, continuing to grow company inputs from the community and leveraging across all marketing and external stakeholders
  - Increased earned media average hits by 33% through member engagement in original content, strategic amplification of member news, and proactive media engagement
  - Launched a Market Development program starting with automotive and targeting data centers and communications for the next industries
  - Future focus: Streamline and update the website for stronger engagement, incorporating the developer experience and technical navigation

- Events
  - Embedded World: March 14 to 16 (Germany) eight member kiosks in RISC-V booth, daily theater presentations, multiple conference sessions
  - RISC-V Summit Europe: June 5 to 9 (Barcelona)
    - 500+ attendees, 42 sessions
    - Keynote by Google's Lars Bergstrom
  - RISC-V Days Tokyo: June 20 (Tokyo) 400+ registrations, 20 sponsors
  - Design Automation Conference: July 10 to 12 (San Francisco) RISC-V Zone (six booths plus theater), 12 theater presentations, 19 RISC-V conference sessions
  - RISC-V Summit China: August 23 to 25 (Beijing)
    - 100+ sessions, 16 co-located events, 34 sponsors, 64 posters. 2,000+ registrations (sold out onsite), 800+ participating companies, 50+ investment institutions, 70+ universities / research institutes, 100 media, and 15 media channels provided live broadcasts
  - RISC-V Summit North America: November 7 to 8 (Santa Clara, CA)

## 2023 RISC-V community engagement

- Learning
  - RISC-V Foundational Associate (RVFA) certification, which is available in English and Chinese, and the launch of the RISC-V Fundamentals Course, with a Chinese translation in progress, were part of a joint promotion together with LF APAC at signature events.
  - The RISC-V Mentorship program hosted 14 mentorships so far in 2023, attracting hundreds of applicants.


**RISC-V CEO Calista Redmond at RISC-V Summit Europe in Barcelona**

  - Capture the Bug Hackathon received 500+ registrations in the first week.
  - Academic and Training SIG created resources to support universities to transition to RISC-V.
  - The Virtual Career Fair for Graduating Students was a successful event, with 127 registered and 44 participants.

- Advocacy + Alliances
  - Sponsored four travel scholarships to RISC-V Summit Europe.
  - Launched the RISC-V Advocate pilot program, and selected 10 individuals to participate
  - Highlighted that 17 Ambassadors continue to grow and engage locally in countries around the world
  - Hosted 37 community events and consolidated RISC-V community groups to ensure a broader reach and cost savings

# OpenPOWER™

In 2023, The OpenPOWER Foundation continued to execute its long-term strategy of accelerating the development of the most open, mature, and high-performance CPU architectures.

The OpenPOWER Foundation increased its membership through new initiatives, such as kickstarting the development of a lower-cost, fully open POWER server system platform. As hyper scalers and enterprises seek more sustainable data center solutions, the new OCP open hardware modular server specification provides ultimate flexibility in next-generation server platforms. OPF has a multi-member initiative to design the first completely open POWER-based solution, including the main chassis, hardware design, firmware, BMC, and software, providing end users with better TCO and reducing e-waste.

OPF's member company, Red Semiconductor, a startup focused on developing a new POWER CPU, was the first to propose next-generation vector instruction modifications to the POWER ISA. Their solution targets math-intensive workloads, with ultimate energy efficiency, providing a path for POWER processor use in edge computing and resource-constrained real-time systems.

21Unity, another member, is building new POWER-based servers and developing a complete open source cloud-hosted office suite for the POWER platform.

The foundation's LibreBMC SIG working group continued its development of the fully open baseboard management controller (BMC). The LibreBMC project delivers a fully open stack of hardware based on POWER running openBMC software installed on OCP's open source DC-SCM module card. Our member company, Axiado, leveraged the LibreBMC project in developing its root-of-trust security card for enterprise server platforms.

OpenPOWER also continued its expansion of its community-supported HUB providers globally, which offer free remote access to POWER-based servers to enable developers working on porting software to the POWER platform. The HUB now provides POWER10-based systems, allowing new AI workloads to take advantage of the P10 matrix math multiplier (MMA) instructions and capabilities.

IAN BATTAGLIA; UNSPLASH

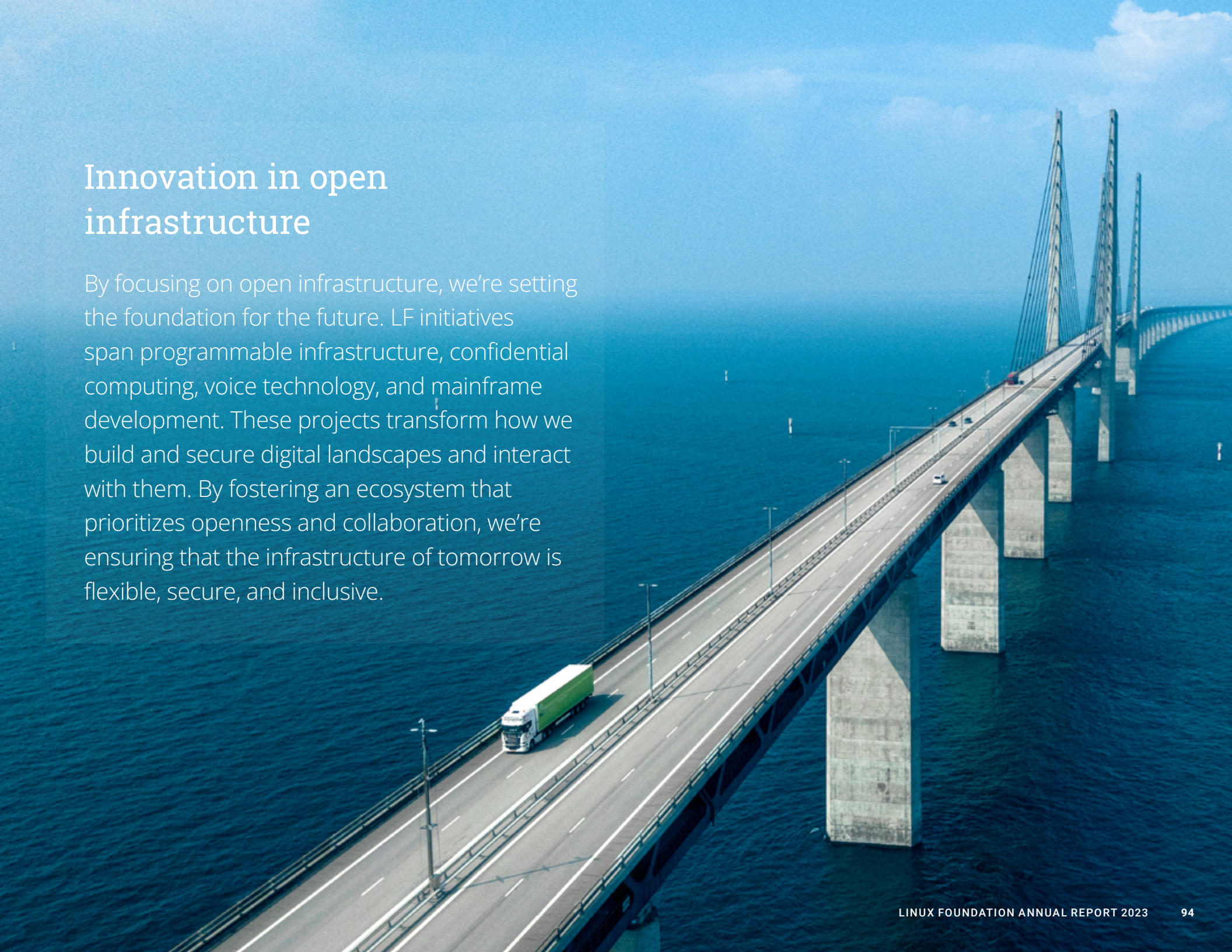
# CHIPS ALLIANCE

The CHIPS Alliance is a global open source hardware community working to accelerate the development of open source hardware and software for next-generation chips and systems. In 2023, the Alliance made significant progress in several areas:

- The Caliptra Root of Trust project joined CHIPS with founding members AMD, Google, Microsoft, and Nvidia to design and implement a configurable hardware macro embedded in all SoCs in a data center server. The goal is to enable secure hardware-based self-authentication to prevent contamination by different forms of security intruders.
- Western Digital and collaborators improved the OmniXtend protocol to extend to memory endpoints to allow coherent exposure of memory over Ethernet communication protocol.
- The development of the Intel System C language/compiler further united architectural specification and chip design, enabling a single source representation for architecture and implementation.
- It was present at three technical conferences and delivered six informative technical talks.
- It provided two virtual/in-person workshops, with 12 detailed technical talks.
- In addition to these technical milestones, the CHIPS Alliance also gained several new members, including:
  - AMD
  - AMI
  - Axiado
  - ETRI
  - Marvell
  - Meta
  - Microsoft
  - Nvidia
  - University of Hawaii

# Innovation in open infrastructure

By focusing on open infrastructure, we're setting the foundation for the future. LF initiatives span programmable infrastructure, confidential computing, voice technology, and mainframe development. These projects transform how we build and secure digital landscapes and interact with them. By fostering an ecosystem that prioritizes openness and collaboration, we're ensuring that the infrastructure of tomorrow is flexible, secure, and inclusive.



OPEN PROGRAMMABLE INFRASTRUCTURE PROJECT

In 2023, the Open Programmable Infrastructure (OPI) Project has continued to build on foundational work from the previous year, making significant progress in fostering a community-driven, standards-based open ecosystem for next-generation architectures based on data processing units (DPUs) and infrastructure processing units (IPUs).

The OPI's key objectives have evolved to include defining a common architecture for DPU/IPU software stacks, fostering an open-source application ecosystem, and collaborating on standards and best practices for DPU/IPU deployment and management. These efforts are designed to lower costs, accelerate market time, and offer users more choices and flexibility, thereby improving performance, efficiency, and security in cloud and datacenter infrastructures.

Industry giants, including Dell Technologies, F5, Intel, NVIDIA, and Red Hat, launched the project in 2021, and this year, they welcomed Arm as a premier member and Fujitsu as a general member. Members collaborate on the technical strategy for the project through various working groups, such as API and Behavioral Model; Provisioning and Platform Management; Developer Platform/ PoC/Reference Architecture; Use Case; and Outreach.

The OPI has been particularly active in outreach and education. The project hosted a half-day tutorial at the SmartNIC Summit in June, showcasing the project's activities and working groups.

This year, the OPI created a lab where project members and community contributors can conduct CI/CD to test example hardware. These efforts build on the project's 2022 goals to simplify network, storage, and security APIs, thereby facilitating more portable and performant applications across both cloud and datacenter environments.

The groundwork that the OPI laid in 2022 and its progress in 2023 set the stage for it to play a major role in developing and adopting DPU/IPU technology, promising a future of increased innovation and competition in the market.

CONFIDENTIAL COMPUTING CONSORTIUM

The Confidential Computing Consortium (CCC), a specialized community under the Linux Foundation, has made significant strides in advancing security within computing throughout the year. Comprising hardware vendors, cloud providers, and software developers, the CCC focuses on accelerating the adoption of trusted execution environment (TEE) technologies and standards, allowing organizations to protect the data that performing computations use in hardware-based attested TEE, filling a critical gap in data security.

The importance of attestation in confidential computing is a key focus, along with engaging with all the stakeholders involved in governance, risk management, and compliance, leading to the creation of special interest groups under the umbrella of the Technical Advisory Council (TAC). The CCC has continued to work with external organizations, focusing on standards bodies and regulators, mirroring the work within the TAC.

The CCC continues to welcome new open source projects and members as the growing industry expectations for better security and increased availability of enabled hardware raise the visibility of data-in-use protection. The CCC has expanded its Outreach work and has been instrumental in hosting significant industry events, such as the Confidential Computing Summit, which saw broad representation from various sectors. Another highlight was a mini summit that the CCC held at the Open Source Summit Europe, emphasizing the community's commitment to fostering community engagement and technological advancement.

The CCC's work is well timed, as computing environments are becoming increasingly diverse, from on-premises setups to public clouds and edge computing. As organizations handle more sensitive data, the need for greater assurances and transparency in data protection controls has grown. To support its growth, the CCC appointed an executive director: Mike Bursell, a security industry expert and long-term contributor to the CCC, who joined in April. The CCC's initiatives have been pivotal in meeting these industry needs, solidifying its role as a leader in the field of confidential computing.

FABIO: UNSPLASH


In 2023, the Open Voice Network (OVN) solidified its position as a vanguard in the conversational AI landscape, making remarkable strides in interoperability, ethical principles, and public education. As a collaborative community of experts, organizations, and enthusiasts, the OVN has been instrumental in shaping the future of open-source conversational AI technologies.

## Interoperability: Bridging platforms

One of the most significant milestones was the release of the "Message Envelope," the first element in the definition and development of an open, universal API for interoperability between conversational AI assistants of different platforms. Users can now effortlessly switch between platforms without the need to turn one off and another on, retrain models, or lose data, marking a monumental step toward universal accessibility and functionality in conversational AI.

## Ethical principles: Setting the standard

The OVN also took the lead in ethical considerations for conversational AI with the launch of the TrustMark Initiative. This translated time-honored ethical AI principles into action, touched on critical issues, including privacy, security, fairness, transparency, and accountability, and offered definitions, educational courses, and an organizational maturity model to developers and users of conversational AI. By setting these ethical standards, the OVN has provided a roadmap for the responsible development and usage of conversational AI technologies.

## Education: Empowering the public

In a bid to educate the public, the OVN launched an Ethical Principles for Conversational AI Training Course on the edX platform. This course offers an in-depth look into the ethical dimensions of conversational AI, equipping learners with the knowledge to engage responsibly with these technologies.

## Community engagement: Webinars and workshops

Throughout the year, the OVN hosted a series of webinars and workshops that focused on conversational AI ethics and interoperability. These events served as platforms for knowledge sharing, discussion, and community building, further cementing the OVN's role as a thought leader in the field.

## Collaboration: Estonia partnership

In a strategic partnership, the OVN entered a joint effort with the Estonia Information Systems Authority to create a system of interoperable voice assistants using the Estonia ISA Bürokratt system and OVN standards.

## Looking ahead to 2024

As we move into 2024, the OVN is poised to continue its pioneering work. The focus will remain on enhancing interoperability standards, developing ethical principles, and expanding educational resources. With these targeted efforts, the OVN aims to make conversational AI technologically advanced, ethically sound, and universally accessible.


The world's largest organizations continue to rely on the mainframe, and as they accelerate digital transformation, advancing their mainframe ecosystem is more critical than ever. The Open Mainframe Project enables organizations to modernize mainframe culture, processes, and tools to empower the next generation of mainframe professionals.

With over 15 current projects and working groups under the Open Mainframe Project umbrella, the project continues to evolve its mission to become the primary foundation for community engagement and scale it across the ecosystem of vendors and academic partners. This year, Open Mainframe Project welcomed a new project, Galasa, which allows developers to test applications at scale, regardless of the platform. It is an open source deep integration test framework that enables agile, reliable, and scalable testing across various technologies and platforms. By supporting consistent testing without code changes, enabling multi-technology integration, and providing efficient test data management, Galasa enhances developer operations strategies.

The Open Mainframe Project's work as an open innovation pipeline enables organizations to gain the maximum value from their mainframe. Several projects and programs hit major milestones, including:

- The five-year anniversary of Zowe continues to make its mark for mission-critical applications and data processing. Zowe, the first-ever open source project based on z/OS, ensures product stability, security, and interoperability with the support of a large open source community. The Zowe framework uses the latest web technologies among products and solutions from multiple vendors and enables developers to use familiar, industry-standard, open source tools to access mainframe resources and services. Further, the project was named the "Best DevOps for Mainframe Solution" in the DevOps Dozen Awards for the second year running. This win reflects the many achievements from this past year, such as an increase in components, extensions, community members, and adoption. As a result, the Open Mainframe Project showcased several use cases for financial institutions, including Bankdata, M&T Bank, and IBA Group.
- Mainframe Open Education (MOE) moves from the Incubation stage to the Active Project stage, which means it is fully mature and operating as an open, transparent, and sustainable project. This year, with many participants using its materials, MOE created digital badges to help identify active contributors.
- Linux introduced new developer resources on s390x. Since support for Linux on IBM Z has been around for more than 20 years, dozens of languages, frameworks, and hundreds of major open source applications have been ported. Users can find a sample by searching the Open Mainframe Project Software Discovery Tool, which offers dozens of monthly updates—and the sea of applications continues to grow. Check out the new resource here.

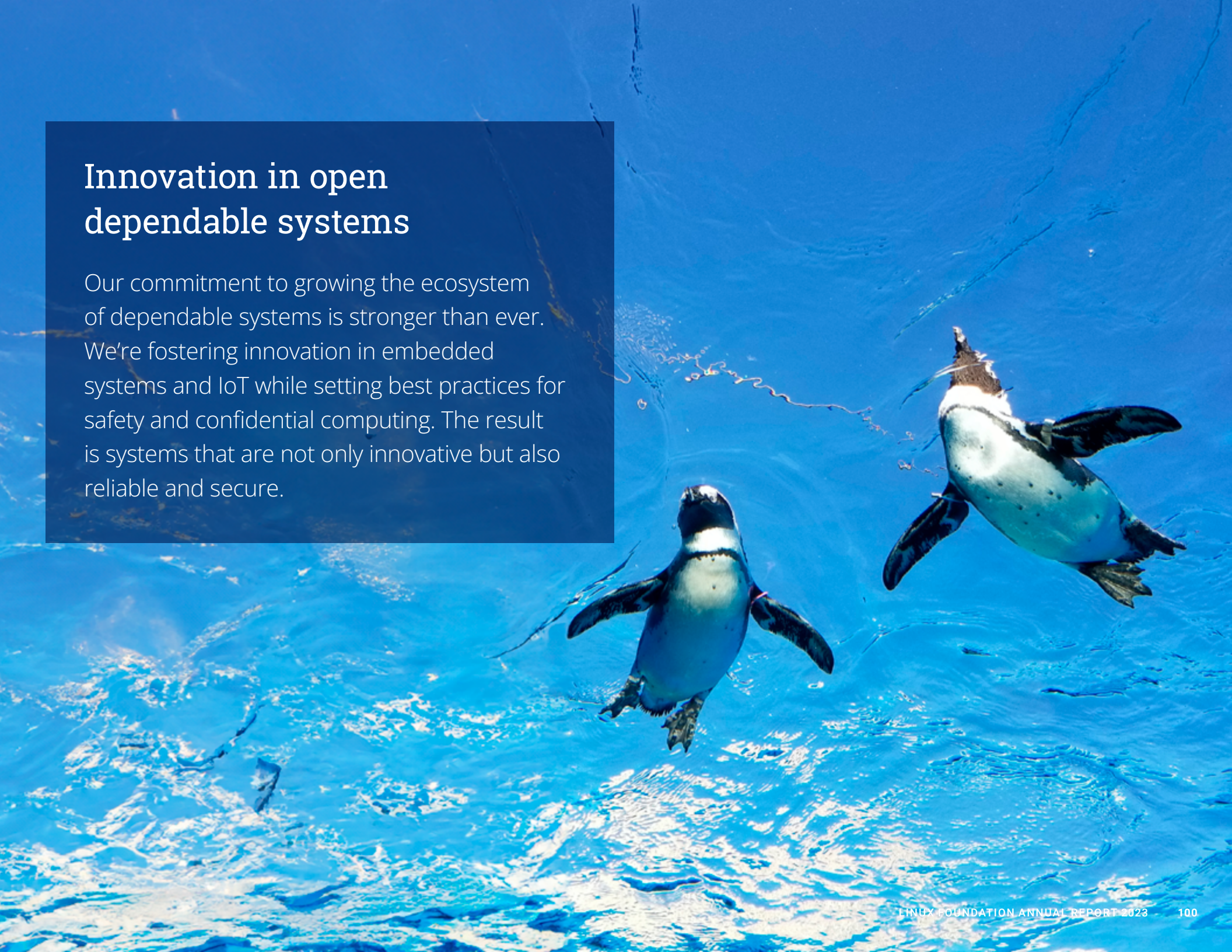
- Zowe has provided more training through a collaboration between the Open Mainframe Project and Interskill, which includes an updated "Basics for Zowe" course and a new "Fundamentals for Zowe" course. Developers who go through these courses will receive Open Mainframe Project digital badges.

This year, Open Mainframe Summit, the premier mainframe event, was co-located with two industry conferences: IBM TechXchange Conference 2023 Community Day in Las Vegas on September 11 and Open Source in Finance Forum in New York City on November 1. Open Mainframe Summit aims to connect and inform those who are interested in growing the use of mainframes and related technology in dynamic technical and educational sessions. It is open to students, developers, corporate leaders, users, and contributors of projects from around the globe who are looking to learn, network, and collaborate. It will feature content tracks that tackle both business and technical strategies for enterprise development and deployment.

The Open Mainframe Project continues to advocate for diversity in the project and technology landscape. Through the "Making Our Strong Community Stronger (MSCS)" collaborative initiative, Open Mainframe has hosted several webinars, presentations, and blogs focused on diversity, equity, and inclusion. This year, MSCS hosted webinars about how to foster inclusive work environments for the LGBTQIA+ community and how to create a multi-generational workforce.


**Open Mainframe Summit 2023**

The Open Mainframe Project also featured project and community leaders in a series of personal blog posts in honor of Black History Month, Asian American & Pacific Islander Month, Women's History Month, International Day of Women and Girls in Science, and Hispanic Heritage Month.



# Innovation in open dependable systems

Our commitment to growing the ecosystem of dependable systems is stronger than ever. We're fostering innovation in embedded systems and IoT while setting best practices for safety and confidential computing. The result is systems that are not only innovative but also reliable and secure.

# Zephyr®

The Zephyr Project, a proven RTOS ecosystem that developers have created for developers, has seen an increasingly widespread adoption of products over the last few years. Zephyr builds a secure, connected, and flexible RTOS for future-proof and resource-constrained devices, and companies have started using it in their products. Products such as Google Chromebooks, ProGlove scanners, Oticon hearing aids, T-Mobile's DevKit, Vestas wind turbines, and Open Collar animal trackers run on Zephyr because it is easy to deploy, secure, connect, and manage and has efficient power consumption.

The breadth of implementations makes Zephyr integral to digital innovation and infrastructure across industries where the Linux kernel is too big to fit.

With so many products running on Zephyr, it is one of the leading projects at the Linux Foundation that meets the U.N.'s Sustainability Development Goals. Zephyr meets SDG 3: Good Health and Well Being, SDG 5: Gender Equality, SDG 9: Industry, Innovation & Infrastructure, SDG 11: Sustainability Cities & Communities, SDG 12: Responsible Production & Consumption, SDG 13: Climate Action, SDG 15: Life on Land, and SDG 16: Peace, Justice and Security.

For example, Zephyr supports systems such as electrical grid monitoring with on-device machine learning. The RTOS supports the transition to renewable energy and helps improve the efficiency and dependability of electricity grids. More efficient grids create lower carbon emissions, which meets SDG 13.

Widespread adoption and awareness have helped the Zephyr Project grow the ecosystem this year, as it welcomed two Platinum members, Analog Devices Inc. and Zeiss, as well as Arduino, Blues Wireless, IRNAS, Sternum and Technology Innovation Institute, and Hunan University as Silver members.

The project achieved several milestones recently, surpassing 80,000 commits since it was released in open source in 2015. This is an average of almost two commits per hour made by 490 individuals, including 166 first-timers, who contributed to the 3.4 release. The community has helped Zephyr RTOS support more than 500 boards running embedded microcontrollers, from Arm and RISC-V to Tensilica, NIOS, ARC, and x86 as single and multicore systems.

ProGlove scanners

Oticon hearing aids

Vestas wind turbines

Open Collar animal trackers

# PREEMPT_RT: Advancing Real-Time Capabilities in Linux

The **PREEMPT_RT** project remains a pivotal initiative under the Linux Foundation, focused on enhancing the Linux kernel with real-time capabilities. The project continues to integrate these capabilities into the mainline Linux kernel, offering a system performance that is both robust and deterministic.

## Maintenance versions

The project has diligently maintained older Linux kernel versions with real-time capabilities. Each version was successfully merged into the mainline Linux kernel, ensuring they benefit from the broader Linux community's quality assurance processes. Here are the actively maintained versions:

- Linux 5.15-rt: Merged into v5.15.133 in October 2021; this version is maintained by Joseph Salisbury and has an EOL set for October 2026.
- Linux 5.10-rt: Merged into v5.10.194 in December 2020; this version is maintained by Luis Claudio R. Goncalves and has an EOL set for December 2026.


- Linux 5.4-rt: This version is currently being synced with the latest stable releases. Maintained by Tom Zanussi, it has an EOL set for December 2025.
- Linux 4.19-rt: Merged into v4.19.232 in October 2018; this version is maintained by Daniel Wagner and has an EOL set for December 2024.
- Linux 4.14-rt: Merged into v4.14.325 in November 2017; this version is maintained by Luis Claudio R. Goncalves and has an EOL set for January 2024.

By maintaining these older versions, the PREEMPT_RT project ensures that systems relying on them continue to receive updates and support, even as new versions are developed.

## 2023 milestones

This year has been particularly significant for the PREEMPT_RT project, marked by several key milestones:

- Latest Development Version: As of October 2023, Linux 6.6-rt is the active development version maintained by Sebastian A. Siewior. This version represents the project's commitment to continual innovation.
- Latest Stable Release: Linux 6.1-rt, maintained by Clark Williams, is the most recent stable version with an EOL set for December 2026.
- In 2023, the project has made strides in extending hardware support, broadening the range of devices and systems that can leverage Linux's real-time capabilities. This is particularly crucial for the manufacturing, healthcare, and telecommunications sectors.

More up-to-date information about the project can be **found on its Wiki page.**

In 2023, the **seL4** project continued solidifying its position as a cornerstone in high-assurance, high-performance operating system microkernels. The year was marked by significant partnerships, sponsorships, and a broadening of its ecosystem, underscoring seL4's critical role in shaping the future of safety- and security-critical systems.

One of the most noteworthy developments was the seL4 Summit 2023, a pivotal event that brought together industry leaders, researchers, and enthusiasts. Several organizations generously sponsored the summit, highlighting the growing industry support for seL4. NIO, a global electric vehicle company and a premium member of the seL4 Foundation, sponsored both the reception and dinner, emphasizing its heavy investment in building a software platform for modern vehicles based on seL4. The Technology Innovation Institute (TII) also joined as a Gold sponsor, aligning its research focus on end-to-end security and resilience in cyber-physical systems with seL4's foundational technology.

The summit itself was a melting pot of innovation and discussion. Panels featuring industry leaders from Gapfruit, Kry10, Magnetite (MIT), and UNSW presented their views on the priorities and vision for their operating systems on seL4. Keynotes from experts at NCSC and Google further enriched the discourse, covering topics from assurance activities with seL4 to ambient machine learning applications.

Beyond the summit, seL4 made strides in other areas as well. Kry10, an Endorsed Service Provider of the seL4 Foundation, offered a full-featured operating system on top of the seL4 kernel, aiming to make seL4-based projects more affordable and manageable. Collins Aerospace, a long-time participant in the seL4 ecosystem, became a Silver sponsor of the summit, reinforcing its commitment to seL4-based cyber-resiliency in autonomous military vehicles.

**seL4 Summit 2023**

New memberships also invigorated the seL4 Foundation. The Autoware Foundation joined, aiming to work on a safe and secure Autonomous Driving software stack based on seL4. Galois became a part of the seL4 Foundation following its acquisition of Adventium Labs, promising to advance the state of the art in software and hardware trustworthiness.

2023 was a landmark year for the seL4 project. Heightened industry involvement, a successful summit, and ecosystem expansion all point to a vibrant future for seL4. As it continues to set the standard for operating system microkernels, its impact on various domains, including automotive, aviation, and defense, is set to grow exponentially.

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

As Linux continues to be a key component in safety-related applications, Enabling Linux in Safety Applications (ELISA) is an open source project that aims to create a shared set of tools and processes to help companies build and certify Linux-based safety-critical applications and systems. Launched in February 2019, ELISA works with Linux kernel and safety communities to agree on what users should consider when using Linux in safety-critical systems.

This year, ELISA increased the technical resources created for the Linux community, including a Seminar Series of no-cost, on-demand videos that provide overviews of a special focus and project workshops for community members who are interested in advancing the milestones and goals of the project.

The ELISA Seminar series hosted sessions that many organizations hosted, including Red Hat about an open source tool, tentatively named Basil, for tracing requirements, code, and tests; AMD about Xen safety certification; the Linux Foundation with AlektoMetis about automating adherence to safety profiles after fixing vulnerabilities; and the Boeing Company about DO-178C Level D certified Linux and NASA.

Two in-person workshops in Berlin and Munich brought together industry thought leaders and open source community members to discuss all safety-related issues, challenges, and next steps for the project.

The project has several dedicated Working Groups (WGs) that provide resources for system integrators to apply and use to qualitatively and quantitatively analyze their systems.

- Aerospace WG is busy surveying aerospace's state of the art on using Linux and the associated certification approach and equivalent Design Assurance Level and identifying the challenges to adopting Linux in aerospace and candidate use cases using Linux.
- Architecture WG is adopting the ks-nav tool set to implement and expand the STPA approach within the kernel.
- Linux Features WG analyzed the potential and challenges of real-time safety-critical systems and presented their work at the Embedded Open Source Summit.
- Medical Devices WG set out to discover the Linux kernel subsystems that OpenAPS used, shared key findings, and upstreamed the workload tracing guide.
- Open Source Engineering Process WG documented how to apply a safety analysis process based on STPA suitable for Linux and other OSS use.
- Systems WG shared the work on creating a reproducible example system consisting of Linux, Xen, and Zephyr on real hardware at the Linux Plumbers Conference.
- Tools WG has enabled Continuous Integration.

**ELISA Berlin Workshop**

# CIVIL INFRASTRUCTURE PLATFORM

In 2023, the Civil Infrastructure Platform (CIP) project solidified its role as a cornerstone for critical infrastructure systems. One of the most significant milestones of the year was the launch of the 6.1-cip kernel series, which joined the existing lineup of super-long-term stable kernels. This new series reinforced CIP's steadfast commitment to maintaining each kernel for at least 10 years, ensuring unparalleled reliability.

The CIP kernels are developed and reviewed with the same meticulous attention as regular long-term-stable (LTS) kernels. Our developers actively review and test LTS kernels, contributing to the overall quality and security of the platform. A key highlight is our work on the IEC 62443 security standard, which aims to fortify the resilience of critical infrastructure systems.

Community engagement remained a priority for CIP throughout the year. We attended events such as Embedded OSS in Prague and participated in the Linux Foundation Open Source Summit Japan, which took place on December 5–6. The summit served as an excellent platform to provide an overview of the project and invite more stakeholders to join its mission.

**Embedded OSS, Prague**

As 2023 ended, the CIP project stood as a beacon of stability and innovation, continually inviting collaboration to strengthen this essential initiative.

# yocto PROJECT

The Yocto Project (YP) is an open source collaboration project that helps developers create custom Linux-based systems, regardless of the hardware architecture. The project provides a flexible set of tools and a space where embedded developers worldwide can share technologies, software stacks, configurations, and best practices. Users can utilize these resources to create tailored Linux images for embedded and IoT devices or anywhere a customized Linux OS is needed. In 2023, the Yocto Project experienced a transformative year, further cementing its importance in developing custom Linux-based systems.

From its origins as a solution to the complexities of embedded Linux development, Yocto has broadened its scope to serve diverse applications, including embedded systems, IoT devices, connected edge servers, and virtual environments.


**From Embedded Open Source Summit Europe in Prague**

In 2023, the Yocto Project made significant strides in community expansion and technological innovation. It made a splash at the Embedded Open Source Summit with a sold-out Yocto Project Dev Day, the first since 2019. The project also debuted its own booth at Embedded World in Nuremberg, Germany, showcasing its growing influence in the embedded systems space.

Highlights of the year included adding eight new members and announcing an extended LTS release plan, extending support from two to four years. These developments underscored Yocto's commitment to long-term stability and security, meeting the diverse needs of its user base. The project also ventured into cutting-edge applications such as cloud detection from space through a custom Linux distribution for Klepsydra AI.

Adding to these milestones, the Yocto Project announced a landmark partnership with Sovereign Tech Fund in October, backed by over $800,000 USD in committed funding. This collaboration aims to advance key areas such as build process improvements, security enhancements, and usability upgrades. This funding enables the implementation of a five-year plan that had previously been out of reach, with the goal of attracting a new generation of developers and maintainers to the project.

The achievements of the Yocto Project in 2023 exemplify its dedication to innovation, community engagement, and technical excellence. As it continues to evolve, Yocto remains an indispensable resource for developers crafting robust, customized Linux distributions for a wide range of applications.

In 2023, the Xen Project has made significant strides in open source virtualization, building upon its two-decade legacy as a pioneer in the industry. This year, the project has focused on community engagement, technological advancements, and expansion into new domains.

Starting with community engagement, the Xen Project welcomed a new community manager, Kelly Choi, who introduced herself through a blog post in August. Her arrival signifies the project's commitment to fostering a vibrant and inclusive community. Additionally, the Xen Project transitioned its communication channels to Matrix in September, aiming to improve the synchronization and flow of information among its global contributors.

On the technological front, the Xen Project held its annual Developer and Design Summit on June 24–26 in Prague, Czech Republic. The summit featured many sessions, keynotes, and design discussions, covering topics from functional safety and open source to the future of Xen Project's weather report. The event served as a platform for experts and enthusiasts to share knowledge, collaborate on new ideas, and discuss the project's roadmap.

LEO WIELING: UNSPLASH

Moreover, the project has been working on various key initiatives, including Functional Safety and Open Source, TEE Support on Arm, and the support of Q35 emulation for Xen HVM guests, among others. These initiatives indicate the project's ambition to adapt to the evolving needs of the industry, from cloud computing to embedded systems.

2023 has been full of consolidation and innovation for the Xen Project. With a renewed focus on community engagement and a strong lineup of technological advancements, the project is well-positioned to continue its role as a leader in open source virtualization solutions.

In 2023, the Dronecode project continues to be a cornerstone in the rapidly evolving landscape of drone technology. As a Linux Foundation Collaborative Project, Dronecode has fostered open source software for uncrewed aerial vehicles (UAVs), democratizing access to advanced drone capabilities. The project has been at the forefront of several groundbreaking software initiatives, including PX4, Pixhawk, MAVLink, QGroundControl, and MAVSDK, each serving a unique purpose in the drone ecosystem.

**PX4**, the open source autopilot software, has seen widespread adoption across various types of drones, ranging from small hobbyist drones to large commercial UAVs. The software's modular architecture and real-time capabilities have made it a go-to choice for developers and manufacturers. In 2023, companies such as Watts Innovations joined Dronecode, signaling a growing interest in integrating closely with the PX4 ecosystem.

**QGroundControl**, the ground control station software, has been pivotal in simplifying the planning and execution of drone missions. Compatible with PX4 drones, it offers a

user-friendly interface that allows for real-time monitoring and control, making it easier for operators to focus on mission objectives rather than technical complexities.

**MAVLink**, the lightweight messaging protocol, has become an industry standard for communication between drone components. It has been particularly useful in facilitating seamless interactions between UAVs and web applications. In 2023, Blue Robotics contributed two major MAVLink projects to the community, further enhancing its capabilities.

**MAVSDK**, the software development kit, has empowered developers to create specialized applications that can interact with PX4 drones. This has opened up new avenues for innovation, as it enabled businesses and developers to tailor drone functionalities to meet specific industry needs.

**Pixhawk**, an open hardware standard for flight management units (FMU) that major semiconductor manufacturers, software companies, and drone engineering companies endorse, saw the release of its sixth generation, the FMUv6X & FMUv6C. The Auterion Skynode, Holybro Pixhawk 6X & Pixhawk 6C, CUAV Pixhawk FMUv6X, and ARK Electronics ARKV6X are based on the sixth-generation standard and have expanded the capabilities of safe and reliable flight controllers available on the market.

**PX4 Developer Summit**, the largest gathering of open source drone developers in North America, was staged in New Orleans on October 21 and 22. This event was significant as it took place next to ROSCon '23 for the first time. After years of work integrating ROS with PX4, the two events provided the perfect opportunity for robotics developers of all types—land, air, and sea—to interact and share knowledge in the field.

The Dronecode Project's role in 2023 extends beyond software development; it has become a hub for collaboration and standardization. In addition to Watts Innovations, organizations such as ARK Electronics, DroneBlocks, SIYI Technology, and Sunflower Labs have joined as Silver members, investing in the project to bring next-level experiences to users.

The Dronecode Project in 2023 has sustained and accelerated its mission to make drone technology more accessible and affordable. Through continuous innovation, collaboration, and community engagement, Dronecode is setting the course for the future of open source drone technology.

AMAR PRECIADO; PEXELS

# Software-defined industry innovation

LF-hosted project communities are at the forefront of helping industries to become increasingly software defined. From meeting the global demands for secure, scalable data networks to creating standards that solve common regulatory challenges, industry-focused open source projects enable common, accessible, secure, and cost-effective solutions that create shared value for all.

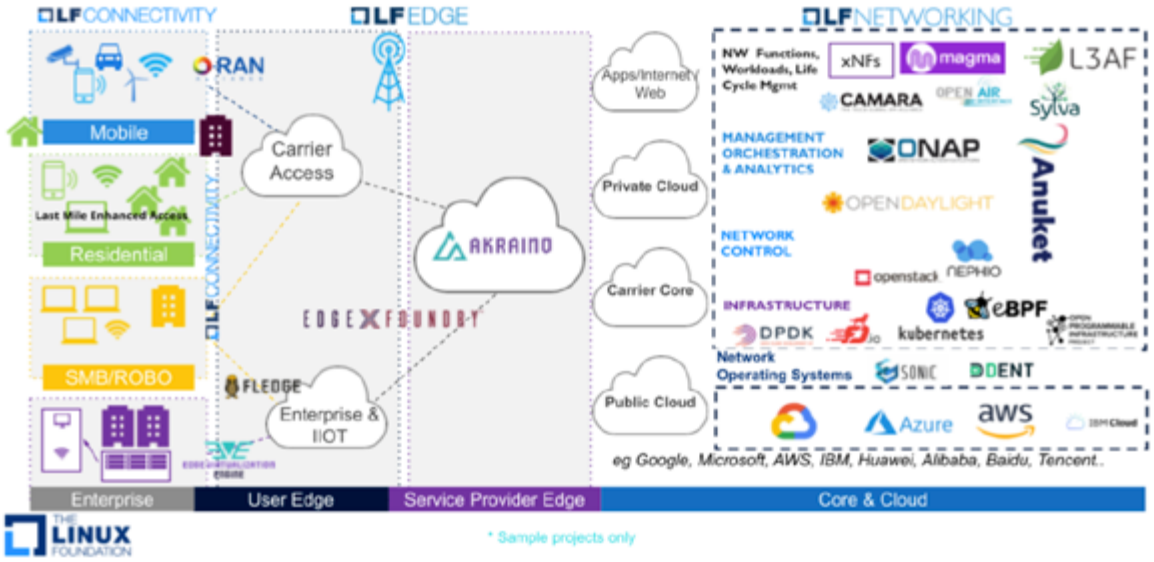
# LF NETWORKING

Now in its sixth year as an umbrella organization, The **Linux Foundation Networking (LFN)** continues to build its role as the nexus of innovation and collaboration across the entire end-to-end open networking stack with broad industry support from enterprises, cloud providers, and telcos. Our robust membership and diverse array of projects enable open source software solution stacks to thrive in commercial-ready production environments globally.

---

The first umbrella fund that the Linux Foundation created, LFN, is the largest open source networking community, with 80% of the top 10 telcos on the board (by CAPEX spent) and the top five vendors.

## Open Source Networking, Edge and Access




LFN software and projects provide the foundation with network services and infrastructure across service and cloud providers, enterprises, vendors, and system integrators, enabling rapid interoperability, deployment, and adoption. With a mission to drive an open source ecosystem that revolutionizes the movement or communication of data on a network—including its data plane, control plane and analytic, orchestration, and automation technologies—for enterprise, cloud, and carrier network constituents, LFN enables worldwide access to the ecosystem and tools needed to grow and sustain the future of connection.

As the world becomes more interconnected and automated, we are seeing a blurring of lines across the market at the use case and architecture level, spreading across Core, Edge, and Access; 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, GSMA, MEF, TMForum,

3GPP, and more) is paramount to scalable digital transformation across the globe.

## Bringing it all together: the 5G Super Blueprint

The barrier to entering 5G network research and development is high due to equipment, software, and integration costs. Integrating multiple open source projects allows us to consolidate different functionalities, making them accessible to a wider audience.

In 2023, the 5G Super Blueprint continued to evolve its role as follows:

- **The availability of a 5G Super Blueprint Library of Solutions:** It serves as a central reference point for completed 5G Super Blueprints. Use cases vary from complete end-to-end solutions to technology building blocks that users can consume, evolve, and expand upon.
- **New blueprints for additional use cases**: These include device authentication for IoT devices and Edge site placement.
- **The publishing of a new white paper / eBook**: *Defining the 5G Super Blueprint: Integration, the Open Way i*s now available and provides an overarching look at its genesis.


## Welcoming Nephio

Nephio, an LF open source initiative of partners across the telecommunications industry working toward true cloud native automation launched in 2022 in partnership with Google Cloud, joined the LFN project umbrella as a "graduated" project in October of 2023. The move enables closer collaboration, expanded shared resources, and simplified and streamlined governance.

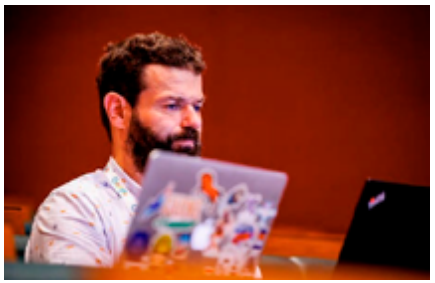
Key achievements from the Nephio community in 2023 include:

- The active participation of 100+ developers & architects
- The full establishment and operation of TSC and SIGs
- The growth and participation of 70+ members
- The release of Nephio R1, with over 90 community member contributions to the release, based on seed code provided by Google
- The hosting of five sessions as a guest community at LFN's June Developer and Testing Forum (D&TF)
- The acceptance of three additional companies— Red Hat, Samsung, and Accuknox— for TSC membership (which now stands at 24)
- F2F meetings held in Mountain View, CA, USA, Oct. 9 & 10 to plan for R2
- Follow-up conversations held at LFN's D&TF from Nov. 13 to 16 in Budapest, Hungary

# LFN and AI

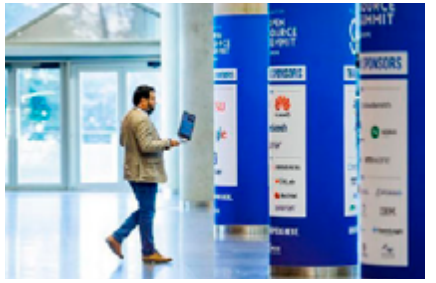
## AI: Defining the architecture of a smart connected world

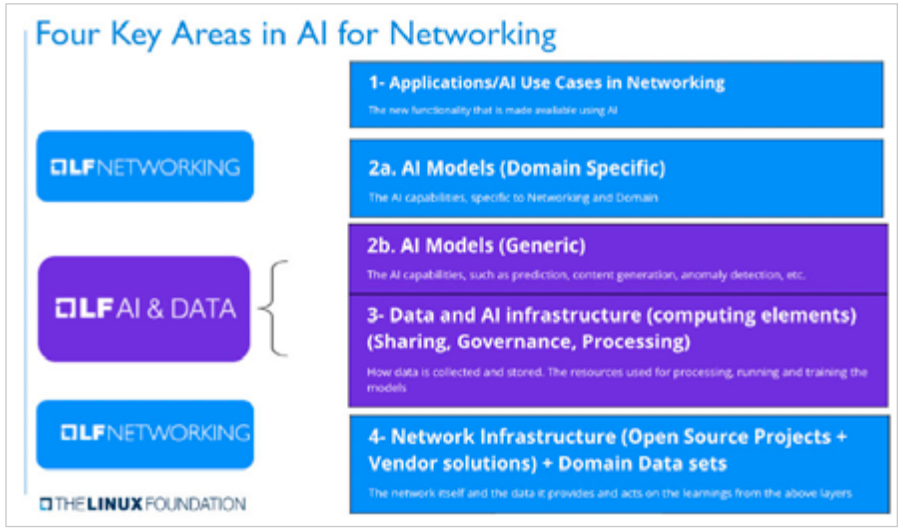
AI will play a huge role in networking. The LFN community is taking a strategic approach to its AI strategy by initiating an **AI Task Force** to help identify, define, and operationalize the role of AI in open networking. The focus is identifying the real areas in which Telco, Cloud, and Enterprise should work in AI, from an "AI for the Network" and the "Network for AI" perspectives. We've already laid some foundations with the work on 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.



**We're working closely with our sister sub-foundations, LF AI & Data**, which represents a horizontal construct that is not domain-specific, and the **OpenSSF Foundation**, which is a security vertical. While LFN works closely with these other groups, we focus on different layers of the solution stack (e.g., the network & network infrastructure layer) alongside LF AI & Data but with some interesting network data.

New areas we're exploring include use cases, domain-specific AI models, and identifying data sets from large carriers to leverage for training the models.






## ONE Summit: regional focus on community engagement

This year, LFN took a regional approach to community engagement with the introduction of ONE Summit Regional Days, a series of smaller, one-day, localized ONE Summit events across the globe. Along with LF Edge and other ecosystem projects, these events were successful and brought localized communities together across:

- North America (Vancouver, Canada)
- Europe (Bilbao, Spain)
- China (Shanghai, China)
- India (Bangalore, India)

Strong sessions covered everything from automation, Access, Edge, Core, AI, Standards, and more. In 2024, we look forward to reconnecting as a global community for a more traditional, large, in-person event at Silicon Valley's ONE Summit flagship event.

# LF EDGE

As defined by Sharpening the Edge II: Diving Deeper Into the LF Edge Taxonomy and Projects, edge computing is the delivery of computing capabilities to the logical extremes of a network to improve the performance, security, operating cost, and reliability of applications and services. As the world becomes more interconnected, data-driven, and reliant on real-time decision-making, edge computing has become a pivotal technology to meet the demands of the digital era.

The LF Edge project umbrella can meet those evolving demands.

Now in its fourth year as an umbrella organization, LF Edge represents the center of gravity for some of the world's most impactful open source edge computing initiatives, including EdgeX Foundry and Akaino projects, among others, building an open, modular framework for edge computing. LF Edge's common governance and collaborative resources unify and open the edge market, with massive global industry support accelerating the adoption and deployment of edge applications across growing and evolving sector verticals, including telecommunications, Cloud, IoT, industrial IoT, retail, AI / ML, factory floor, smart home, and more.

According to IDC, the expectation is that the global market for edge computing will reach $317B by 2026, growing at a compound annual growth rate of 17.6% between 2022 and 2026.

As data gravity continues to shift away from the centralized cloud to a distribution from edge to cloud, all organizations benefit from edge computing due to the lower latency, reduced bandwidth costs, and maximized security and privacy. This means the work of LF Edge is more crucial than ever.

Compelled by the robust set of Akraino blueprints in deployment; EdgeX's 10M+ container downloads and growing IIoT platform, the project's tenet publication, the State of the Edge Report, and a diverse set of new deployment stories and technical white papers that provide strategic guidance on how to scale, 2023 highlights include:

- **Security:** The Akraino community published an Akraino Platform Security White Paper to define the security requirements of its Akraino blueprints.
- **Gaming:** Members Arm, Tencent, Zenlayer, YSEMI, Genymotion, and Alicon

SE investigated how to leverage Akraino blueprints to improve gaming scenarios across user experience, cost, operation, and maintenance to help improve the commercial feasibility of cloud games.

- **Retail:** Deployments from IBM, Intel, and Scale Computing leverage EdgeX Foundry's Open Retail Reference Architecture project, Open Horizon, and Secure Device Onboard to build commercial solutions that have applications across multiple industries to address how to rapidly scale actionable insights at the point of interaction — i.e., delivering AI at the Edge (see Using Open Source to Scale Retail Applications at Edge Locations ).

- **Industrial:**

  - The Fledge project graduated to Stage 3 in 2023. IIoT widely uses Fledge in applications across industries, and it continues to evolve with contributions from a thriving community of developers and adopters. Focused on industrial data pipelines to and from industrial assets and systems, edge applications, and edge machine learning, Fledge users and contributors are suppliers and integrators to industrial markets as well as industrial companies and work in process and discrete manufacturing to help produce drone military aircraft, engines, aluminum car parts, food processing, chemical polymers, energy, oil and gas, paper products, premium wines, professional auto racing digital twins, and more.
  - EdgeX Foundry outlined how Eaton, a global leader in electrical power management, adopted EdgeX Foundry as its common edge platform, with EdgeX empowering their engineers to accelerate product development, code reuse, and more.

- **Continued collaboration with industry alliances & projects**

  - Along with ETSI and Open Compute Project, we once again co-hosted the Edge-Native AI Hackathon that XYZ placeholder.
  - The Fledge project has expanded into LF Energy's Project FledgePower with 67 energy companies and suppliers and OSDU (an Open Group Project) with 167 oil and gas companies and suppliers, all working toward a common goal.
  - **LF Edge partnered with LF Networking, CAMARA, the GSMA, and TMForum** to outline
  - Additional work with ETSI included the publication of *How to Build Edge Solutions with LF Edge Akraino Blueprints & ETSI Multi-Access Edge Computing (MEC) APIs*, which detailed the impact of the collaborative, award-winning PCEI blueprint.
  - There was a new collaboration with Open Grid Alliance.


Driven partially by the growing demand for AI applications, we expect the next 12 months to be a significant turning point for the edge market. Please join us along the journey!


In 2023, Software for Open Networking in the Cloud (SONiC), an open source network operating system (NOS) that Microsoft created, continued its impressive growth and maturation. With over 75 leading organizations collaborating, SONiC has established a vibrant community powering diverse scenario, including datacenter, bare metal, AI, gaming, enterprise, edge, and 5G environments. Having joined the LF in April 2022, SONiC now benefits from a strengthened governing board comprising esteemed leaders from 17 major contributing companies, driving strategic decisions and innovations.

Regarding technical advancements, the SONiC community achieved significant milestones in 2023. Notable releases include 202305 and 202311, featuring enhancements such as Secure Upgrade, Static Route BFD, Enhanced PDDF, and more. Furthermore, the community organized successful events globally, including Open Source Summit North America, SONiC Forum in China, SONiC Workshop in India, and OCP Global Summit in San Jose, further spreading awareness and fostering collaboration within the SONiC ecosystem. The collaborative efforts of the SONiC community are propelling the project to greater heights, solidifying its position as a versatile and powerful NOS.


DENT, a NOS utilizing the Linux Kernel, Switchdev, and other Linux-based projects, has made significant strides in 2023. Its DENT 3.2 release, "Cynthia," built upon and added new key features utilized by distributed enterprises in retail and remote facilities, providing a secure and scalable Linux-based NOS for disaggregated switches adaptable to edge deployment. Below are some additional highlights from 2023:

- Amazon continues to successfully utilize DENT as part of its Just Walk Out technology in third-party retail stores worldwide to automate a more efficient customer experience.
- The group held a mini-summit in October, "Enabling the Evolution of Disaggregated Enterprise Networking with Linux," co-located with the OCP Global Summit in San Jose, CA.
- An end user solutions group formed to collaborate on guidance and strategy around software releases, features, functionality, testing, technological direction, and end user perspectives so that the technology meets user requirements and adds value.
- There was an addition of four new members: BISDN, Bootlin, Micas, and PLVision.

The next release, due in Q1-2024, will include features such as a new Yocto-based build system, SAI-based interface to hardware, In-Kernel PoE, and support for new hardware platforms.


The DPDK project witnessed a trajectory of technical advancements and community collaboration, further positioning it as a frontier in packet processing innovation and network performance enhancements. Below is an extended delineation of the technical achievements and innovation from the start of the year until now:

## DPDK v23.0 release

- Optimized performance: The DPDK v23.0 release signified a leap in performance optimization across diverse hardware platforms. This led to accelerated packet processing speeds and diminished latency, crucial for real-time and high-demand network applications.
- Enhanced security features: There was an increase in security in this release, with robust measures to guarantee data integrity and safeguard against potential system vulnerabilities. These enhancements are indispensable in a digital ecosystem increasingly threatened by diverse security challenges.
- Extended hardware compatibility: The support for contemporary network interface cards and field programmable gate arrays was a substantial move. It has allowed users to leverage modern hardware capabilities fully, thereby elevating network performance and efficiency.
- Innovative feature development: The continuous addition of features catering to evolving networking needs such as packet filtering, load balancing, and network function virtualization remains a hallmark of DPDK's innovative journey.

## Community contributions and feature enhancements

- Performance fine-tuning: There were numerous code submissions aimed at optimizing core functionalities, algorithms, and data structures. This continual optimization is pivotal in harnessing maximum performance from network hardware.
- Bug resolutions: The community's commitment to addressing bugs has led to a more stable and reliable DPDK framework, ensuring seamless functionality and user satisfaction.
- Novel features introduction: The ongoing feature enhancements embody DPDK's responsiveness to emerging network challenges, allowing for a more adaptable and efficient user experience.

## Knowledge dissemination and collaborative engagements

- A new drive for marketing and communications included a new monthly newsletter, new member user stories, and developer spotlights.
- The collaborative discussions on DPDK's forums and mailing lists served as incubators for innovative solutions. These platforms have facilitated remarkable knowledge-sharing and collaborative problem-solving among new and seasoned community members.

## DPDK Summit 2023

- The DPDK Summit 2023 in Dublin was a convergence point for industry leaders, developers, and enthusiasts. The event spotlighted technical discussions and workshops that enriched the understanding of packet

processing technology and fostered innovative approaches to challenges in the domain.

- This delineation reflects a trajectory of sustained technical innovation and community engagement that has positioned DPDK as a vanguard in packet processing technology. The accrued technical achievements from the year's outset have significantly contributed to the overarching growth and success of the DPDK project.

Magma is a next-generation open source packet core that delivers the latest innovations at a lower cost of ownership. It has a from-the-ground-up design that delivers flexibility and openness for the next generation of service providers, including MNOs, ISPs, MSOs, and Satellite providers.

This year marks Magma's first full year as a community-run project after moving away from Meta. Magma continues to innovate by bringing modern software networking techniques to the challenge of rural Internet access under the auspices of the LF.

2023 saw the launch of Magma 1.8 along with the community taking the initiative to provide prospective users with a starter kit for Magma 1.8—including a bill of materials, estimated cost of ownership, and instructions on how to deploy and configure Magma in the field—early in 2024. The community also

embarked on a bounty programme that is progressing steadily and will launch in the first half of 2024.

Looking forward, Magma aims to release version 1.9 in early 2024, which will include these critical improvements over Magma 1.8:

- Performance improvement in the 4G core, migrating to C++ code, and optimizing data structures
- 5G SA support on container-based environments
- Testing with new gNB for 5G SA
- Minor improvements in logging and unit testing infrastructure
- Critical defects related to 5G NSA, SCTP event handlers, etc.
- Fixed known defects from past releases.
- New artifactory support

Magma 1.9 will also include various security fixes at a 4G / 5G code level to resolve issues related to negative / disruptive cases that can occur in packet handling.


openIDL, an insurance-specific permissioned open source distributed ledger network, through the power of its open governance model, infuses efficiency, transparency, and security into industry data exchange. With openIDL, insurers can exchange data with third parties while retaining the privacy of their data.

A primary business case for insurance carriers to utilize openIDL's network is to greatly reduce the cost and exhaustive complexity of regulatory / statistical reporting to state regulators. With the support and guidance of the American Association of Insurance Services, the nonprofit insurance statistical reporting agent and industry advisory organization that brought openIDL's vision to fruition, carriers can break free from expensive proprietary conglomerates and keep even more control and oversight over their data and competitive business assets.

Furthermore, since openIDL is a nonprofit, open source, and antitrust industry collaboration, it has become a trusted platform for regulators to come together with the aim of tackling industry-wide challenges such as climate-related catastrophic events and exploring how efficient, accurate, and secure data exchange may help the insurance market as well as contribute to climate-related catastrophic event efforts at large.

Our team has grown with openIDL's new executive director and former Connecticut State Insurance Deputy Commissioner, Josh Hershman. Since starting in June, Josh has engaged new state insurance departments such as Delaware, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont and welcomed the Montana State Department of Insurance as a member of our ecosystem of associates.

openIDL has recently engaged Capgemini in PoC support and strategic planning, stirring promising interest from many sectors within the industry.

openIDL's team launched a node-building workshop series for its members in which the engagement has been phenomenal and has led to great strides and advancements in the architecture of the growing network.

The consortium's efforts in establishing an operational alpha net platform are evolving and expanding and will enhance onboarding procedures, development testing, and the eventual support of the production network.

openIDL continues to leverage and involve the significant contributions of other LF projects.

As openIDL is one of the few LF projects in which the LF will operate and manage a consortium based on Hyperledger Fabric and other open source contributions. It establishes the foundation of a permissioned decentralized network in which significant benefits will unfold with cross-industry and regulatory data exchange as well as other interested open source participants and collaborators.

One of the greatest insights to have surfaced this year is openIDL's potential to be the best industry-positioned platform for data standard generation and governance. We will see an ever-increasing need for industry and cross-industry data standards as insurance continues to evolve and stretch farther than ever before. openIDL is a perfect place for the future of insurance to land.

# AUTOMOTIVE GRADE LINUX

Automobiles have become the largest mobile device that most people will ever purchase. As automakers race to roll out new features and functions to keep pace with consumer demand, they rapidly embrace the concept of software-defined vehicles (SDVs) that are built using open source technology.

Automotive Grade Linux (AGL), an open source software platform for connected car technology, has worked on SDVs for the past eight years. With over 150 members, including 11 automakers, AGL unites the automotive and tech industries around a shared software platform for all in-vehicle applications, including infotainment, instrument cluster, and telematics, with a head-up display, advanced driver assistance systems, functional safety, and autonomous driving on the roadmap.


**Currently, AGL-based infotainment systems are on the road in Toyota, Lexus, and Subaru vehicles globally.**

Currently, AGL-based infotainment systems are on the road in Toyota, Lexus, and Subaru vehicles globally. Further, more are expected over the coming years, as many AGL members have already integrated the AGL platform into their production plans.

## Automotive Grade Linux Unified Code Base

Built from the ground up by the AGL community, the AGL Unified Code Base (UCB) is an open source software platform that includes an operating system, middleware, and application framework, providing 70% of the starting point for a production project. With major contributions from automakers and suppliers, the UCB can serve as the de facto industry standard for infotainment, telematics, and instrument cluster applications. Sharing an open source platform enables code reuse and a more efficient development process. Developers and suppliers can build their solution once and deploy it for multiple automakers.

The AGL community continuously evaluates open source technologies for automotive use cases to ensure that only best-in-class software is integrated into the platform. In 2023, AGL completed the transition to newer technologies, including VirtIO for cloud native AGL applications and Flutter, a UI and app development framework for infotainment systems, which will allow manufacturers to cut the development time and cost of deploying new applications in the vehicle.

AGL had two milestone platform releases in 2023: UCB 15 "Optimistic Octopus" and UCB 16 "Prickly Pike." These releases included updates to application and security frameworks, web apps, VirtIO virtualization enhancements, board support updates, new Flutter reference apps, and Flutter workspace automation. Both releases are based on the Yocto 4.0 (kirkstone) Long-Term-Support board support packages.

## Software-Defined Vehicle Expert Group

A new SDV Expert Group (SDV EG) was officially launched to accelerate the development of AGL software that is decoupled from hardware limitations, enabling automakers and service providers to deliver a continuously updated driving experience. The SDV EG made significant progress toward defining the requirements and use cases for AGL regarding SDVs, standardizing the VirtIO virtualization framework across various automotive architectures, and laying the groundwork for workload orchestration for on-board automotive systems.

## Community engagement

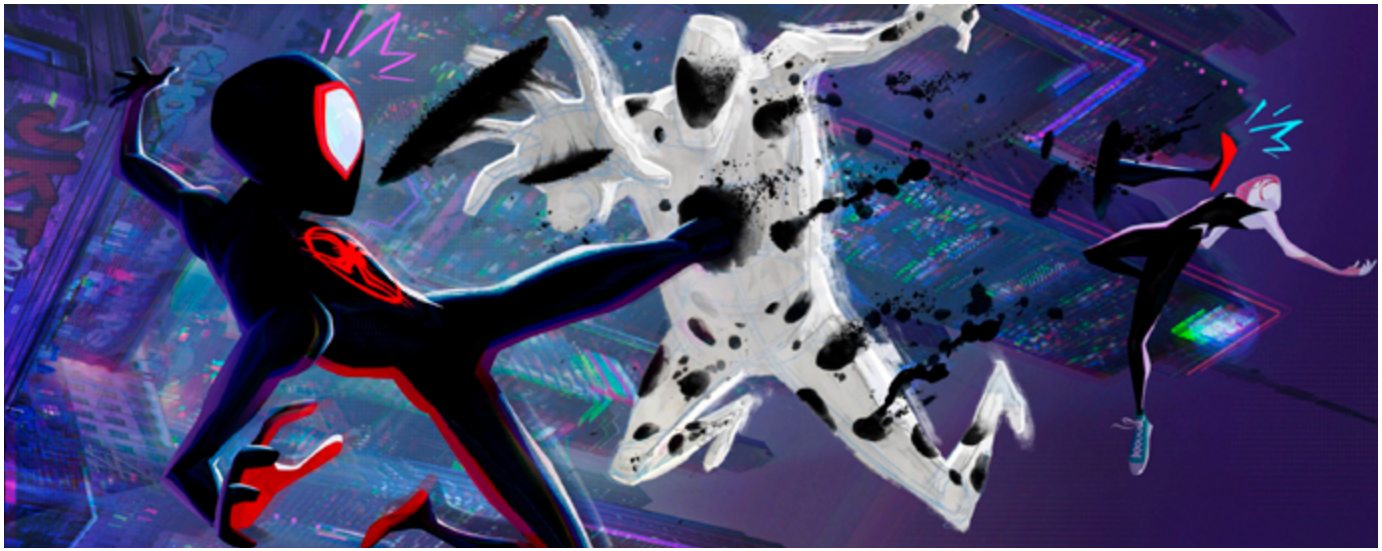
AGL returned to CES 2023, one of the largest annual tech conventions around the world, displaying AGL demos that both the community and AGL members developed, including Renesas, Panasonic, AWS, Igalia, EPAM Systems, and VNC Automotive. More than 750 attendees attended demos in the spacious AGL booth at the Las Vegas Convention Center, with another 150+ attending a private invite-only after-hours reception in the booth.

Additionally, AGL hosted two in-person all-member meetings (AMM) in Berlin, Germany, and Tokyo, Japan. The AMMs brought together the AGL community to learn about the latest developments, share best practices, and collaborate to drive rapid development.

**Dan Cauchy, Executive Director of AGL, at Embedded Automotive Summit 2023.**

ASWF /* ACADEMY SOFTWARE FOUNDATION

Developed in partnership with the Academy of Motion Picture Arts and Sciences and the Linux Foundation, the **Academy Software Foundation (ASWF)** provides a home for open source software developers in the motion picture and broader media industries to share resources and collaborate on technologies for image creation, visual effects, animation, and sound.



**SPIDER-MAN™: ACROSS THE SPIDER-VERSE; courtesy of Sony Pictures Imageworks**

An active, growing community supports ASWF, and this community has welcomed five new members over the past year: Bolt Graphics, CoreWeave, Framestore, HP, and OTOY. Total commits grew by 73% over the past three years, and during this period, over 90 organizations participated in code commits, 41 of which were new.

## Project growth

In 2023, the ACWF welcomed OpenImageIO as a new project. OpenImageIO is a ubiquitous library for VFX applications and pipelines to perform scripted manipulation of digital image files, focusing on scalability and functionality for professional VFX and animation feature film workflows. Larry Gritz created and open sourced OpenImageIO to the community in 2008 at Sony Pictures Imageworks, and it is one of the VFX industry's earliest open source projects.

Many ASWF's projects have become de facto industry standards, which most VFX and animation studios use and support. Investment into ASWF projects continues to grow, resulting in several new subprojects:

- The Open Review Initiative, an umbrella project within the Foundation focused on the playback, review, and approval of motion pictures and related media, welcomed two new projects: xSTUDIO and Open RV. xSTUDIO is a modern and flexible Playback and Review application that DNEG developed to meet the needs of content creators throughout the production process. Open RV is an open source version of RV, a native review and playback tool that Autodesk developed. VFX, animation, and content creation teams use it globally.

- OpenPBR is a new subproject of MaterialX that Autodesk and Adobe developed with guidance from the MaterialX Technical Steering Committee. The new open source shading model provides creatives a more artist-friendly bridge between software applications.

## Community engagement

The Foundation's flagship event, Open Source Days, is the leading event dedicated to open source software for visual effects, animation, and digital content creation. In-person and virtual registration doubled in 2023 with visual effects/animation studios, software vendors, and other professionals presenting on emerging open source projects, best practices, and the latest trends in open source for the motion picture industry. In addition, the ASWF introduced a new Virtual Town Hall Series leading up to the Open Source Days Main Program. Over several weeks, Foundation projects, including MaterialX, OpenColorIO, OpenAssetIO, Open RV, xStudio, OpenTimelineIO, and OpenEXR, shared milestones, highlights and future roadmaps and answered questions from the community.

Open Source Forum, the Foundation's other main event, was opened to non-members for the first time. Held at the Academy Museum of Motion Pictures, the annual event brought together the industry's influential software engineers, tech executives, and open source leaders for a day of content and discussion.

The Foundation launched a new virtual Dev Days event, a global 48-hour codeathon to encourage more contribution and developer engagement. Developers of all experience levels were encouraged to spend eight hours learning about a project, interacting with project leadership, and writing code over two days. Participating companies included Autodesk, Sony Pictures Imageworks, Lucasfilm, DreamWorks Animation, Wētā FX, and Walt Disney Animation Studios.


## Diversity and inclusion

This year marked the third annual Summer Learning Program, which the Foundation's Diversity & Inclusion Working Group led. The Summer Learning Program provides practical skills and mentorship to underrepresented students and young people looking to explore technical careers in the animation and VFX industries.

The focus for 2023 was the LGBTQIA+ community. In total, 20 participants were provided free online learning access and matched with industry professionals from studios, including Industrial Light & Magic, Pixar Animation Studios, Netflix, and Activision Blizzard, for one-on-one mentoring.

# FINOS

In a year marked by transformative growth and innovation, Fintech Open Source Foundation (FINOS) has solidified its position at the forefront of financial technology evolution. Through collaborative efforts, the foundation has bridged the gap between financial services and technology constituents, fostering an environment of open source innovation.

## Community

The results of our dedicated efforts to bridge this gap are evident in the increasing maturity of both our community and projects. We have had a record growth rate in community numbers and engagement rate (e.g., 67% in unique contributor growth). Our events continue to enjoy yearly participation growth, with over 1,700 registrants in the first half of the year alone, in-person conferences doubling their attendance, and the newly introduced hackathons stimulating collaboration and team formation across different institutions, including both member and non-member participants. We focus on hackathons, in-person conferences, and the Technical Oversight Committee (TOC) to highlight the maturity of our community-bound activities.

## Hackathons

This year, we reintroduced hackathons as a community engagement tool, and our community responded with tremendous enthusiasm for collaborative innovation. The FINOS Interoperability & Regtech Hackathon brought together 100+ participants at our member BMO offices in New York and London, where 11 teams took up different challenges and incorporated existing FINOS projects into their solutions. The Global Accessibility Awareness Day Hackathon, in partnership with Discover, enjoyed 199 registrations, with 79 teams collaborating for two weeks and submitting 11 projects. As a result of these events, eight projects were added to FINOS Labs, and three projects were contributed to FINOS: the FDC3 Java API, TraderX, and A11yTheme Builder.


**FINOS Annual Member Meeting 2023**

## Member Meeting and Open Source in Finance Forum Conferences

Our community is very energized when it comes to sharing experiences and successes in person, and this energy was in full supply at our London Member Meeting in June, where over 350 participants came together to learn, network, and share insights at JP Morgan's Embankment conference venue. Attendees

participated in nine thematic roundtables, resulting in proposals for new Special Interest Groups and projects. During OSFF in New York, we partnered with our sister LF Foundations—Open Mainframe, Open JS, FinOps, and OpenSSF—to enable sharing and collaborative innovation across the tech and financial services cohorts. In addition, we continue to expand our Project Expos, allowing teams to demonstrate how FINOS projects are being applied to deliver business solutions effectively and efficiently.

## Technical Oversight Committee

Another evidence of our community's maturity is its readiness to step up and drive the project landscape vision for the foundation through meritocracy. After a 12-month pilot, the FINOS Governing Board approved the formation of the Technical Oversight Committee in July, the technical governing body of w. The TOC collaborates closely with the FINOS team and the Governing Board to provide technical oversight for the projects in the FINOS portfolio.

## Diversity, equity, and inclusion

Finally, the Diversity Equity and Inclusion Special Interest group (DEI SIG) led several events across our community—over 330 people registered for the FINOS Tech Gateway London DEI event, which included presentations from five member firms, and Big Boost Mondays meetups were kicked off in London and in Dublin by request from the FINOS community.

## Strategic initiatives and projects

Each year, with input from our Governing Board and members, FINOS identifies areas of strategic business value from our 50+ projects and defines Strategic Initiatives with Executive Sponsorship from Governing Board representatives, focusing attention on the FINOS team. In 2023, we focused on Open Source Readiness (OSR), Interoperability/ FDC3, and Open RegTech.

**OSR:** This is FINOS' term for helping the finance industry "do open source properly," which is a core part of FINOS' mission. We have seen great progress in this regard, which the results of our annual survey show. This year, the OSR SIG delivered the OSR Body of Knowledge, with 80+ articles that over 20 individuals from the community have written, sharing their collective experiences and lessons learned on the open source journey. In addition, we released an **OSR Training Course (LF137)** and **Certified Open Source Developer (COSD) certification**, which delivers standard and comprehensive training for technologists in financial services companies and significantly accelerates the adoption of open source best practices across the industry.

**Interoperability/FDC3:** FDC3 is the fast-growing standard for application and cross-industry interoperability in finance. We unveiled the FDC3 2.0 Conformance Program at the Member Meeting and introduced a new class of FDC3-compatible Desktop Agents. This was followed by the release of two FDC3 training courses, a Certified FDC3 Practitioner course and certification exam, and FDC3 version 2.1. The FDC3 community of contributors and maintainers is hard at work!

**Open RegTech:** The Open RegTech initiative promotes industry collaboration to drive innovative approaches to regulatory compliance. This year, our community came together around infrastructure-based and business-focused projects with the introduction of the Common Cloud Controls and the addition of the Common Domain Model (CDM) projects. In addition, we initiated the creation of the RegTech Council, which will sponsor projects based on selected regulatory priorities.

A surge in project contributions marked this year, each echoing the foundation's ethos of open source advancement. The organic influx of projects, such as JupyterLab Templates and Regular Table, coupled with the launch of the pivotal Common Cloud Controls and CDM projects, exemplified the foundation's project-centric focus. We also unveiled the ambitious FINOS Zenith SIG, aimed at enabling the financial services sector to discover and harness the potential of emerging technologies, such as Cloud Computing, Blockchain & DLT, Generative AI, and Robotics & RPA, to revolutionize the industry.

The year 2023 is a testament to FINOS's unwavering commitment to driving open source innovation in the financial sector. With the continued influx of members, innovative projects, and an ever-growing and engaged community, FINOS is set to lead and define the future of open source in finance. We remain committed to pushing boundaries, encouraging innovation, and fostering a community where everyone has a voice.


**In its third year, the annual FINOS research report analyzes quantitative and qualitative data to understand industry-wide trends in open source adoption, from banking, to asset management, to hedge funds.**

# Innovation in technology domains

LF projects accelerate technological innovation through diverse open source software initiatives. From AI, JavaScript frameworks, cloud native computing environments, continuous delivery systems, 3D engines, data lakes, machine learning, and blockchain technologies, we're shaping the future of technology and cross-technology landscapes. By fostering an ecosystem that encourages collaboration and openness, we ensure that open source technology continues evolving in groundbreaking and accessible ways.

OpenJS Foundation

Security is a key priority for websites and companies alike. JavaScript and its ecosystem are critical technologies for running online businesses securely. This year at the **OpenJS Foundation**, we have significantly increased our commitment to securing the consumer web with new funding and initiatives for OpenJS Foundation open source projects, Node.js, jQuery, and more. With the vast array of security threats the web poses to companies, now is the time to check the health of your web security.

## New funding from Sovereign Tech Fund

The OpenJS Foundation has achieved significant milestones this year focused on improving JavaScript security. We announced that the Sovereign Tech Fund, which the German Federal Ministry for Economic Affairs and Climate Action financed, awarded the OpenJS Foundation €875,000 ($902,000). This is the largest government investment in a Linux Foundation project. It allows us to deliver infrastructure updates across our project portfolio through a single-scalable solution and develop and deliver security and maintenance policies and practices for critical projects.

## Security personnel for Node.js

Our continued work with OpenSSF's Project Alpha-Omega has granted funding for the second year to improve Node.js security. Alpha-Omega is committing $300,000 to improve supply chain security by improving Node.js security infrastructure. The funding bolsters the Node.js security team and vulnerability remediation efforts, focusing on supporting better open source security standards and practices. The fund started in 2022 and renewed in 2023.

## Creating a healthy web through jQuery security

Alpha-Omega has committed another $350,000 to reduce potential security incidents for jQuery by helping modernize its consumers and its code. OpenJS, working with the jQuery maintainers and industry experts, and continue work on an expansion of its infrastructure, and build and and will release a free Healthy Web checkup tool. It will be provided widely to businesses and organizations around the world.

"By supporting a long-term resilient and sustainable open source ecosystem, the development and maintenance of relevant software components can be improved, thus strengthening competitiveness and innovation as well as efficient governance and an empowered civil society."

***– Fiona Krakenbürger, co-founder, Sovereign Tech Fund***

## Championing our community

We're thrilled to work with several folks making an impact in our community by creating security best practices.

### Node.js security team

Through our work with Alpha-Omega, Rafael Silva from Nearform has led the Node.js security updates each month for the past two years. Through implementing work such as the permission model, security best practices, and reviving the Node.js security team, he has continued to make an impact on the Node.js community. He has also engaged new contributors through the Grace Hopper Conference and the Node.js TSC. Thank you, Rafael!

### Security Collaboration Space

OpenJS and its Cross Project Council seek to share best practices, guidance, and support among OpenJS and other JavaScript projects in the ecosystem. This is due to the tireless efforts of Collaboration Space members: Darcy Clarke, Joe Sepi, Jordan Harband, Matteo Collina, Michael Dawson, and Robin Ginn. True collaboration is hard work; thank you!

### Future forward

The future is bright for the security of the web and our projects—we're grateful to our members, community, and supporters for the successes of 2023.

---

"Creating a space where we can cross-collaborate on emerging security topics enables us to reduce potential risk and take ambitious security goals for all our OpenJS projects. This shines through in the foundation's efforts and priorities."

***– Joe Sepi, Cross Project Council chair, OpenJS Foundation and Open Source at IBM***


**OpenJS Collaborator Summit 2023**

# CLOUD NATIVE COMPUTING FOUNDATION

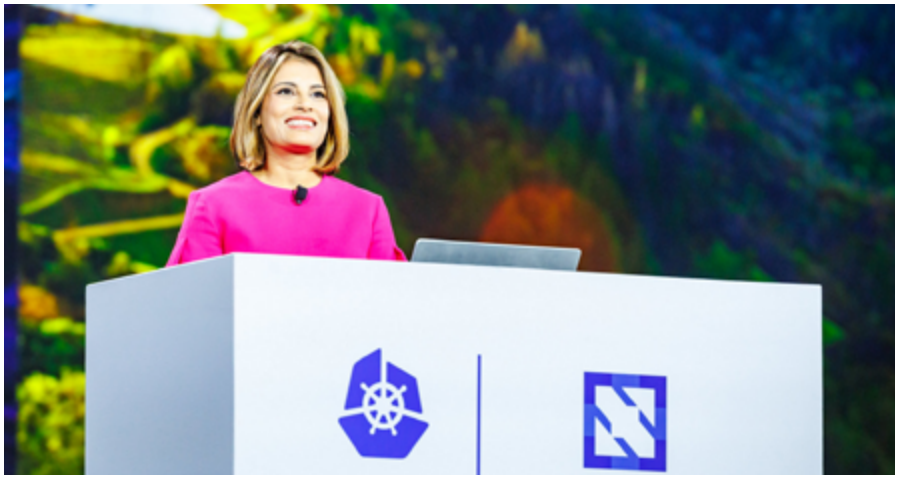
## "The Cloud Native Computing Foundation—a community in bloom"

CNCF is the vendor-neutral hub of cloud native computing, with an unrelenting mission to make cloud native ubiquitous. With more than 820 members, we are one of the world's largest open source foundations, home to 173 projects by 212,000 contributors representing almost 200 countries. Cloud native technology is changing the world and the skies beyond, from helping CERN to uncover the composition of the universe and how it works to powering satellites in outer space. As stewards, the CNCF is deeply committed to steering the future of cloud native technologies in a direction that benefits all stakeholders.

## A community in bloom

The cloud native ecosystem would be nothing without our incredible community of doers. Throughout 2023, CNCF worked to provide platforms and opportunities for community engagement, learning, and knowledge sharing; KubeCon + CloudNativeCon Europe was Europe's largest ever vendor-neutral, open source conference, with more than 10,500 joining in person, alongside 6,000 virtually. CNCF also hosted 30 Kubernetes Community Days, doubling the number hosted in 2022.

Since 2016, CNCF's Cloud Native Ambassadors have fostered an open and welcoming community for conversation, collaboration, and learning. In 2023, we announced new requirements and standards for the program to



**Priyanka Sharma, Executive Director of CNCF at KubeCon+CloudNativeCon North America 2023**


**KubeCon + CloudNativeCon Europe 23**

**CNCF's Cloud Native Ambassadors, KubeCon + CloudNativeCon Europe 23**

**KubeCon + CloudNativeCon Europe 23, Europe's largest ever vendor-neutral, open source conference**

improve its impact on the industry, which quickly drew more than 308 applications, leading to the appointment of 155 ambassadors.

## Evolving programs

This year, CNCF hit a significant milestone, forming the CNCF End User Technical Advisory Board (TAB), which launched in October. This pioneering initiative ensures that the needs and perspectives of end users receive adequate and effective representation in CNCF community decisions. Composed of representatives from end user members, the End User TAB serves as a bridge between end users and the various CNCF governing bodies, including the Governing Board and the Technical Oversight Committee.

## Ecosystem maturity

This year, there were 15 new projects accepted into the CNCF, alongside three project graduations—KEDA, CRI-O, and Istio—reflecting the maturity of the cloud native ecosystem.

Istio, which provides zero-trust networking, policy enforcement, traffic management, load balancing, and monitoring without requiring application rewrites, has quickly become the **third most active CNCF project** for pull requests, with **support from over 20 vendors** and **dozens of contributing companies**.

Since 2022, we have released several documentaries celebrating the success of CNCF's significant projects and their impact on the open source ecosystem. This year, we released **"Inside Envoy—The Proxy for the Future,"** charting Envoy's growth from an in-house solution within rideshare giant Lyft as it rapidly evolved into a proxy that fundamentally transformed the industry and the careers of those involved.

## Focus on security

In 2023, security was one of the most critical and fast-growing areas in the cloud native ecosystem, but equally one of the most challenging.

To that end, CNCF launched CloudNativeSecurityCon, a first-of-its-kind event where developers and security experts collaborated to build expertise in practical, everyday security needs to advance organizations' security posture.

Security takes an entire community, and in 2018, we started performing and open sourcing third-party security audits, along with the NCC Group, to improve the overall security practices of our ecosystem. This year, we shared the results of the Kubernetes third-party audit based on the 1.24 release with the help of the Kubernetes SIG Security Third-Party Audit Working Group.

Alongside these ongoing security auditing engagements, we had the determination to make fuzzing a first-class citizen in developing CNCF projects by integrating projects into the OSS-Fuzz fuzzing infrastructure. In 2023, this free service for continuously analyzing projects through fuzzing, a proven technique for finding software bugs, uncovered more than 2,500 issues.

## Cloud Native education

We're determined to help individuals looking to get started in cloud native, so following the success of the Kubernetes and Cloud Native Associate (KCNA) and Certified Kubernetes Security Specialist (CKS) programs, this year CNCF launched the Kubernetes and Cloud Security Associate (KCSA) certification to provide an entry point for growing security knowledge.

As part of our commitment to education, CNCF launched the Zero to Merge incubator. In this four-week program, participants learn to communicate effectively with CNCF project maintainers, identify existing problems, collaborate on open GitHub issues, and create pull requests for approval. Efforts such as these keep our community informed, inspired, and engaged with the ever-evolving cloud native landscape. We also launched an end user-focused newsletter titled "Wisdom of the Cloud" to further bolster these efforts.


**CloudNativeSecurityCon North America 2023**

## The rising tides of open source

As the tides of the technology world continue to rise, the CNCF's commitment to innovation and community engagement has never been more vital. The work accomplished in 2023 showcases a continued pursuit of excellence, uniting open source projects and contributors from around the globe.

The CNCF epitomizes the collective power of the open source community, with 15 new projects, an enriched ambassador program, the launch of significant new programs and training initiatives, and an unyielding focus on emerging technologies.

By embodying the philosophy that "rising tides lift all ships," we are not just driving industry innovation; we are shaping the future of technology. We are the stewards of a movement that transcends boundaries, catalyzing change, fostering inclusivity, and empowering the next generation of tech leaders.

# CD.FOUNDATION

The continuous delivery (CD) ecosystem is flourishing, with the creation of many new tools and technologies to elevate existing ones in pursuit of improving developer experience and productivity. This all increases organizational performance and cultivates digital transformation efforts.

2023 at the CD Foundation has been a great year, with some key community initiatives becoming mainstream with the establishment of more cross-project and cross-community efforts, especially in the interoperability area. The community efforts around CDEvents—to develop a common specification—are gaining traction within the ecosystem, and CDF projects Jenkins, Spinnaker, and Tekton are adopting them. Efforts to collaborate across foundations are happening as well, with Argo, Flux, and Harbor being a few of the projects taking part in the conversations. What's even better is that projects that are not part of any foundation are also adopting the specification, such as Testkube. Some of the key use cases that CDEvents addresses are interoperability, scalability, observability, and supply chain security. In addition to these use cases, there have been discussions regarding the implementation of CDEvents in a value stream management context.

Software supply chain is another area the CD community and projects have concentrated on this year. In addition to identifying and documenting various metrics to evaluate supply chain maturity, Tekton took the lead by adding new features, such as SLSA support, Sigstore integration, and trusted resources, for their users.

Finally, the community members contributing to various efforts and projects within the CD ecosystem had the opportunity to meet and chat with their peers during KubeCon + CloudNativeCon Europe 2023 and cdCon + GitOpsCon 2023, allowing them to start new collaboration efforts or continue with existing ones.

cdCon + GitOpsCon

cdCon + GitOpsCon Panel

Christie Wilson, Tekton

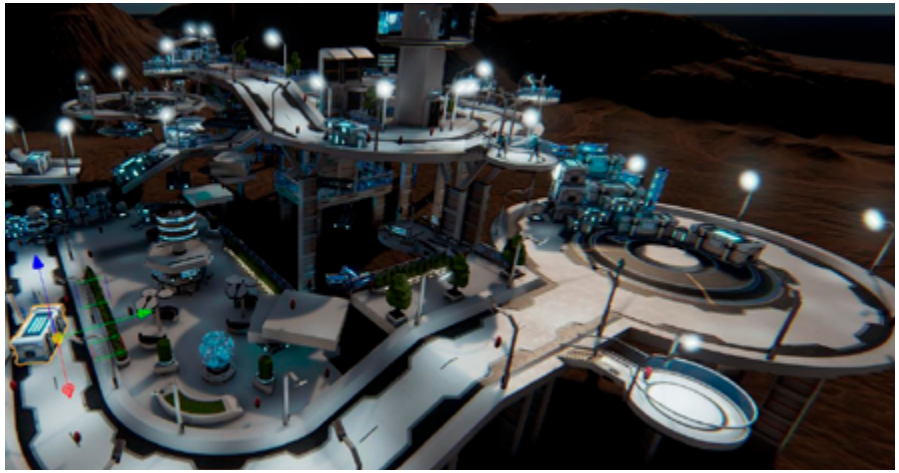
# Open 3D Foundation and Open 3D Engine

Real-time 3D technology is catapulting innovation to new heights in industries spanning gaming, robotics, motion pictures, virtual / augmented reality, artificial intelligence (AI) and machine learning, digital twin, manufacturing, automotive, healthcare, architecture, and more. The projection for the visualization and 3D rendering software market is $8 billion by 2027. Once considered the realm of game developers, real-time 3D engines have become the foundation for delivering these experiences.

Hosted under the Linux Foundation, the Open 3D Foundation is home to a thriving community of artists, content creators, developers, and technology leaders focused on building and fostering a modular, fully-featured, high-fidelity, real-time, open source 3D engine.

In its second year, the community has sustained its momentum, with over 2 million lines of code changed, including over 18,000 commits, 6,500 issues, and 2,000 forks. Pull request creators now total 240, including Lionbridge, Amazon Web Services (AWS), Robotec.ai, and Huawei. Stars have grown to 7K, and Google, Tencent, Microsoft, and Amazon are among the top star followers. O3DE's active Discord community, in addition to its social followers, now exceeds 3K.

O3DE software releases continue to focus on performance, stability, and usability enhancements. The community celebrated two new releases, O3DE 23.05 and O3DE 23.105, which introduced core workflow enhancements and improvements in the authoring experience. O3DE now supports NVIDIA's PhysX 5.1, as well as OpenXR-compatible devices with new OpenXR and OpenXRVk plug-ins (known as Gems in O3DE).



**The new Multiplayer Sample Game (MPS) helps game developers jumpstart new projects.**

The Multiplayer Sample Game (MPS) introduced with the O3DE 23.05 release provides client and dedicated server reference implementations of common game elements at play to help game developers jumpstart new projects. This sample game also delivers key examples of integrations with O3DE systems, such as terrain, lighting, audio, scripting, and VFX. It also utilizes the Atom Renderer's advanced features to achieve its visual goals, including global illumination, cascade shadows, emissive surfaces, bounce lighting, temporal anti-aliasing, and hybrid reflections (screen space and ray tracing).

We introduced Project Eureka, an academic collaboration with

the Rochester Institute of Technology (RIT) to put O3DE in the hands of next-generation game developers. Through this initiative, we are underwriting a team of students to build a commercial game using O3DE while enabling the students to build their portfolios and learn from industry experts. Within the first month, the student team ported their game, State of Matter, from Unity to O3DE, and their current focus is on extending the game. Project Eureka is the first of its kind and will grow the library of O3DE assets for use by other aspiring creators; identify O3DE feature gaps from these student developers in real time; build a pipeline of talent for internships, mentorships, and employment; and foster O3DE adoption among the next generation of developers, artists, and content creators.

"O3DE is a modular, fully-featured, AAA, open source gaming engine, giving developers so many more options and much more freedom to build games creatively and exactly the way they want. We're so happy to be able to offer this opportunity to our students and expect it to become a popular program that future students clamor to be a part of."

***—Aaron Nieboer, adjunct professor, RIT, and production associate, MAGIC Spell Studios***

**The O3DE ROS 2 Gem enables the engine for robotics applications, such as picking apples within an orchard.**

As real-time 3D engines tackle applications well beyond game development, O3DE has seen increased adoption in the robotics industry due to the engine's modularity and core functions across content creation, physics, and sensor simulations.

Robotec.ai, a software leader that empowers the development of simulation platforms for robotics applications, joined the O3DF and created two plug-ins (known as Gems in O3DE) to extend the engine's capabilities for robotics simulations. The O3DE ROS 2 Gem integrates O3DE with the robot operating system (ROS) and contains a number of components to build robotic simulations, such as sensors, controllers of different types of drives for mobile robots and joint systems, manipulator arms, dynamic spawning of robots, and other utilities and tooling.

The O3DE RGL Gem provides GPU-accelerated Lidar simulation for 30x faster performance.

"WO3DE has what I consider to be the best kind of ROS integration, in the sense that we write ROS2 code in the simulator. So, we can use all the packages directly without any bridges, which impacts performance and enables us to communicate directly to the ROS ecosystem and record data efficiently."

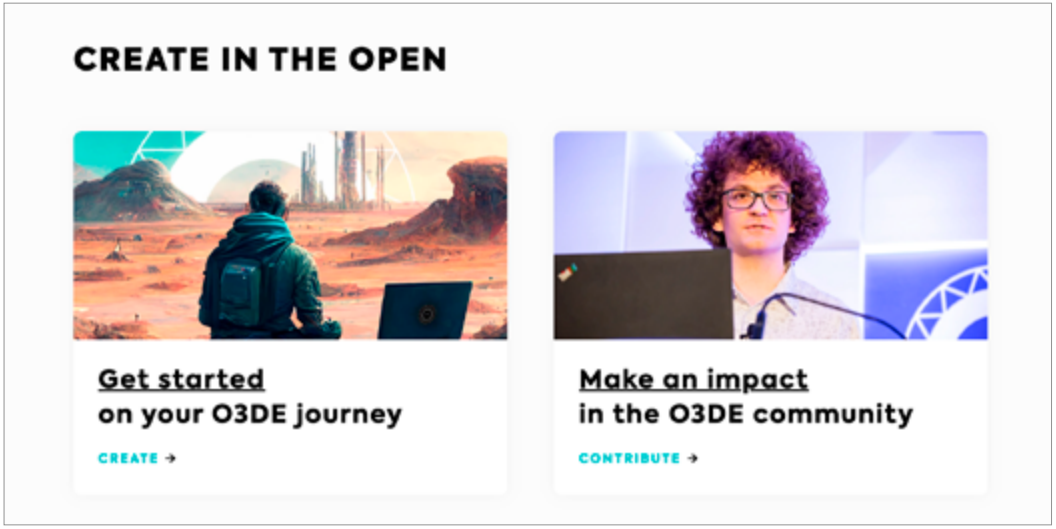
***—Adam Adam Dąbrowski, VP of Robotics and Simulations, Robotec.ai***

Through a series of panel discussions and podcasts, we are shining a light on O3DE's value in robotics and a range of other applications and industries, such as virtual and augmented reality.

In addition to a full lineup of panel discussions, podcasts, blogs, videos, user stories, and educational content, this year brought the launch of the new O3DE website to streamline onboarding, provide contributors and users with unique paths, and showcase O3DE usages.

We continue to highlight diversity within the O3DE community, including profile interviews with Suzanne Freyjadis, director of global development at the International Game Developers Association (IGDA); Sheri Graner Ray, award-winning game designer, author, consultant, and speaker; and Chanelle Mosquera, programmer writer at Amazon Web Services.

We look forward to an even more exciting year ahead!




**The new O3DE website provides unique paths for contributors and users.**


**Suzanne Freyjadis, director of global development at the International Game Developers Association (IGDA)**

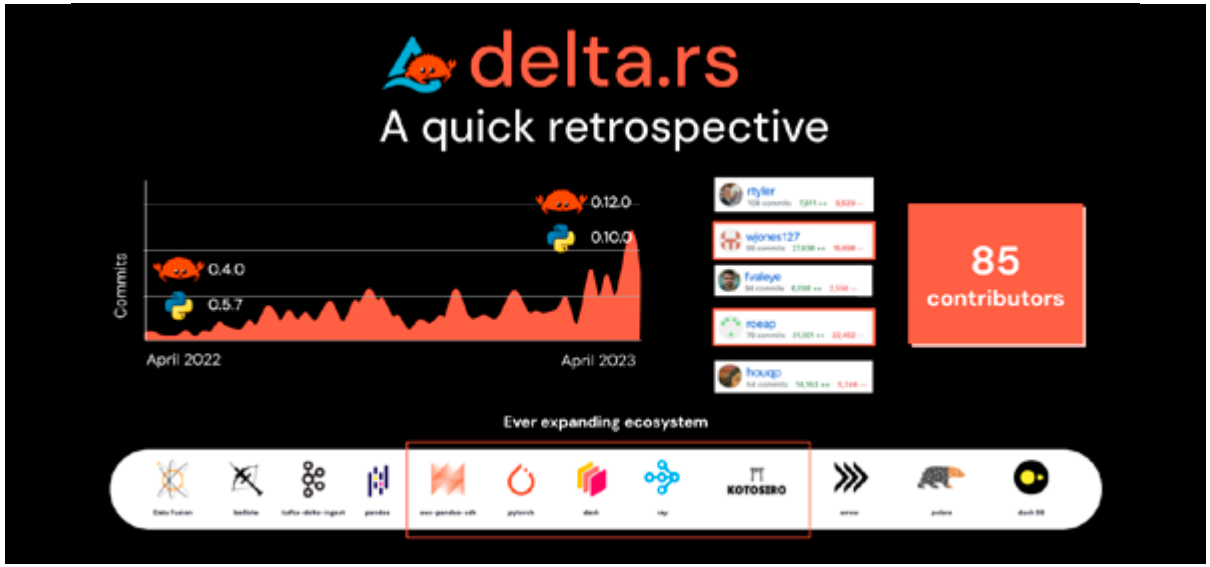
# DELTA LAKE

## 2023: The year of Delta 3.0

Delta Lake is the open source universal storage format that unifies analytics and AI on all your data. It is the benchmark for fast load and query performance across all open lakehouse storage systems. More than 10,000 companies use it in production because of its out-of-the-box enterprise readiness.

In June 2023, Delta Lake introduced Delta Lake 3.0, with the following powerful features to unify your analytics stack and make it easier to connect to Delta Lake:

- Delta Universal Format (UniForm) enables you to read Delta in the format the application requires, improving compatibility and expanding the ecosystem. Delta will automatically generate metadata needed for Apache Iceberg or Apache Hudi so that users don't have to choose or do manual conversions between formats. With UniForm, Delta is the universal format that works across ecosystems.
- Delta Lake has a diverse ecosystem of connectors, including Trino, Flink, Rust, and Python, all following the Delta protocol and enabling seamless data interactions across multiple systems. Delta Kernel simplifies building Delta connectors by providing simple, narrow programmatic APIs that hide the complex details of the Delta protocol specification.




"Delta Lake 3.0, including Universal Format and Kernel, underlines the open source community's dedication to enhancing data reliability and delivering advanced analytics. This release is a step forward in creating a community-driven ecosystem of data integrity, seamless collaboration, and real-time analytics tools."

***– Mike Dolan, SVP of projects, The Linux Foundation***

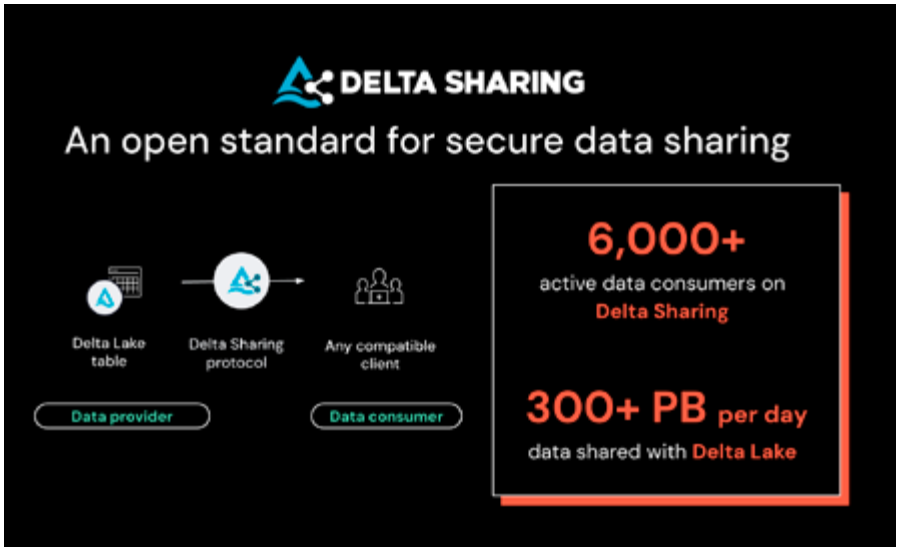
## Community highlights

### RUST

- In the last year, Delta-rs went from Rust 0.4.0 and Python 0.5.7 to Rust 0.12.0, including great performance improvement, and Python 0.10.0, including Zorder. Led by R. Tyler Croy (Scribd), QP Hou (Neuralink), and Florian Valeye (Backmarket), there are now 85 contributors to the project and two new maintainers, Will Jones (LanceDB) and Robert Pack (BASF). Significant improvements to delta-rs include Aws-pandas-sdk. You can now use lambda functions to work with Delta Lake, delta-torch to simplify the PyTorch integration with Delta Lake, and Kotosiro Sharing, created by Shing OKAWA, a minimalist Rust implementation of the Delta Sharing protocol.

### SHARING

- Since its launch, many organizations have adopted Delta Sharing. There are 6,000+ active data consumers on Delta Sharing, with over 300 petabytes of data shared with Delta Lake per day. The Delta Sharing ecosystem is ever-expanding with new partners such as Cloudflare, Dell, Oracle, and Twilio to seamlessly share data between their platforms and Apache Spark™, pandas, PowerBI, Excel, and any other system that supports the open protocol.



# PyTorch

In its inaugural year, the PyTorch Foundation made a significant impact by launching PyTorch 2.0. In September 2022, we welcomed PyTorch to the Linux Foundation from Meta, which formed the PyTorch Foundation with founding members AMD, AWS, Google, Meta, Microsoft, and NVIDIA. Since then, we've seen significant growth, including a 20% increase YoY in growth in new repositories, more than 600,000 repositories on Github, over 12,000 commits in 2023, and 60% of AI research implementations choosing PyTorch. We're grateful to our founding members for their support to move the foundation forward.

## Forward thinking technologies

### PyTorch 2.x

This next-generation release solidifies Accelerated Transformers (formerly Better Transformers) as a stable feature. The Beta version includes torch.compile as the core API for PyTorch 2.0. Additionally, it introduces the scaled_dot_product_attention function within torch.nn.functional, the MPS backend, and functorch APIs in the torch.func module. This version also incorporates other Beta / prototype improvements spanning various domains, such as inference, performance, and optimization for training on GPUs and CPUs. Just released in October, PyTorch 2.1 boasts automatic dynamic shape support in torch.compile, torch.distributed.checkpoint for saving/loading distributed training jobs on multiple ranks in parallel, and torch.compile support for the NumPy API.We look forward to the PyTorch 2.x series evolving!

### PyTorch Edge and ExecuTorch

At PyTorch Conference this year, we announced ExecuTorch, the all-new solution for enabling on-device inference capabilities across mobile and edge devices with the backing of industry partners like Arm, Apple, and Qualcomm Innovation Center. This suite of tools enables ML developers to perform on-device model profiling and better ways of debugging the original PyTorch model through benefits like portability, productivity and performance.

**Above images from 2023 PyTorch Conference.**

## Project and community growth

### Expanded Membership

In June 2023, PyTorch expanded its membership to additional organizations to actively contribute to shaping the future of comprehensive machine learning frameworks alongside fellow industry experts. The PyTorch Foundation's goal is to help end users navigate the PyTorch ecosystem, recruit talent, adopt PyTorch, and support open source AI technologies successfully. Being a part of the PyTorch Foundation grants opportunities to help build the future of end-to-end machine learning frameworks alongside industry peers' access to resources that allow them to be stewards of stable, secure, and long-lasting codebases.

### Bolstering community

In 2023, we were thrilled to showcase an impressive influx of new ecosystem tools significantly enriching the PyTorch community. The PyTorch Ecosystem Tools projects contain a wide range of projects contributed by experts from academia, industry, application development, and machine learning. These diverse ecosystem tools help PyTorch flourish. They offer invaluable support for tasks such as pose estimation, probabilistic modeling, performance profiling, model interpretability, speech recognition, quantum computing, data augmentation, optimization, and neural architecture search. Read more about our ecosystem here.

"At Intel, we believe in the power of collaboration and open source innovation to propel the ecosystem toward an AI everywhere future. Joining the Governing Board of the PyTorch Foundation is a testament to Intel's commitment to advancing and democratizing AI. By harnessing the collective expertise and resources within the deep learning community, we aim to accelerate the development of PyTorch and continue to drive breakthroughs in AI research and applications."

***– Wei Li, Vice President and General Manager of AI and Analytics (AIA) at Intel.***

## New PyTorch members

GRAPHCORE

HUAWEI

Hugging Face

IBM

intel

Lightning AI

Creators of PyTorch Lightning

Hyperledger Foundation

Hyperledger Foundation is home to the premiere open source enterprise blockchain community. Since 2015, it has been building and shaping the enterprise blockchain market, with frameworks, tools, and libraries that support real-world needs. It now has hundreds of members worldwide, an extensive landscape of DLT platforms, tools, and labs, seven regional chapters, eight SIGs, and close to 100,000 meetup participants in 84 countries around the world.

In 2023, Hyperledger Foundation introduced a new look: an update of the iconic node logo, now with a trio of nodes that represent the foundation, its members, and the global community. The new colors reflect Hyperledger Foundation's core values: open, global, trusted. The intent of the overall look and feel of the design is for a mature market and ecosystem and an enterprise audience.

Enterprises are getting down to business with blockchain technologies. In the last year, CEOs of companies such as Goldman Sachs and BNY Mellon have penned articles on the long-term value of distributed ledger and blockchain technology. Global adoption is widespread as well. The 2023 State of Enterprise Blockchain Adoption Report from CasperLabs revealed that "nearly 90% of businesses in the U.S., U.K., and China are starting to use blockchain." A recent brand study undertaken by Linux Foundation Research showed sustained enterprise adoption and development rates that confirm blockchain is becoming a more established core technology.

With its growing and diverse community, ecosystem, and project landscape, Hyperledger Foundation is working to ensure the market continues to advance. While there is still a lot of innovation to come, traction is growing in several key areas:


**Hyperledger Foundation's new look for 2023.**

**Central Bank Digital Currencies (CBDCs)**: Around the world, many central banks are exploring new retail and wholesale digital currency models. Openly developed technologies are proving to be fundamental building blocks for these efforts. The growing list of countries tapping into Hyperledger technologies for projects includes Australia, the Bahamas, Brazil, Cambodia, France, India, Nigeria, Norway, Spain, and the Philippines. It also includes the European Central Bank. For details on these projects and more, download the newest version of the Hyperledger in Action in Central Bank Digital Currencies e-book.

**Tokenization:** The use of digital tokens to represent both

digital and physical assets on a distributed ledger is proving key to reducing much of the inherent economic friction of the current global economy. Adoption in the financial sector is driving new asset classes, including CBDCs, unlocking huge amounts of capital, and bringing new investors to the table. But the tokenization of real-world assets, including everything from artwork to racehorses and real estate to precious metals, is also driving down transaction times and costs and creating new business models.

Hyperledger technologies are playing a key role in the tokenization of both digital and real-world assets. **TOKO** is a digital asset creation platform built by global law firm DLA Piper to digitize and distribute real estate, fine art, debt, and even intellectual property assets. Its construction included a combination of a permissioned Hyperledger Fabric network and the Hedera Token Service.

IPwe launched its Smart Intangible Asset Management (**SIAM**) platform in early 2023 and used it to tokenize the majority of the world's patents as patent NFTs. **With verified data, about 25+ million patents stored on a hybrid Casper Blockchain and Hyperledger Fabric network**, enterprises no longer must spend weeks or months manually verifying patent data, and smart contracts will trigger the transactions automatically.

**Enterprise Ethereum:** Ethereum advancements are driving enterprise adoption of blockchain technologies on multiple fronts. Last year's merger and the ongoing efforts of the Enterprise Ethereum Alliance have broadened the corporate market for Ethereum as an enterprise platform.

Hyperledger Foundation has long maintained there will not be one blockchain to rule them all. The Hyperledger project landscape includes several blockchain platforms, including

**Hyperledger Besu**, which can serve as either a public or private execution client for Ethereum. Besu is one of the most used and adopted Ethereum clients and the only one that provides enterprises with parity to the Ethereum mainnet. It offers flexibility for organizations that want to mix, match, or keep their options open when it comes to private and public chains.

The Ethereum Foundation (EF) opted to include Hyperledger Besu in the **Execution Layer Client Incentive Program** (ELCIP) to foster the community development of enterprise-grade blockchain software.

Hyperledger Besu has been adopted in a range of deployments, including CBDC projects and some of the largest European and Latin American blockchain consortiums, namely **Alastria**, European Blockchain Services Infrastructure (**EBSI**), and **LACChain**. Read more on the LACChain deployment in this case study: **LACChain introduces permissioned public blockchain ecosystem built on Hyperledger Besu to Latin America**.

Digital Identity: Verifying identities and information in a digital world is critical for establishing trust. In March, the White House included "Support Development of a Digital Identity Ecosystem" as a strategic objective in the **National Cybersecurity Strategy**.

Decentralized technologies, such as distributed ledgers and verifiable credentials, are at the core of a new generation of digital identity implementations, driven in many cases by governments. Examples range from a travel pass jointly conceived and built by Aruba and SITA to digitized government-issued business credentials in both Rhode Island and British Columbia.

SITA and its development partner, Indicio, rolled out the travel pass with Aruba and are now **introducing** Digital Travel Credentials to the broader travel market. Built using Hyperledger Aries and Hyperledger Indy, the solution enables passengers to store a digital version of their passports in a mobile wallet.

**John Jordan, Executive Director of Digital Trust Service, Province of British Columbia, with Jim Zemlin, Executive Director of the Linux Foundation**

In British Columbia, the BC Digital Trust represents the government's commitment to build confidence online by delivering easy-to-access digital solutions that are safe and secure. Digital Trust solutions are built using open source software, including several Hyperledger technologies, and include the BC Wallet, a smartphone app that allows users to receive, store, and present digital credentials such as permits, identities, and licenses.

One early use case is enabling members of the Law Society of British Columbia to use digital credentials stored inside their BC Wallet to identify themselves, proving they are a lawyer in good standing, to gain access to court materials, swiftly and remotely.

In Rhode Island, the Department of Commerce is leading the way with a Hyperledger-powered application for digitizing certified public accountant credentials. It's a first step toward using digital services to make it easier to do business.

There is a very active and innovative developer community supporting this work. In the last year, they've helped expand the project landscape with the addition of Hyperledger AnonCreds and many components in the Hyperledger Aries tool kit.

**Climate Change Initiative:**
Blockchain is playing a role on many fronts of the climate change battle. DLT and related technologies are valuable in uniting parties to collect, validate, and innovate with climate data. There is a growing range of such applications leveraging Hyperledger technologies, including green finance, sustainability reporting, climate accounting, and supply chain traceability.

In the last year, industry and regulatory efforts have begun to emerge that are driving new, coordinated efforts to mitigate climate damage. This includes a new EU regulation on deforestation-free products and a mandate that will require companies introducing electric vehicles and other industrial batteries into the European market to include a digital battery passport for each battery that proves sustainable, responsible, and circular sourcing.

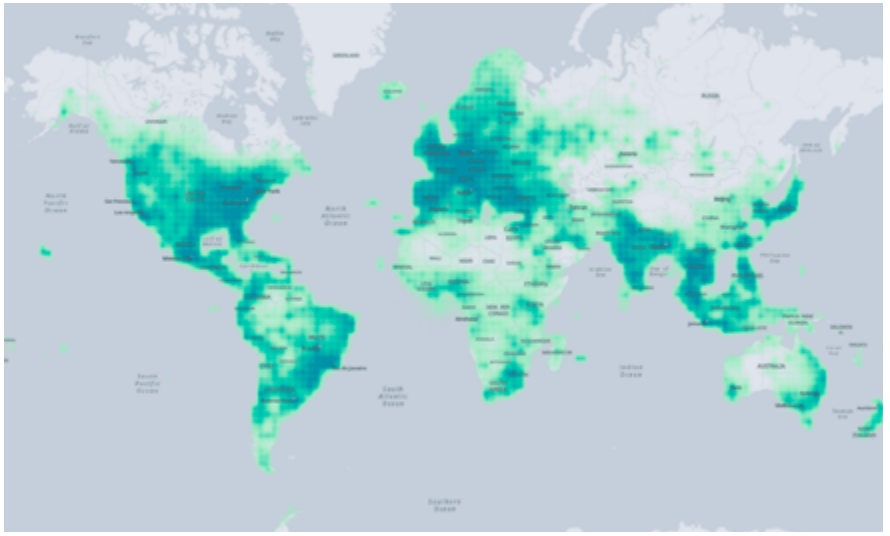
In this new case study, Circulor, which has already united electric vehicle OEMs and supply chain participants on a Hyperledger Fabric-based platform, is taking the lead in the battery passport space. To ready the market for the new rules, Circulor has expanded its solution to track the physical flow of critical battery materials from extraction to final production and into second life and recycling.

# OVERTURE MAPS FOUNDATION

In December 2022, the Overture Maps Foundation (OMF) began as a Joint Development Foundation project to create reliable, interoperable open map data to power current and future mapping products and services. Developers and map creators face significant challenges today. There's the complex and costly task of collecting and updating high-quality data from various sources. Many datasets, even when describing the same real-world entities, use different conventions and terms, creating integration issues. Additionally, open map data can have errors and might not have a useful structure for commercial applications. The purpose of the OMF is to address these challenges.

OMF aims to consolidate map data from various sources through open collaboration, ensuring availability under open data licenses. A key feature is OMF's alignment with the Global Entity Reference System (GERS), designed to provide easy integration and enhance mapping experiences. In July 2023, OMF released its first worldwide open map dataset. This dataset, available to the public, has four themes: Places of Interest (POIs), buildings, transportation networks, and administrative boundaries. These layers amalgamate various open map data sources, all undergoing stringent quality checks, reinforcing their reliability. An emphasis on the Places dataset, a cornerstone for many location-based applications, draws from the vast inclusion of almost 60 million places globally.

This release is a testament to OMF's collaborative spirit. Founded by AWS, Meta, Microsoft, and TomTom, the Foundation now includes over fifteen organizations specializing in mapping and geospatial technology. As global map data requirements evolve, the complexities and costs associated with its collection and upkeep have surpassed the capabilities of any singular entity.



**Overture places data includes almost 60 million places worldwide.**

"We needed to build a bigger community to bring together technology, engineering skills, and data," Marc Prioleau, the executive director of OMF, encapsulated this ethos: "Our aim at OMF is straightforward: Elevate the realm of open map data to power current and next-generation map products. With the collective insights of our expanding community, it's not just about amassing datasets. Instead, it's a conscious effort to lay the groundwork for a future where map data remains current and interoperable, serving a wide range of applications. OMF is about harnessing available high-quality data sources and building bridges

of cooperation. It's a journey, and every step, every release, every partnership counts."

OMF's strategy for the latter half of 2023 focuses on releasing a basemap for all target layers and a stable Global Entity Reference System (GERS) reference for each layer. Central to OMF's innovation is the Global Entity Reference System (GERS). Recognizing the importance of conflating diverse geospatial data sources, OMF introduced GERS to assign unique IDs to every real-world object across its data themes. In October 2023, OMF released its second version of open map data. In this release, the Overture Buildings theme included over 1.3 billion features from multiple data providers, and GERS IDs were assigned to over 1.6 million building footprints across several cities in North America, South America, and Europe. This ensures a seamless integration of datasets, eliminating ambiguity and setting a new standard in open map data structure.

In a rapidly evolving world of data, OMF exemplifies the power of collaborative innovation in open source. By converging collective expertise, OMF is sculpting a future where reliable, interoperable, and open map data sets the stage for countless applications and solutions.

DENNIS KUMMER; UNSPLASH

# Best practices in innovation management

Best practices are at the heart of what we do. Initiatives such as TODO Group, CHAOSS, OpenChain, and FinOps are pioneers in providing the tools and methodologies for enterprise open source use, contribution, and data-driven cloud spending. By setting the standard for open source project management, our projects ensure that innovation is groundbreaking, sustainable, and efficient.


## Helping open source leaders take a sustainable a pproach to open source in their organizations

TODO is an open community of practitioners and organizations that are committed to creating and sharing knowledge and collaborating on practices, tools, and other ways to run successful and effective Open Source Program Offices (OSPOs) and Open Source Initiatives.

Over the past decade, our community has released numerous popular guides, studies, courses, and toolkits in collaboration with other open source projects. Key achievements this year include:

- OSPO Definition v2.0
- OSPO Glossary
- OSPO Book
- The Business Value of OSPO Report
- 2023 State of the OSPO & OSS Initiatives Study
- Improved OSPO Landscape

## Fostering cross-community collaboration

TODO features active working groups where participants collaborate on shared challenges within the OSPO/OSS realm. These challenges range from quantifying the value of OSPO using metrics and integrating them into open source software to crafting guides that empower individual contributors to support the broader OSPO community.

- CHAOSS OSPO Metrics Working Group
- OSPO Career Path Training Courses Working Group
- Open Source Employee Engagement Guide Working Group

### Project collaboration highlights

TODO works with sister projects at The Linux Foundation, including OpenChain (Standards and process management best practices), CNCF (CloudNative Adoption), SPDX (SBOM), OpenSSF (Security), and CHAOSS (Project and Community Health Metrics), that support the pillars of the OSPO framework—Compliance, Strategy, Community and Governance—in their respective areas of expertise.

## Supporting regional OSPO communities:

The OSPO Local Meetups Japan initiative dives into the current landscape of Open Source Program Offices in Japan. It also promotes the adoption of open source strategies within organizations. The TODO Group and OpenChain Japan Working Group support these initiatives.

### Project collaboration highlights

OpenChain Project has an extensive global community of over 1,000 companies that collaborate to make the supply chain quicker, more effective, and more efficient.

## OSPOlogyLive Europe

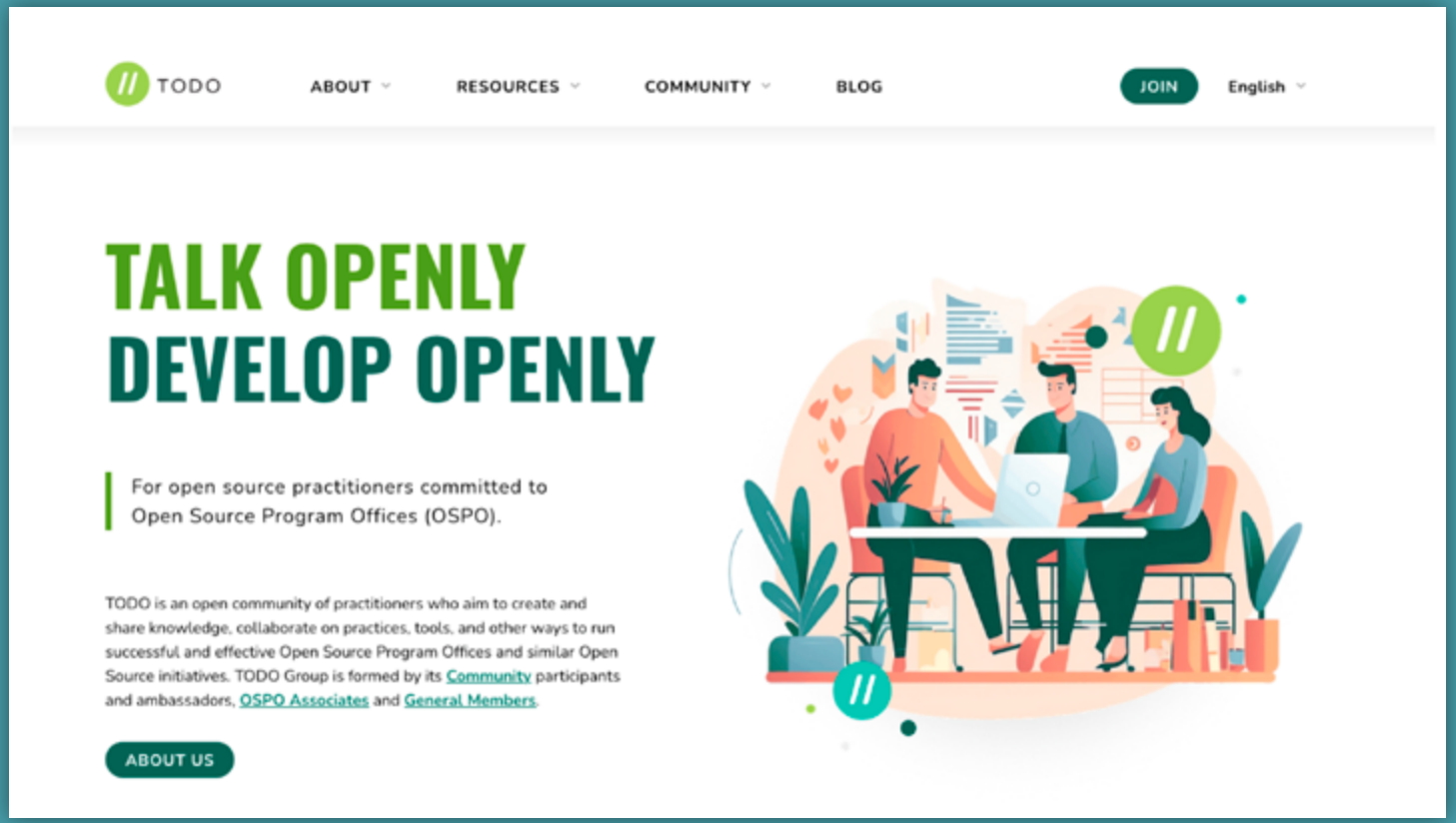
OSPOlogyLive brings together different stakeholder groups engaging in open source across Europe, including industry leaders, open source project maintainers, and policymakers, for a day of insightful expert-led panel discussions, presentations, and roundtable/ workshop sessions.

### Project collaboration highlights

OSPOlogyLive is a collaborative effort. Organizers include representatives from TODO, InnerSource Commons, LF Energy, OpenChain, SPDX, CHAOSS, and OpenSSF projects.


## Enhancements in infrastructure and documentation

The heart of TODO is its contributors and maintainers. We've recently upgraded our contributor ladder, enhanced website accessibility, and revamped our onboarding guide. These improvements aim to streamline the contributor experience. We've also created a process to recognize consistent and impactful contributors through the TODO OSPO Ambassador program.



# CHAOSS

The Community Health Analytics in Open Source Software (CHAOSS) is a Linux Foundation project that is committed to creating metrics, models, and software to better understand the health of open source communities globally. The project serves various stakeholders, including open-source contributors, communities, companies, and foundations.

## Key milestones and initiatives for 2023

**Dawn Foster, Director of Data Science, CHAOSS**

- **Launch of the CHAOSS Data Science Initiative:** Dr. Dawn Foster, the new director of data science, spearheads this initiative, which aims to develop new data science methods and tools to help the CHAOSS community better understand and measure open source community health.
- **Release of new metrics and metric models:** Throughout the year, CHAOSS continued to innovate by developing new metrics and metric models to measure open source community health more comprehensively and nuancedly.
- **Community expansion:** The project's core focus was building a diverse and inclusive community. CHAOSS has made an effort to include more people from underrepresented groups as contributors and users.
- **Increased adoption of CHAOSS metrics and tools:** CHAOSS worked diligently to increase the adoption of its metrics and tools across open source projects, communities, and engineering teams.
- **CHAOSScon 2023:** The annual CHAOSScon event served as a platform for discussing open source project health, updates from CHAOSS, use cases, and hands-on workshops.

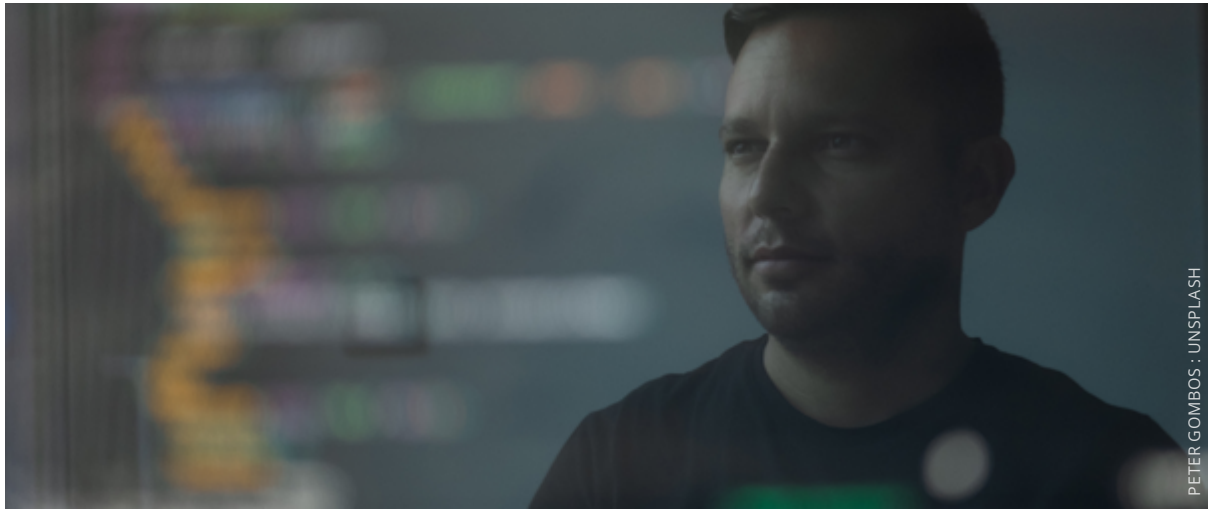
## Additional projects

- **CHAOSS curriculum:** CHAOSS created a curriculum to educate open source projects and communities on measuring and improving their health.
- **CHAOSS data repository:** CHAOSS created a centralized data repository to facilitate easier access to key metrics and analyses.
- **Visualization and analysis tools:** CHAOSS developed new tools to visualize and analyze its metrics in a more user-friendly manner.
- **Collaborations:** CHAOSS also collaborated with other open source organizations to promote the use of its metrics and tools.

# OPENCHAIN

The **OpenChain Project** had an exceptional year. Our proposal for an ISO standard for open source security assurance (ISO/IEC DIS 18974) passed the required ballots and will be published shortly. It joins our existing ISO/IEC 5230 standard for open source license compliance to provide the market with simple, clear process management norms around the fundamental requirements to use open source in the commercial space.

This year also marked a clear recovery from COVID-19 restrictions regarding community events and momentum. Our local language teams in Japan, Korea, Germany, Taiwan, and mainland China resumed frequent face-to-face events. Meanwhile, our global teams have taken advantage of the Open Source Summit events worldwide to hold mini summits. The year 2023 is also the first year that we have introduced new yearly elections around many critical work groups, and our chairs for specification (Helio Chissini de Castro from CARIAD and Chris Wood from Lockheed Martin) and education (Nathan Kumagai from Qualcomm) deserve special credit in recognition of their exceptional work. They join our current project board chair—Jimmy Ahlberg from Ericsson—to help with leading the next generation of open source business process management.



PETER GOMBOS : UNSPLASH

With an ever-expanding community of conformance and supporting partner networks, the project is well positioned to continue to expand its mission of a trusted supply chain. Our ISO standards are going deep into procurement, and while LINE, Alibaba Cloud, BlackBerry, and LG Electronics are a few headline conformance announcements this year, the most important story is what is happening regarding customer and supplier company relationships.

This year, we have worked closely with certifiers such as PwC, CAICT, and Deloitte to position our solutions for reduced risk and increased efficiency as a "go-to" item for any company considering using open source. In combination with police adoption wins, such as the inclusion of our ISO standard for open source compliance in Japanese government guidance, our strategy of long-term embedding into business process management continues to obtain results.

# FinOps Foundation

The FinOps Foundation's mission is to advance every individual who manages the value of the cloud wherever they are by creating connections, inspiring growth, and empowering best practices. FinOps is an evolving discipline and cultural practice that enables organizations to maximize business value by helping engineering, finance, technology, and business teams collaborate on data-driven spending decisions.

The FinOps Foundation saw significant growth in 2023, with individual community numbers rising to over 12,000, an increase from 7,000 in 2022, including representation from 48 of the Fortune 50. The corporate membership program also exceeded 100 organizations, rising from 72 in 2022, including Microsoft joining in 2023, as well as an increasing number of enterprise organizations, such as Apple, AIA, JPMorgan Chase, Fidelity Investments, HERE Technologies, and Capital One. These organizations are joining to educate teams, network with their peers, and develop their FinOps practices through open source best practices.

## Community events: growth of FinOps X, roadshows, and meetups

FinOps X, the annual conference for FinOps that the Foundation hosts, nearly tripled in size compared to 2022, with over 1,100 attendees, 145 speakers, and a wide range of community representation, including those doing FinOps at 30 of the Fortune 50 with an NPS score of 76 (exceptional).

With the continuing demand for in-person events, the Foundation is hosting Roadshow events in strategic cities, including New York, London, Paris, San Francisco, Washington D.C., and Seattle. The Foundation has also launched an updated Meetup program with 34 certified meetup organizers worldwide.

Attendance at the monthly FinOps Virtual Summits continues to top 1,000 participants for the one-to-two-hour sessions featuring learning and stories from five to ten speakers in each session.

## Training and certification

Training and certification for FinOps have rapidly increased as more organizations embark on a talent transformation with cross-functional persona such as finance, engineering, and procurement upskilling in FinOps to maximize cloud value investments. The FinOps Certified Practitioner is on track to more than double the number of certifications completed this year compared with the previous year, now totaling over 8,000.

The FinOps Certified Professional, a prestigious course including over 40 hours of material, has been completed by 70 practitioners—a status that is looked at for those looking to lead a FinOps team at an organization.

This year, we have launched additional training courses focusing on FinOps Personas, including Engineering, Finance, Procurement, Product Owners, and Leadership, as we look to support the wider needs of people in an organization who drive the culture change required for a successful FinOps adoption. We have also been able to support our community by awarding $427,000 in FinOps Foundation Training

scholarships to 600 people in 45 different countries.

## Focus™: FinOps open cost and usage specification

FOCUS™ is a technical specification to build and maintain an open standard for cloud cost, usage, and billing data.

By making billing data easier to understand and more consistently reportable between multiple vendors, FOCUS™ will remove complexity and overhead from processes such as allocation, chargeback, budgeting, forecasting, and other FinOps capabilities to maximize business value in the cloud.

Google Cloud and Microsoft are on the project-steering committee alongside contributors from large enterprise platforms and service providers. We look forward to the version 1.0 release at the end of 2023. Forrester described the promise and need for FOCUSTM in its recent article, Hyperscalers: It's Time to FOCUS.

## Community resources and contributions

The year 2023 has been busy for deliverables, including the launch of the FinOps Landscape to help practitioners discover tools and services in this growing category. The FinOps Assessment, debuting alongside our other announcements, helps practices understand where they are in terms of FinOps maturity and recommends community assets to support their growth wherever they are on their journey.

In 2023, Working Groups nearly doubled our community-created, open source FinOps content, including educational stories, guides, and papers, from 17 to 29 Working Group-generated assets. We have 13 Working Groups actively working on new deliverables across core FinOps topics that enrich the Framework or cover new ground, such as FOCUS or disciplines that intersect with FinOps (such as Sustainability and IT Asset Management).

We look forward to the continuing work of our Special Interest Groups, which create the grounds for deeper discussion around topics that strengthen FinOps culture and adoption while delivering new perspectives. These groups include Diversity, Equity, and Inclusion; Sustainability; Women in FinOps; and our Government Sector group, and we hope to add even more as we continue our growth.

## The future

FinOps has become the standard approach for managing the value of the cloud, with most large organizations globally adopting the practice. In 2024, the FinOps Foundation will invest in growing the global community, continuing to expand the FinOps Framework and support the FOCUS project, and introducing a goal to shift left FinOps education into University Programs to drive FinOps curriculums in computer science, finance, and related business degrees.

# No innovation without collaboration

True innovation can't happen in a vacuum—it requires collaboration. This year's Legal Summit, our broad communications on stopping patent trolls, and the Open Source Congress are a testament to this ethos. These initiatives brought together communities of legal experts, technologists, and innovators to address the complex challenges confronting open source projects and communities.

# Generative AI: A legal risk or open collaboration opportunity?

The year 2023 started with abundant energy as Generative AI (GenAI) was thrust to the forefront of many industry conversations. Many lawsuits were filed, several ethics, policy, and regulation debates kicked off, and the year started with more questions than answers.

The open source legal community quickly came together at LF Legal Summit to understand the new GenAI's capabilities and discuss the underlying legal framework, related implications, and potential risks. Many lawyers were pressed to provide internal guidance to their companies and developers regarding their use of GenAI technologies and what would be appropriate for an open source codebase. With topics and speakers from across the GenAI technical, ethical, and legal communities, the LF's legal community was able to lay the groundwork for the next steps, as companies and open source projects decided how to proceed with GenAI.

We thank all the contributors and speakers who helped navigate the GenAI landscape at the Legal Summit and throughout the year. Through these collaborative efforts, not only was the LF able to provide consensus-developed guidelines to developer communities, but we also welcomed RWKV into LF AI & Data. Additionally, RWKV is the first project community we have hosted, and it implements an open source license (Apache-2.0) with open governance, as communities are now openly collaborating on how their LLM evolves.

Thanks to all our contributors' efforts (legal and technical), we are confident that the LF community ended the year with more clarity and consensus on GenAI than when the year started.

# Open Invention Network and Unified Patents

In 2019, Open Invention Network, IBM, and Microsoft, along with the Linux Foundation, partnered with **Unified Patents** and **launched** an Open Source Zone with the intent of deterring non-practicing entities with invalid patents, better known as "patent trolls," from asserting against open source software packages.

Due to the uncertainty and high cost of patent litigation, patent trolls threaten or file lawsuits against open source implementers to extract settlements, despite their patents likely becoming invalid if challenged.

Unified Patents is an international organization of more than 250 members that seeks to improve patent quality and deter unsubstantiated patent assertions in technology fields. Unified Patents is the only offensive entity with a successful history of ***detecting*** campaigns from nonpracticing entities (NPEs), ***disrupting*** assertions, and ***deterring*** further troll investment.

Since the initial launch, Amazon, Apple, CableLabs (cable company trade org.), DAZN, Mercedes-Benz, Meta, and ServiceNow have joined, allowing Unified to increase its deterrence efforts in the open source field.

Examples of OSS packages and tools defended include: Android, Apache Ambari, Apache Cassandra, Apache Cocoon, Apache Hadoop, Apache modules mod_evasive and fail2ban, Apache Traffic Control, Apache Zookeeper, Argo, Automotive Grade Linux, AV1, Bluez, Ceph, ClamAV, Container Network Interface, CoreDNS, DigiKam, Eclipse CHE (Kubernetes), Envoy, FreeMesh, frredesktop.org's OpenWFD, iFolder, iptables, KDE Konqueror, Kubernetes, KVM, LibreMesh, LibVLC, Linkerd, Linux kernel "ip" command, Linux kernel NFS module, Magento, Nagios, OAuth, OpenACH, OpenSwan, QEMU, Quagga, Redis, Rygel, sedutil, Signal, Varnish Cache, and WebM.

To date, Unified has challenged 54 patents, resulting in the following:

- 39 invalidated
- Five initially determined to be flawed
- One awaiting review

In addition to patent validity challenges, Unified runs PATROLL, a bounty program for prior art. People submit their prior art to demonstrate that the patent in question is invalid. Winning submissions can result in thousands of dollars in prize money. Over $200K in prizes has been awarded. For more information and to participate, visit **www.patroll.art**

# Linux Foundation's response to the U.S. Patent and Trademark Office's proposed rules changes

Earlier this year, the open source community faced a significant threat when the U.S. Patent and Trademark Office proposed rule changes that could severely undermine the integrity of the patent system and, by extension, open source innovation.

The proposed changes aimed to restrict third parties from challenging questionable patents, effectively giving free rein to NPEs, or "patent trolls," to exploit the system, increasing the volume of patent litigation and raising expenses for startups and foundations alike. The changes will also make it more challenging for watchdog organizations such as Unified Patents and the Electronic Frontier Foundation to prevent bad patents from being granted.

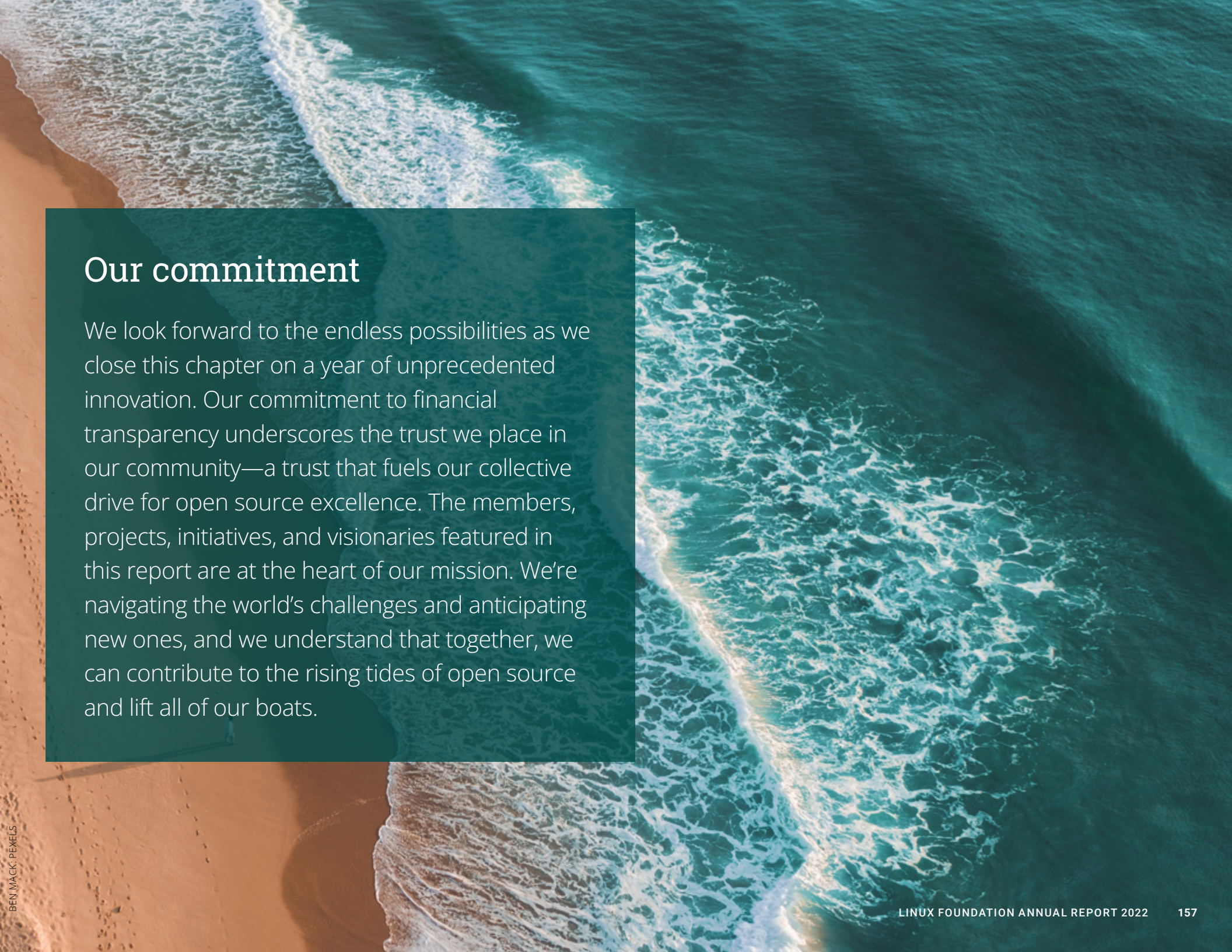
We called on all community members to voice concerns before the June 20 deadline. Many of you joined an informational webinar on June 7 and participated in the public call for comments using the templates we provided to facilitate this response.

Approximately 14,500 comments were submitted, and this volume will be critical to determine whether the rule changes go through. We are already hearing that our efforts made a difference and expect a successful result for our free and open source software communities. Thank you to all who stood with us to support open innovation.

# Open Source Congress

On July 27 in Geneva, Switzerland, 53 leaders from 37 organizations convened by special invitation for open source, standards, and policy organizations. Participants discussed priority issues,  discussed current priority issues and ways to coordinate across organizations to address future issues. The discussions were captured in a report entitled *Standing Together on Shared Challenges: Report on the 2023 Open Source Congress* that LF Research published as a follow-up to the January 2023 report, *Enabling Global Collaboration: How Open Source Leaders are Confronting the Challenges of Fragmentation*.

During the Congress, participants engaged in panel discussions, breakouts, and a workshop, where topics included open source security, technology policy and regulation, AI, diversity, equity, and inclusivity. These productive sessions broadly affirmed the unique role of open source as a global public good requiring international collaboration, stewardship, and effective governance. The gathering strengthened existing networks, established new channels to aid communications, and created a sense of goodwill among those present.

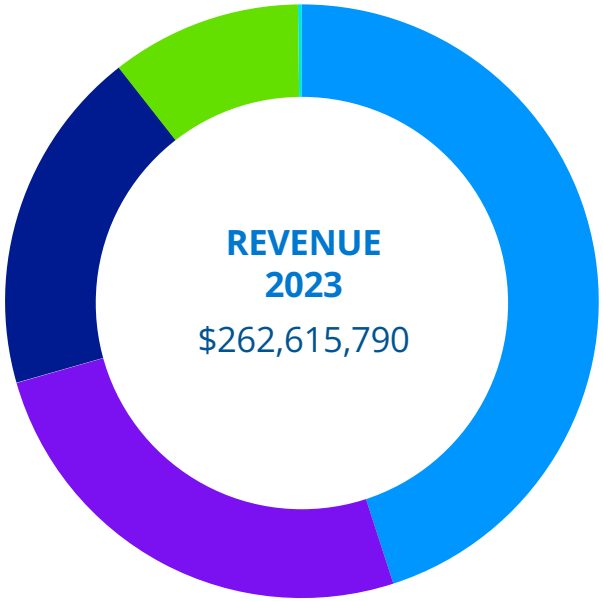


## Our commitment

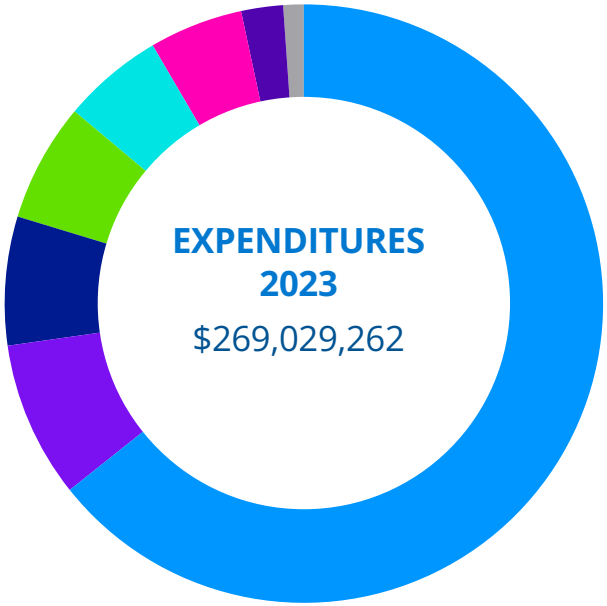
We look forward to the endless possibilities as we close this chapter on a year of unprecedented innovation. Our commitment to financial transparency underscores the trust we place in our community—a trust that fuels our collective drive for open source excellence. The members, projects, initiatives, and visionaries featured in this report are at the heart of our mission. We're navigating the world's challenges and anticipating new ones, and we understand that together, we can contribute to the rising tides of open source and lift all of our boats.

BEN MACK: PEXELS

## Revenue and expenditures




- Membership & donations **45% ($118,213,748)**
- Project support **26% ($67,077,259)**
- Event sponsorships and registrations **19% ($49,517,576)**
- Training and certification **10% ($27,253,092)**
- Other **0.2% ($554,115)**



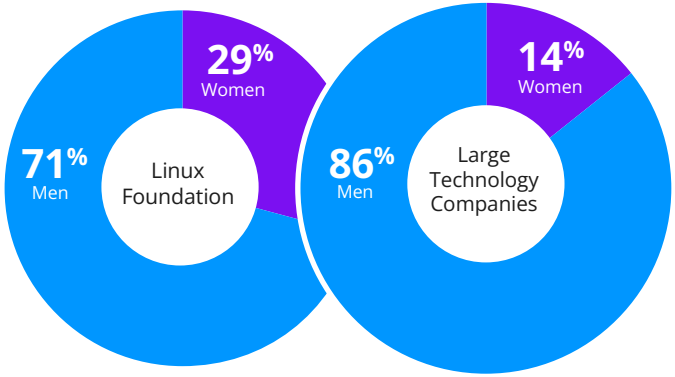

- Project support **64% ($171,854,065)**
- Project infrastructure **9% ($22,584,890)**
- Training and Certification **7% ($18,570,211)**
- Corporate operations **6% ($17,123,359)**
- Event support **6% ($14,602,847)**
- Community tooling **5% ($13,529,484)**
- Linux kernel support **2% ($7,804,150)**
- International operations **1% ($2,960,256)**

The Linux Foundation's revenue is derived from four main sources, Memberships and Donations, Project Support, Training and Certifications, and Event Registration and Sponsorship. In 2023 we are forecasting revenues of $262.61M. In 2023 the Linux Foundation is forecasting to spend over $269.02M supporting our mission.

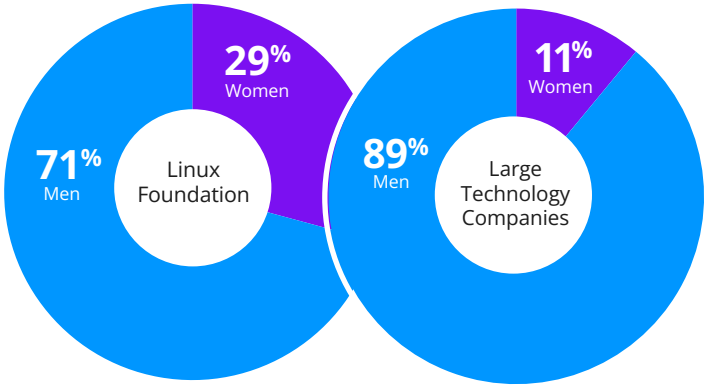
The LF and our directed fund projects operate on calendar year zero-based budgets, and any net surpluses are reserved for use by those projects in subsequent years. Annual aggregated expenses across the LF and our Projects may exceed annual revenue during a period, but the deficit is made up with reserve funds from the respective projects. Aggregate revenue across our organization reflects actuals, and project expenses reflect conservative forecasts. Please see the Foundation's most recent 990 for details on overall reserves

## Profile of the Linux Foundation

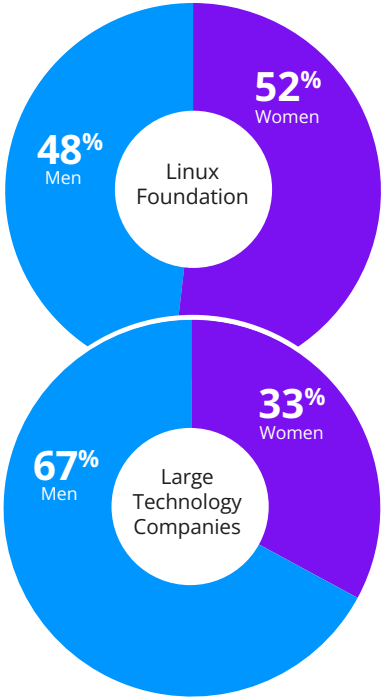
### Board seats representation



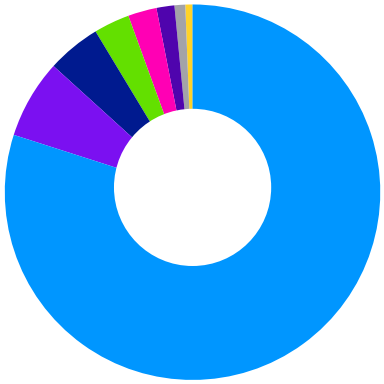

### Executives representation




### Overall representation




## Linux Foundation employees around the world



- United States **80%**
- Europe **7%**
- Canada **5%**
- Philippines **3%**
- Japan **3%**
- India **2%**
- Australia **1%**
- South America **1%**

THE LINUX FOUNDATION

## About The Linux Foundation

The Linux Foundation is the world's leading home for collaboration on open source software, hardware, standards, and data. Linux Foundation projects are critical to the world's infrastructure including Linux, Kubernetes, Node.js, ONAP, Hyperledger Foundation, PyTorch, RISC-V, and more. Linux Foundation focuses on leveraging best practices and addressing the needs of contributors, users, and solution providers to create sustainable models for open collaboration. For more information, please visit us at www.linuxfoundation.org.

## Connect with us

twitter.com/linuxfoundation

facebook.com/TheLinuxFoundation

linkedin.com/company/the-linux-foundation

youtube.com/user/TheLinuxFoundation

github.com/LF-Engineering

548 Market St
PMB 57274
San Francisco, California 94104-5401 US

info@linuxfoundation.org
www.linuxfoundation.org