



# **Annual Report 2022**

## Leadership in Security and Innovation

[www.linuxfoundation.org](http://www.linuxfoundation.org)



# Contents

Security, innovation, and impact: A message from our Executive Director .....	5
2022 in numbers .....	5
Growing the global impact of open source .....	5
Exceeding industry standards in diversity and inclusion .....	7
Facing the challenges ahead: Cybersecurity and techno-nationalism .....	7
Enabling innovation and security at the Linux Foundation .....	9
Linux Foundation Board of Directors .....	11
Thank you to our members .....	12
Linux Foundation members .....	13
Platinum members .....	13
Gold members .....	13
Silver members .....	14
In memoriam: Shubhra Kar .....	22
Serving over 986 open source project communities .....	23
Innovation with an evolving Linux kernel .....	24
Fostering growth, quality, and velocity .....	25

---

## CELEBRATING THE INNOVATORS 26

Innovation with a global impact .....	27
Saving wildlife: Peace Parks Foundation and OpenJS Foundation .....	27
OpenCollar animal tracking and the Zephyr real-time operating system .....	27
Data modeling for climate change: OS-Climate .....	28
Open charging for electric vehicles: EVerest (LF Energy) .....	28
Mine-to-manufacturer traceability of a conflict mineral: Circulor (Hyperledger Foundation member) .....	28
Employee and student health v erification: Cardea .....	29
Improving network access for underserved communities: Magma .....	29
Securing open source software: OpenSSF .....	29
Welcoming the PyTorch Foundation .....	30
Investing in European innovation: The launch of Linux Foundation Europe .....	31
OpenWallet Foundation: Advancing interoperability in digital wallets ....	33
Sylva .....	34



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

All images in this book  
are sourced from [Linux  
Foundation Flickr](#), [Unsplash](#),  
[Pexels](#), and [Stocksnap](#).

All icons used within are from  
[The Noun Project](#).

---

## SOFTWARE SUPPLY CHAIN SECURITY 35

Engaging the public sector on  
open source software worldwide ..... 36

OpenSSF..... 37

2022 highlights ..... 37

Software Package Data Exchange (SPDX) ..... 41

Related security activities at the Linux  
Foundation ..... 42

Internet Security Research Group (ISRG)..... 42

---

## LF RESEARCH: MEASURING THE IMPACT OF OPEN SOURCE INNOVATION 43

2022: A year of insights ..... 44

Focusing on people:  
Maintainership and mentorship ..... 44

Focusing on priority issues:  
Core research projects ..... 45

People-powered innovation  
within industry verticals ..... 46

Focusing on technology trends:  
Research from Linux Foundation projects..... 47

---

## LFX 48

---

## MENTORSHIP AND DIVERSITY 51

LFX Mentorship ..... 52

Mentorship and Events ..... 53

Diversity, equity, and inclusion efforts..... 55

Grace Hopper Conference ..... 55

Open Hardware  
Diversity Alliance ..... 57

Open Mainframe Project  
diversity efforts ..... 57

---

## INVESTING IN TRAINING AND CERTIFICATION 58

Leveraging learning to support  
talent acquisition and retention..... 59

New courses in 2022 ..... 60

Certifications and credentials..... 61

Scholarships ..... 61

10th Annual Jobs Report  
summary of findings ..... 61

---

## EVENTS 62

Returning to our global community ..... 63

Looking forward to 2023..... 64

---

## INNOVATION IN TELECOMMUNICATIONS AND THE EDGE 65

Open source networking:  
Reshaping global connectivity for  
five years and counting ..... 66

5G Super Blueprints:  
Enabling integrated, accelerated cross-stack  
5G use case deployments ..... 67

Edge and IoT now mandating open source  
frameworks: A market four times the  
size of cloud computing ..... 68

U.S. GOV OPS..... 69

Nephio.....	70
SONiC.....	70
DPDK.....	70
Magma.....	71
eBPF.....	71
ORAN-SC .....	71
DENT .....	71

---

## **INNOVATION IN WEB, CLOUD, AND DEVOPS 72**

OpenJS Foundation.....	73
Bringing JavaScript users together through diversity among people and projects .....	75
Cloud Native Computing Foundation.....	76
Contributor-led innovation .....	76
Humanizing security.....	76
Building the road ahead .....	77
Continuous Delivery Foundation .....	78

---

## **COMMUNITIES BUILDING OPEN SOURCE BEST PRACTICES 80**

TODO Group (open source program offices) ...	81
OSPO educational publications .....	82
FinOps Foundation: Advancing how organizations understand and value cloud usage .....	83

Gathering and inspiring FinOps practitioners from all types of organizations globally.....	83
Increasing investments into our thriving community.....	84
Building upon our innovative momentum into 2023 and beyond .....	85

---

## **INNOVATION IN ENTERTAINMENT 86**

Academy Software Foundation.....	87
Open 3D Foundation and Open 3D Engine .....	89

---

## **MAKING AN IMPACT ON PEOPLE AND THE PLANET 92**

LF Energy.....	93
OS-Climate .....	96
Green Software Foundation (GSF).....	99
AgStack.....	99
OpenTreatments and RareCamp .....	100
Linux Foundation Public Health.....	101
Hyperledger Foundation.....	102
Climate change initiatives.....	102

---

## **INNOVATING WITH HARDWARE, EMBEDDED, DEPENDABLE, AND IOT SYSTEMS 103**

RISC-V International.....	104
---------------------------	-----



OpenPower .....	106
CHIPS Alliance.....	107
Open Programmable Infrastructure (OPI) .....	109
Automotive Grade Linux .....	110
AGL Unified Code Base.....	110
Software Defined Vehicle.....	111
Trust over IP Foundation .....	112
Confidential Computing Consortium .....	113
ELISA .....	113
Yocto Project.....	114
sel4.....	114
Zephyr .....	115
Open Mainframe Project .....	116
Civil Infrastructure Platform .....	117
Dronecode .....	117
Open Voice Network.....	118

---

## **INNOVATION IN OPEN STANDARDS      119**

Standards and specification development ....	120
LF Energy Carbon Data Specification Consortium .....	121
LF Energy Super Advanced Meter .....	121
Open19.....	122
Quantum Intermediate Representation .....	122
Alliance for Open Media .....	123

The Coalition for Content Provenance and Authenticity.....	123
OpenAPI Specification .....	124
Uptane .....	124
GraphQL .....	124
R Consortium.....	125

---

## **UNIFIED PATENTS OPEN SOURCE ZONE      126**

---

### **INNOVATING WITH ARTIFICIAL INTELLIGENCE, MACHINE LEARNING, DATA, BLOCKCHAIN, AND FINANCIAL SERVICES      128**

Creating communities with the LF AI & Data Foundation .....	129
LF AI & Data by the numbers.....	130
Delta Lake .....	130
OpenHPC .....	132
Hyperledger Foundation.....	132
openIDL .....	133
FINOS.....	134
Maintainer highlights.....	136

---

## **FINANCIAL TRANSPARENCY      137**

Revenue.....	138
Expenditures.....	138
Profile of the Linux Foundation.....	139
Linux Foundation around the world.....	139

# Security, innovation, and impact:

## A message from our Executive Director

The year 2022 was successful for both open source and the Linux Foundation, despite economic headwinds. Our success during a year of many challenges is a tribute to you, our member supporters. You stuck with us and even increased your commitments. Thank you. I also want to credit the hundreds of thousands of project contributors who run our projects and the hard work and diligence of the Linux Foundation's talented employees. Kudos all around.

### 2022 in numbers

In 2022, we continued to demonstrate strong growth across all metrics. We added 79 new projects and shipped 52.6 million lines of code weekly across more than 12,000 repositories. The Linux Foundation is now the leading player in the open standards space, with over 200 open standards efforts across

numerous industries. Further, open source users downloaded 12.6 billion containers, and we saw a strong bounce back for in-person activities. We gathered over 92,000 people from 176 countries and over 12,000 organizations at 230 official events, setting a new attendance record. Lastly, we convened over 29,000 community meetings.

During 2022, over 2.7 million people received training and certifications from the Linux Foundation, with over 10,000 people signing up for our free open source security training course on release day. We will continue to develop the research and insights field, with Linux Foundation Research releasing 15 unique reports in 2022. Financially, we are more stable than ever before—revenues continue to increase, yet no single member company represents more than 1%



of our total revenues. In 2022, we set a new membership record, with over 3,000 organizations proudly posting their logos on our site.

### Growing the global impact of open source

The Linux Foundation aims to have an impact on the world around us. Each year, we ask ourselves: Are we moving the needle? In 2022, the answer was a resounding yes.

Here's a simple thought exercise. There are currently 605,000 technical contributors working on our projects. Based on the global averages of programmer salaries, that amounts to a \$26 billion contribution in developer hours in 2022. This is arguably a low estimate. The salary budgets of the R&D arms of major technology companies, which produce far less code, are in the tens of billions of dollars a year. It is not an

“Ensuring that a project like PyTorch lives in a neutral home where all can benefit equally is a big deal.”

exaggeration to say that contributors to Linux Foundation projects, and open source in general, comprise the largest distributed engineering workforce globally by orders of magnitude.

We can do anything we put our minds to by working together and collaborating under the auspices of a neutral foundation. The code we develop in our projects touches billions of lives and makes the planet safer, cleaner, more just, and more prosperous.

► In October, PyTorch joined the Linux Foundation. PyTorch is one of the fastest-growing open source projects in the world today, and more than half of the world’s artificial intelligence and machine learning applications depend on its framework. PyTorch is the foundation of models for predicting diseases, directing autonomous vehicles, and creating new medicines. Ensuring that a project like PyTorch lives in a neutral home where all can benefit equally is a big deal.

- RISC-V is now the world’s fastest-growing semiconductor chip instruction set architecture (ISA). It was a small project when it first came to the Linux Foundation in 2018. Today, RISC-V is on track to be the top ISA for 80 billion computer cores by 2025. We are seeing an explosion of RISC-V designs across many applications, including IoT, aerospace, automotive, mobile devices, and datacenter hardware.
- When the U.S. Cyber Safety Review Board (the equivalent of the U.S. Transportation Safety Board) released its official review of the Log4J event, nine of the 19 recommendations came directly from OpenSSF’s Open Source Software Security Mobilization Plan.
- Over 60% of the world’s top-grossing films in 2022 used open source software stewarded by the Academy Software Foundation, which allows the creative industries to share the costs of creating foundational tools for special and visual effects.

- LF Energy and its SOGNO Project members in Germany, Greece, Ireland, Italy, and Romania are improving power delivery efficiency. Considering the skyrocketing energy prices in Europe, SOGNO demonstrates the critical importance of open source for tackling transnational challenges that affect citizens’ lives.
- We are partnering to monitor livestock movements through the Open Collar Initiative, an open hardware project built with code housed in the OpenJS Foundation and using IoT code from the Zephyr Project. The Peace Parks Project uses open source software to fight poachers in South Africa.
- The OS Climate project is pioneering efforts to create software standards and mechanisms for efficient inventories and common definitions of carbon emissions and offsets, laying the foundation for better carbon tracking and trading platforms.

These impacts add to the growing influence of open source code and ecosystems housed in the Linux Foundation. Although Linux is now the dominant operating system on the planet, the Linux Foundation is much more than Linux. From supercomputers to tiny IoT devices, Android phones to automobiles, and space satellites to more than 1 million drones, the world increasingly runs on open source. Open source adoption will only accelerate and spread.

### Exceeding industry standards in diversity and inclusion

We accomplished all this while delivering on our promise of prioritizing diversity and inclusion. At the Linux Foundation, women hold 32% of executive roles. That's roughly triple the average at technology companies. On key project boards, women comprise 28% of members, which is double the percentage found on corporate boards in tech. Moreover, more than half of our employees are female, which is roughly 20% more than the tech

industry writ large. Mentorship is one of the most effective tools for accelerating diversity. The LFX Mentorship program works with more than 240 open source developers, including 30 new kernel developers. In 2022, 20% of mentorship applicants were women, and 70% were from lower middle- or working-class economic backgrounds. During the past year, we provided over \$1 million in travel funding to 289 people from underrepresented communities, 246 maintainers and students, 104 diversity registration scholarships, and 65 needs-based registration scholarships to attend career-changing events.

Beyond the numbers, we continued advancing programs and technologies to foster even greater levels of diversity, equity, and inclusion (DEI). Our events team rolled out comprehensive DEI policies for all Linux Foundation events, including free childcare, nursing rooms, and all-gender restrooms. Many of our projects participated in the Grace Hopper Celebration to encourage

minorities, women, and nonbinary people to join and contribute to free and open source software projects. Today, all our large projects have ongoing diversity initiatives. A notable example is the Inclusive Naming Initiative, which provides guidance on inclusive language best practices and specific word choices. The Software Developer Diversity and Inclusion (SDDI) Project and the Diversity Empowerment Summit are popular and growing. We are also looking to instantiate diversity through code. The Five-Fifths Voter Project, part of the Call for Code for Racial Justice, is an application that aims to combat voter suppression.

### Facing the challenges ahead: Cybersecurity and techno-nationalism

In 2022, we witnessed the emergence of cybersecurity and techno-nationalism as the key challenges to the ongoing growth and adoption of open source. In cybersecurity, the imperative of securing the open source supply chain and providing assurances

“We accomplished all this while delivering on our promise of prioritizing diversity and inclusion. At the Linux Foundation, women hold 32% of executive roles. That's roughly triple the average at technology companies.”



that open source code is safe has become a matter of international concern. Increasingly, cyberattacks, such as ransomware and malware, are impacting the physical world. Two examples of this are hospitals rerouting ambulances and shipping companies being unable to route trucks or planes. Therefore, OpenSSF and its initiatives in software bill of materials, code signing, secure coding, and broad vulnerability scanning will become even more critical.

With greater restrictions on collaboration and trade, the world risks losing the benefits of open source and open collaboration. As one of my heroes, former U.S. Secretary of State Madeleine Albright, said, we must compartmentalize our disputes and agree on common areas of interest. Open source is non-zero-sum in the best way. If it works, everyone benefits. Our job at the Linux Foundation is to continue to advocate for more open collaboration to drive global dividends in technology innovation.

For 2023, we will continue to focus on impact, diversity, and moving the needle on solving big, complex problems, such as climate change, software security, and food security, to push the envelope of technology. Together, we are smarter, faster, and better. I look forward to seeing all of you in the coming year as we continue on this open source journey together. Thank you for your support and commitment.

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



# Enabling innovation and security at the Linux Foundation

## Nithya Ruff, Board Chair

Welcome to the 2022 Linux Foundation Annual Report. I lead the Open Source Program Office (OSPO) at Amazon, and this report marks my fifth as Board Chair of the Linux Foundation.

In late September, I had the distinct pleasure of attending the Open Source Symposium hosted by the University of California at Santa Cruz (UCSC). UCSC is a leader in open source, and this symposium was a fabulous event where I reconnected with peers and learned new things about my chosen field. It both was amazing and felt normal.

After two years of distance and viewing the world through the lens of video conferencing, I have tremendously enjoyed getting back out there and meeting so many of you in person. One of my



favorite things about open source is the community friendships and the personal bonds that we build. Open source is much more than a methodology and set of practices; seeing those people you care about makes this crystal clear. Meeting people in person also fuels innovation. Face-to-face encounters and hallway chats invariably yield not just greetings

but also insights and ideas and even plants seeds for new projects and technologies.

I am incredibly impressed by the trajectory of the Linux Foundation and the progress we have made on so many fronts in the past year. I daresay we enter a golden age of open source innovation, with the Linux Foundation guiding new entrants and paving the way for collaboration on new fronts. You, the members, made this progress through funding and by dedicating engineers and code to Linux Foundation initiatives. I also want to salute the Linux Foundation team for raising the bar in 2022 with a host of new programs and initiatives—LF Research, LFX, more blogs, more podcasts, website improvements, improved tooling and project infrastructure, and more.

The theme of this report is innovation and security, and 2022 was a breakout year for the Linux Foundation on both fronts. PyTorch joining the Linux Foundation and the rapid adoption of RISC-V join the ongoing success stories of the CNCF and cloud native and builds on the progress of the Linux kernel itself. The innovation communities hosted by the Linux Foundation made significant progress against shared global challenges in finance, transportation, energy, and food security. We are witnessing a grand expansion of open source at all levels, particularly in code and infrastructure. We also fine-tune and develop methods and practices for peer-based innovation and collaborative problem-solving.

With this grand expansion comes greater responsibility. For open source to continue to prosper

“It takes resources,  
people, and  
commitment to  
achieve these big goals.  
Whenever I go out and  
meet with you, I return  
more encouraged.  
The opportunity is  
immense, and your  
continued support  
makes it possible.”

and for the world to embrace it, we must make open source more secure. This is self-evident and is a generational technology challenge—a true moonshot. The difference is that moonshot can only stick the landing if everyone works together, because the problem is far too sprawling and complex otherwise.

Unlike landing on the moon, open source security is a moving target. Software and technology are constantly evolving, and billions of lines of fresh code ship daily. We must create a culture of security, tooling, and programs to help better secure all open source software at every project lifecycle stage. It is essential for massive efforts like Linux and Kubernetes down to small JavaScript dependencies that may have a single maintainer but can still “break the Internet.”

On the consumption side, we must make it easier for consumers of open source to know exactly what they are getting—with SBOMs, code signing, security scorecards, and more. The OpenSSF has stepped up to this task with its many contributors and contributing organizations. I am confident we are on a path that will vastly improve open source security within the next few years.

It takes resources, people, and commitment to achieve these big goals. Whenever I go out and meet with you, I return more encouraged. The opportunity is immense, and your continued support makes it possible. Thank you, and I can’t wait to see you all in 2023.

**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*



Eileen Evans  
*At-Large Director*



Melissa E. Evers  
*Intel*



Frank Fanzilli  
*At-Large Director / Treasurer*



Peixin Hou  
*Huawei*



Eric Johnson  
*GitLab, Inc.—Silver Director*



Ken Komoyama  
*Fujitsu*



Xin Liu  
*Tencent*



David Marr  
*Qualcomm*



Chris Mason  
*Meta*



Ben Maurer  
*Meta*



Hisao Munakata  
*Renesas—Gold Director*



Jessica Murillo  
*IBM*



Yuichi Nakamura  
*Hitachi*



Shojiro Nakao  
*Panasonic—Gold Director*



Sarah Novotny  
*Microsoft*



Daniel Park  
*Samsung*



Phil Rob  
*Ericsson*



Nithya Ruff  
*Chair*



Keiichi Seki  
*NEC*



Chris Wright  
*Red Hat*



Jim Wright  
*Oracle*



Jim Zemlin  
*Executive Director*

# Thank you to our members

After two long years of a global pandemic, 2022 ushered in a new era of promise for open source. Thanks to the generous support of LF members like you—and the support of a diverse and global contributor and maintainer community—we have advanced the adoption of powerful new open source solutions and reignited the communities behind them. Thanks to your dedication to open source, we are again coming together at events. With each event, we celebrate our project developers, contributors, reviewers, and maintainers in person, whose cumulative efforts now service much of the global software stack.

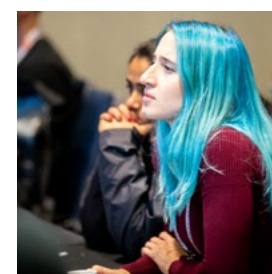
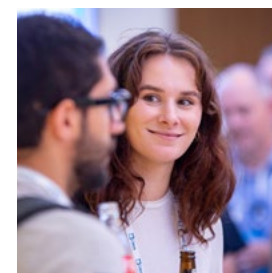
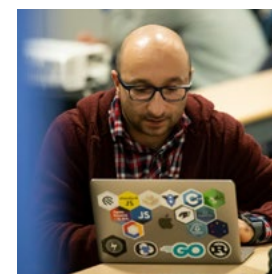
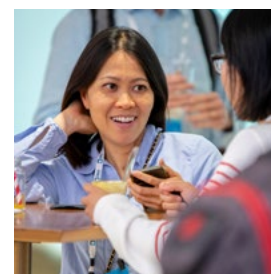
In January, you called for more sustainability, inclusion, and global perspectives. We listened.

Since then, we have expanded our climate and environmental initiatives. We published actionable insights and datasets through LF Research. We provided hundreds of scholarships to underserved communities, welcoming diverse and talented people from around the world to help build a better, more equitable open source future. All of this was made possible with your support.

Thanks to your spirit of collaborative innovation, we welcomed new projects across many fields including cutting-edge areas like Digital Wallets and AI. We brought government and enterprise together to improve the state of open source software security. We expanded into Europe to foster region-specific open source transformation. With your continued support, we will drive open source transformation in regions worldwide.

As we head into a year marked by global conflict, rising inflation, and economic turbulence, your unwavering support for collaborative innovation will enable us to solve new challenges, build innovative solutions, and broaden the adoption of open source technologies.

Thank you for your commitment to open source at the Linux Foundation. We wish you safety, prosperity, software security, and, above all, success in 2023.



# Linux Foundation members

## Platinum members



## Gold members



## Silver members

### #

0Chain  
1Crew  
1NCE GmbH  
1Password  
23 Technologies GmbH  
3-Shake Inc  
3K Technologies  
6WIND S.A.  
99Cloud Inc.

### A

A10 Networks  
ABB Ltd  
ACC ICT  
ACKSTORM  
AIA  
AIFRICA  
AIM (agile-im.de)  
ALPS ALPINE  
ANTMICRO LTD  
APE FACTORY  
APIIDA AG  
AQSACOM  
ARIMA  
ARMO (Cyber Armor)  
ASRock Rack  
Incorporation  
ASUS Cloud Corporation  
ATB Ventures  
ATIX AG  
AVEVA Group  
AVL Software and  
Functions GmbH

AVSystem sp. j.  
Aarna Networks  
Absa Bank Limited  
Accuknox  
Acend GmbH  
Acnodal, Inc.  
Acorn Labs, Inc  
Acornsoft  
Acumatica Inc.  
Ad Hoc LLC  
Adaptive Financial  
Consulting Limited  
Adfolks LLC  
Adobe Inc.  
Adva Optical Networking  
SE  
Advanced Driver  
Information Technology  
Corporation  
Advanced Micro Devices  
(AMD)  
Adventium Labs  
Aerospike  
Affinidi Pte Ltd  
Afi Technologies  
Agenda d.o.o.  
Agile Lab  
Agree Technology Co., Ltd.  
Ahana Cloud, Inc.  
Airbnb  
Airbyte  
Airlock by Ergon  
Informatik AG  
Airwayz  
Aisin Corporation

Aiven Inc  
Akamai Technologies, Inc.  
Akatsuki inc.  
Akenes SA (Exoscale)  
Akuity, Inc.  
Alauda, Inc  
Alerant Zrt.  
Algorand  
Allianz Investment  
Management  
Alluxio, Inc.  
Allwinner Technology, Co.  
Ltd.  
Altair  
Alter Way Cloud  
Consulting  
Althea  
Altinity  
Altoros  
Amadeus IT Group, S.A.  
Amantya Technologies,  
Inc  
Amazon Web Services, Inc.  
Ambassador Labs (f/k/a  
Datawire)  
Amberflo.io  
Ambient IT  
Amdocs Limited  
American Express Banking  
Corp.  
American Tower  
Corporation  
Amido  
Ampere Computing  
Anaconda, Inc

Anchnet  
Anchore, Inc  
Andes Digital  
Anglepoint Group Inc  
Anjuna Security, Inc.  
Anodot Inc.  
Anonymo Labs, Inc.  
Ant Group Co., Ltd.  
Aokumo Inc.  
Apiiro  
Apollo GraphQL  
Appaegis, Inc.  
Appddiction Studio  
Apple Inc.  
Appstellar  
Apptio  
Appvia Ltd.  
Aqua Security Software,  
Inc.  
ArangoDB  
Arcadyan  
ArcherOS Software Co.,  
Ltd.  
Archera  
Arcontech Group PLC  
Arduino  
Argonaut  
Arista Networks, Inc.  
Arkamys  
Arm Limited  
Armory Inc.  
Arnica  
Arrikto, Inc.  
Arvancloud

Ascensio System SIA  
AsiaInfo Technologies  
(China) Co., Ltd.  
Aspecto Inc  
Aspen Mesh  
Asserts  
Astra Linux  
Aternos GmbH  
Atlassian Inc  
AtomicJar Inc  
Atos France  
Audiokinetic Inc.  
Augtera Networks  
AuriStor Inc.  
Authzed  
Autodesk  
Automat-IT  
Automatic Data  
Processing, Inc. (ADP)  
Automotive Intelligence  
and Control of China  
Co., Ltd.  
Avanade Inc.  
Avanza Innovations IT  
Solutions LLC  
Avast Software, Inc.  
Avesha  
Avisi Cloud  
Aviz Networks  
Axcelinno  
Axiata Digital Labs  
Axis Communications

### B

B1 Systems GmbH  
BCW Group  
BMC Software, Inc  
BMW  
BNP Paribas  
BONbLOC Inc  
BS Company Srl  
Baidu USA LLC  
Balena, Inc.  
Bancolumbia  
Bank of America  
Corporation  
Bank of Montreal  
Bank of New York Mellon  
Banma Information  
Technology  
Baumer Management  
Services AG  
BayLibre Inc.  
BeOpenIt  
BedRock Systems Inc.  
Beechwoods Software,  
Inc.  
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)	Boost Security	Capital One Services LLC	Chronosphere, Inc.	Cloudwiry	CoreHive Computing LLC
Beijing Proinsight Technology Co., Ltd.	Booz Allen Hamilton, Inc.	CarbonLaces	Ciena Canada, ULC	Cloudyuga Technologies Private Limited	CoreStack
Beijing Security Consensus Technology Co., Ltd	Bosch	Carbonated	Cinema GmbH	Clyso GmbH	Coredge.io
Beijing Shengxin Network Technology Co., Ltd. (QINGTENG)	Boston Consulting Group	CasperLabs LLC	Cirba d/b/a Densify	CoSoSys S.R.L.	Corsha
Beijing Shuyue Mingjin Technology Co., Ltd.	BoxBoat Technologies	Cast AI Group, Inc.	Circle Internet Services, Inc	Cockroach Labs	Cortex
Beijing Sup-info Information Technology Co. Ltd	Brickdoc (Ningbo) Cloud Computing Technology co., Ltd.	Catalogic Software	Circulor Ltd.	Codasip s.r.o.	Cosaic, Inc.
Beijing Teamsun Technology Co., Ltd	Broadcom Corporation	Catalyst Cloud	Cirrus Logic	Code Zero Technologies Inc	Cosmonic
Beijing VNET Broad Band Data Center Co., Ltd.	Brobridge	Catena cyber	Citi	CodeWave	Couchbase, Inc.
Beijing Xiaomi Mobile Software Co., Ltd	Bunnyshell	Caylent Inc	Civo Ltd.	Codefresh, Inc.	Cox Communications, Inc.
Bell Canada	Buoyant, Inc.	Centilytics	Clastix SRL	Codethink	Crafter CMS
BellSoft	Business-intelligence of Oriental Nations Corporation Ltd	Cerbos	Cleartrace	Cog Systems	Crayon
BetterCloud	Bytedance Ltd	Certizen Limited	Clockwork.io	Cognizant Technology Solutions	Creationline, Inc.
Biqmind Pte Ltd	<b>C</b>	Chainguard	Cloud Kinetics	Coinbase Inc.	Cribl Inc
Bitrock	CINQ ICT	Chainyard	CloudBees, Inc.	Colder Products Co	CrowdStrike
Blameless Inc	CISEL Informatique SA	Chaitin Tech	CloudBolt Software	Collabora Ltd.	Crunchy Data Solutions, Inc.
Block, Inc.	CME Group Inc.	Changzhou Citos Software Co., Ltd.	CloudControl, Inc.	Comcast Cable Communications, LLC	Cryptape Technology Co., Ltd.
Blockchain Technology Partners, Inc.	CNO	Charter Communications	CloudCover Pte. Ltd.	Commvault Systems, Inc.	Cuemby Inc.
Bloomberg Finance L.P.	CORE 24/7 LLP	Checkmarx	CloudFerro Sp. z o.o.	Component Soft Kft.	Cybeats
Blue Sentry	CRYPTOSENSE	Chef Software Inc.	CloudFix	Connect 5G, Inc.	CyberArk Software Ltd
BlueArch Group Inc.	CSEngineering	Chengdu Yuan Lai Yun Zhi Technologies Inc.	CloudIQ Technologies	Conoa AB	Cybertrust Japan Co., Ltd.
Boeing	CTO.ai	China Electronic System Cloud Data and Intelligence Technology Co., LTD. (CECLOUD)	CloudLinux	ConsenSys AG	Cybozu, Inc.
Boer Technology (BTech)	CVS Health	China Mobile Communication Company Ltd	CloudMatos LLC	Constantia	Cycode, Inc.
BondEvaluate Pte. Ltd.	CYSEC SA	China Systems Holdings Limited	CloudNatix, Inc.	ContainIQ	<b>D</b>
Bonifii	Cable Television Laboratories Inc.	China Telecommunications Corporation	CloudOps Inc.	Container Solutions BV	D2iQ, Inc. (f/k/a Mesosphere)
	Cachengo	China Unicom	CloudZero	Continental Automotive Systems	DAEKYO CNS
	Calyptia	China-ASEAN Information Harbor Co., Ltd	Cloudbase Solutions S.R.L	Contino	DB Systel GmbH
	Camptocamp		Cloudera, Inc.	Contrast Security	DENSO CORPORATION
	Canamunda Services GmbH		Cloudical	Control Plane Corporation	DENX Software Engineering GmbH (DENX)
	CanaryBit		Cloudshape Inc	ControlPlane.io	DLT Global Inc.
	Canonical Group Limited		Cloudsmith Ltd	Convex Opco Inc.	DNEG
			Cloudsoft Corporation Ltd	CoolIT Systems Inc.	
			Cloudstratex		
			Cloudthread		



Dalian Hi-Think Computer Technology, Corp.	Deutsche Bank AG	EPAM Systems, Inc	Esperanto Technologies Inc.	Ford Motor Company	Gitpod GmbH
DaoCloud Network Technology Co., Ltd.	Deutsche Telekom AG	EXEM	Estateably Inc.	Fortanix	Globant LLC
Daon Inc	DevOps Institute	EasyStack Inc.	Ethernity CLOUD	Fortress Information Security	Globo
Data Essential	DevSamurai	Edge Delta	Exein	FossilID	Go Firefly, Inc
Data Storage Research, LLC d/b/a DSR Corporation	DevsOperative	EdgeRay Technologies Co., Ltd	Exivity	Foundries.io LTD	GoDaddy Operating Company, LLC
DataCore Software	Dhiway Networks Private Limited	Edgecore Network Corporation	Exotanium Inc.	Fournine Cloud Solutions	Goldman Sachs & Co. LLC
DataStax, Inc.	DiDi USA	Edgeless Systems	Expedia Group	FreedomFi	Goliath
Databricks Inc.	Diagrid	Educational Testing Service (ETS)	Expert Thinking	Fullstaq	GotoAdmins
Datachain, Inc.	Diamanti, Inc.	Eficode Oy	Exstratus	FuriosaAI, Inc.	Grafbase
Datadog, Inc	Dianomic	Elasticsearch, Inc.	Extreme Networks, Inc.	Futurewei Technologies, Inc.	GramLabs, Inc. (d/b/a StormForge)
Datadivers	Didim365	Elasisys AB	<b>F</b>	<b>G</b>	Granulate Cloud Solutions Ltd
Datree.io	DigiCert, Inc.	Elastx AB	F5, Inc.	G-Research	Grape Up Sp. z.o.o.
Datto, Inc.	Digital Asset Holdings, LLC	Electronics and Telecommunications Research Institute	Far-Galaxy Networks	GRAVITI TECHNOLOGIES INC	Grapheene inc
Daugherty Business Solutions	Digital Impact LLC	Elektrobit Automotive GmbH	FLANT EUROPE OÜ	GSBN	Gravitational, Inc ,ÄÜDBA,ÄÜ Teleport
Daynix Computing LTD	Dimagi Inc	Elementl	FOSSA	Gaia Information Technology	Green Hills Software LLC
Debricked	Direktiv	Elotl, Inc	Fabrick S.p.A	Garden Technologies Inc.	Gremlin, Inc.
DeepFactor	Distributed Ledger Technologies (DLT) Pte Ltd.	EngineerBetter Ltd	Fairwinds Ops, Inc	Gatsby Inc	Guangdong OPPO Mobile Telecommunications Corp., Ltd.
Deepfence, Inc	Dito	Entando Inc.	Fauna, Inc.	Gemini Open Cloud Computing Inc.	Guangxi Tidu Technology Co., Ltd. (TIDU)
Deepshore GmbH	Docker, Inc.	Enterprise DB Corporation	Federal Express	GenX	Guangzhou Xiaopeng Motors Technology Co Ltd
Dellfer, Inc.	DoiT International	Entigo OÜ	Federal National Mortgage Association (Fannie Mae)	GenXcomm Inc	Guida
Deloitte Consulting LLP	Doppler	Enveil	Federated Wireless	General Electric Company	<b>H</b>
Delta Electronics Worldwide	Dorado Software	Envisor	Fidelity Technology Group, LLC	Genesis Global Technology Limited	HAProxy Technologies
Dembach Goo Informatik GmbH & Co. KG	DornerWorks, Ltd.	Eolinker	Filecoin Foundation	Genvid Technologies Inc	HCL Technologies Ltd.
DeployHub, Inc.	DreamBig Semiconductor Inc.	Equideum Health	Finout	German Edge Cloud GmbH	HENSOLDT Cyber GmbH
Depository Trust and Clearing Corporation (DTCC)	DrimAES	Equinix, Inc.	FireHydrant	Ghost Locomotion Inc.	HERE Global B.V.
Desay SV Automotive	Dynatrace LLC	Era Software, Inc.	Firecell	Giant Swarm GmbH	HP Inc.
Design Barn Inc	<b>E</b>	Ernst & Young LLP	Flanksource	GienTech	HSA Foundation
Desotech srl	EGAR Global NoCode	Escala24x7	Flexera	GitHub, Inc.	
	EMQ Technologies Co., Ltd.	Escape	FlexiDAO	GitLab Inc.	
		Espeo Software	Flowchain		
			FogHorn Systems		

HSBC	Highway9 Networks	Identity Technologies Inc	IoT.bzh	Keysight Technologies Inc.	Larsen & Toubro Infotech Ltd
HackerOne	Honda Motor Co., Ltd.	Igalia, S.L.	Isovalent Inc.	Kioxia Corporation	LatticeX Foundation
Hadean Supercomputing Ltd	Honor Device Co. Ltd	Imagination Technologies Group Ltd.	Itera Technologies a.s.	Kiratech SpA	Lawrence Livermore National Laboratory (LLNL)
Hammerspace	Horizon Robotics	Imperas Software Ltd	Itopia	KitBash3D	LeanIX GmbH
Hangzhou FIT2CLOUD Information Technology Co., Ltd	Hound Technology Inc. dba Honeycomb	Indeed, Inc.	Ituum OU (DBA Dysnix)	Kloia Software and Consulting Ltd	Lear Corporation
Hangzhou Harmony Cloud Technology Co., Ltd.	Hub Security	Index Analytics	<b>J</b>	Klotho	Legit Security
Hangzhou Langhe Technology Co. Ltd. (Netease)	Humanitec	Indicio	JFrog, Inc	KodeKloud	Lenovo (United States) Inc.
Hangzhou MoreSec Technology Co., Ltd.	Humio	Indra	JMA Wireless	Komodori Inc.	Li Auto Inc.
Hangzhou Nuowei Information Technology Co. Ltd.	Hygraph	IndyKite Inc.	JPMorgan Chase	Kong Inc.	Lightbend Inc
Hangzhou WOQU Technology Co., Ltd.	Hyland Software, Inc.	Infineon Technologies AG	JVC KENWOOD Corporation	Konsulko Group	Lightlytics
Hanover Insurance Group	Hyundai Mobis Co., Ltd.	InfinyOn Inc	Jeli.io	Koor Technologies Inc	Lightrun Ltd
Harness Inc.	Hyundai Motor Company	InfluxData Inc	Jetstack Ltd	Kry10 Limited	Lightstep, Inc.
Harpoon Corp	<b>I</b>	InfoCert	Joby Aero	Krypc Corporation	Linaro Limited
Hartford Financial Services Group Inc.	IDnow GmbH	Infoblox Inc.	Joisto Group Oy	KubeOps	Lineo Solutions, Inc.
HashiCorp Inc	IFS World Operations AB	Information Data Systems	Jump Operations, LLC	Kubermatic GmbH	LinkedIn Corporation
Hasura, Inc.	IGNW	Infosys Limited	Juniper Networks, Inc.	Kubernetes Innovation Labs LLC (Kubeshop)	Linklogis Inc
Hedera Hashgraph LLC	IHS Markit	Infracloud Technologies INC	<b>K</b>	Kubiya Inc	Linode LLC.
Hedgehog	IITS Consulting	Infracast	KBSYS Inc	Kublr	Linutronix GmbH
Helios	ILKI FRANCE	Inigo	KDDI Corporation	Kumina B.V.	Liquid Avatar Operations Inc.
Helium Systems, Inc.	IN-COM Data Systems	Innablr Pty Ltd	KINX	KylinSoft Coporation (Beijing)	Liquid Reply
Hermes Fund Managers Limited (Federated Hermes)	ING Group	Innogrid	KNS Group LLC (trademark YADRO)	Kythera AI	Lockheed Martin
Heroic Labs	IO Builders Blockchain Technologies & Ventures	Inspur Group	KPIT Technologies Limited	<b>L</b>	Loft Labs, Inc. (DevSpace Technologies)
Hewlett Packard Enterprise Development LP	IOG Singapore Pte. Ltd	Instaclustr	KPMG	L4B Software GmbH	Logiq.ai Inc.
	IOTech Systems Limited	Instana, Inc.	KSOC	LG Electronics Inc.	Logshero Ltd.
	IPChain Association	IntellectEU	KUKA Deutschland GmbH	LINBIT USA LLC	Lumedic Acquisition Corp
	IPwe	Intelligent Systems Services	Kaleido	LMAX Exchange Ltd	Luxoft Global Operations GmbH
	ITAU BBA USA SECURITIES, INC.	InterCloud	Kaloom Inc.	LPI.org	
	ITRenew	Interdynamix	Kasten, Inc.	LSD OPEN	
	IVIS Automotive Solutions	Intesa Sanpaolo	KatRisk LLC	Lablup Inc.	<b>M</b>
	lauro Systems	Intuit, Inc.	Kentik	Lacework	MATRIX Software
	IdRamp	Intuitive Technology Partners, Inc.	Kernkonzept GmbH	Laird Connectivity, Inc	MBDA Italia S.p.A
		InwinSTACK	Keyless technologies LTD	Lantronix Inc.	MDxBlocks Inc.



MIA s.r.l.	Mezmo	NCC Group	New H3C Technologies Co., Ltd	Open Source Alliance	PantaRei Design
MSys Technologies	Micro Focus International plc	NCSoft Corporation	New Relic, Inc.	Open Source Automation Development Lab (OSADL) eG	Paramount Software Solutions Inc.
MUFG Union Bank	Micron Technology	NEOS	NexCloud	Open Source Consulting Inc.	Parasoft
MacStadium	Micware Co. Ltd.	NGINX International Limited	NextGen Tek Consulting	Open Source Security, Inc.	Particule
MaibornWolff GmbH	Mido Holdings Co., Ltd (Midokura)	NHN Corporation	Niantic	OpenNebula	PayPal Holdings, Inc.
Mail.Ru Cloud Solutions	Milligan Partners	NIO	Nikon Corporation	OpenSynergy GmbH	Pegasystems Inc.
MakinaRocks	Mindtree Limited	NIPA	Nippon Seiki Co. Ltd.	OpsLevel	Peloton Interactive
Man Technology	Minio, Inc	NSONE, Inc.	Nirmata, Inc.	OpsMx	Penten
Marelli Corporation	Mirantis, Inc.	NTT Corporation	Nissan Motor Co. Ltd.	OpsVerse	Perceptio AB
Marketnode	Miraxia Edge Technology Corporation	NTT DATA MSE CORPORATION	Nokia Corporation	Opsera	Percona
Marvell Semiconductors Ltd	Mission:data Coalition	NVIDIA Corporation	Nomura Holding America	Optic	Permit.io
MasterCard Incorporated	Mithril Security	NXP Semiconductors Netherlands B.V.	Nomura Research Institute, Ltd.	Optum/UnitedHealth Group	Phoenix Software International
Matrix I.T CloudZone LTD	Mitsubishi Electric Corporation	Nanjing Pengyun Network Technology Co., Ltd.	Noname Security	Orange SA	Phylum
Mattermost, Inc.	Mitsubishi Motors Corporation	Nanjing eCloud Technology Co., Ltd.	Nordic Semiconductor ASA	Orca Security, Inc.	Ping An Technology (Shenzhen) Co., Ltd
Mavenir Systems, Inc.	Mobilise Cloud Services	NatWest	Numbers	Ori Industries	PingCAP
Maxon Computer GmbH	Model9	National Instruments Corporation	Nutanix, Inc.	Origoss Solutions Ltd	Pioneer Corporation
MayaData Inc. (f/k/a CloudByte, Inc)	Mondoo	Navitas Business Consulting Inc.	Nuvitek	Orkes Inc	Pionix GmbH
Mayfield Fund	Monetago Inc	NearForm Ltd	<b>O</b>	Ortec Finance	Pipekit Inc
Mazda Motor Corporation	Monokee	Nebulon	OBSS	Osaka NDS Co., Ltd.	PlanetScale, Inc.
McKinsey & Company, Inc	Monostream AG	Neo4j, Inc.	OGIS-RI Co., Ltd.	Oteemo Inc.	Plat'Home Co., Ltd
MediConCen Limited	MontaVista Software, LLC	NetApp, Inc	OKESTRO	Oticon A/S	Platform9 Systems, Inc.
MediaTek USA Inc.	Morgan Stanley	NetFoundry	OSNEXUS	Ovoo Spv s.r.o.	Point72, L.P.
MegaEase, Inc.	Morpheus Data	Netdata	OVH SAS	Oxeye	Polar Signals Inc
MegazoneCloud	Moscow Exchange (MICEX-RTS)	Netflix, Inc.	Occentus Network	Ozone Cloud Inc.	Polar Squad
Meinberg Funkhrehn GmbH & Co KG	Motojeannie	Netgate	Octo Consulting Group	<b>P</b>	Polyverse Corporation
Memfault Inc	Moxa Inc.	Nethopper	OctopusDeploy	PANTHEON.tech s.r.o	Portainer.io
Mercedes-Benz Tech Innovation GmbH	MyFitnessPal LLC	Netris, INC.	OhmConnect Inc	PBG Consulting	Posedio - Professional Cloud Consulting
Merck & Co., Inc.	Mycelial	Neuroglia	Okteto	PRODYNA	Poste Italiane SPA
MetaBlox Foundation	<b>N</b>	Nevexis	OnGres	Paladin Cloud	Postman
Metrics Design Automation Inc.	NAMUTECH Co., Ltd.	New Black	Ondat	Palmer NFT Studio	Precisely Holdings, LLC
MetroStar Systems			Opaque Systems Inc.	Palo Alto Networks	Precision Innovations Inc
			Open Raven		Prefect

Pricewaterhouse Coopers LLP	RStudio PBC	Ripple, Inc.	Salesforce.com, Inc.	ServeTheWorld AS	SingleStore, Inc.
Prisma Data, Inc	RTE (Reseau de Transport dElectricite)	Rivos Inc	Salsify	Serverless	Singularity Data
Prodigy Education	RX-M, LLC	Roadie	Saltware	Services4-IT	Sirius XM Radio Inc.
Profian	Rackner	Robin Systems, Inc	Sartura	Shanghai Mandao Technology Co., LTD	Sivantos GmbH
Profisea	Rackspace US, Inc.	Robusta.dev	Sateliot	Shanghai Pudong Development Bank	Skyload
Progressive Insurance	Radisys Corporation	Rocket Software, Inc.	Sauce Labs Inc	Shanghai Sectrend Information Technology Co.,Ltd	Slim.AI
Project N	Rafay Systems, Inc.	RodeoFX	Savoir-faire Linux	Shanghai Vonechain Information Technology Co., Ltd	Smallstep
Proofcraft Pty Ltd	Raft	Rookout Ltd.	Scaleway	Shanghai Yunzhou Information Technology Co. Ltd (ZStack)	SmartBear Software, Inc.
ProsperOps	Raftt	Royal Dutch Shell	Scality Inc.	Shanghai Zhuyun Information Technology Co., Ltd.	Smartiful, Inc.
Pulumì	Raintank, Inc. ,Äi Grafana Labs	Ruby Protocol	Scantist Pte. Ltd.	Shenzhen Forms Synttron Information Co. Ltd	Snapper Future Tech Pvt Ltd
Puppet, Inc.	Rapid Silicon	<b>S</b>	Scarf Systems, Inc	Shenzhen Goodix Technology Co.,Ltd.	Snow Software Inc
Pure Storage	RapidAPI	S&P Global Inc.	Schaeffler Technologies	Shenzhen Jiangxing Intelligence Inc.	Snyk Limited
Puzzle ITC GmbH	RapidFort, Inc.	SADA Systems	Schellman & Company, LLC	Shenzhen Wise2C Technology Co.,Ltd	SoKube
<b>Q</b>	Raytheon Technologies	SAIC Motor Corporation Ltd	Schneider Electric	Shenzhen ZhiLiu Technology Co., Ltd.	SociV©tv© Gv©nv©rale
QAware GmbH	ReadMe	SANCLOUD LTD	Schwarz IT GmbH & Co. KG	ShiftLeft	Socket
Qamcom Group AB	Reblaze	SAP	Science Applications International Corporation	Shipa	SoftBank Corp.
Qiming Information Technology Co., Ltd.	Recurve	SAS Institute Inc.	Scott Logic Ltd	Shopify Inc.	SoftIron Inc
QingCloud Technologies Corp.	Red Date (Hong Kong) Technology Limited	SHE BASH	ScoutAPM	Shoreline	Softax SP.j.
Quali	Red Kubes BV	SHINESOFT	Scribe Security	SiFive	Softchoice LP and Softchoice Corporation
QualitySoft Corporation	Red Reply	SICPA SA	Seagate Technology LLC	Sibros Technologies	Software Mind
Qualys, Inc.	Redeploy	SIGHUP, Inc	Searce	Sidero Labs	SoftwareONE AG
Quant Network	Redpanda Data	SIMBA Chain	Second State	Siemens AG	SolidRun Ltd
Quobyte Inc.	Release Technologies, Inc.	SMBC Americas	SecureKey Technologies, Inc.	Silicon Laboratories Inc.	Solo.io
<b>R</b>	Reliance Jio Infocomm Limited	SOCNOC AI	Seekret Software Security Ltd.		Sonatus, Inc.
R3 LLC	Replicated, Inc.	SOLIZE Corporation	Selective Insurance Group		Sonatype, Inc.
RADTONICS	ReversingLabs	SORAMITSU CO., LTD.	Selector Software, Inc.		Sosivio
RANDA Solutions	Revolgy	STMicroelectronics International N.V.	Sempre.ai		Spacelift, Inc.
RBC Capital Markets, LLC	Rezilion	SUSE LLC	Senofi		Sparkfabrik srl
REALTO GROUP INC	Ribbon Communications Operating Company, Inc.	SVA System Vertrieb Alexander GmbH	Sense Reply		Spectral
REGnosys Limited	Ricoh Company, Ltd.	SWIFT, INC.	Sentara Healthcare, Inc.		Spectro Cloud, Inc.
RNG Technology		SYSGO GmbH			SpeedScale
		Saleor Commerce			SphereEx
					Spirent Communications Inc

Splunk Inc.	Suzuki Motor Corporation	TenneT	TmaxCloud	Uffizzi	Videndum Media
Spotify AB	Swisscom	TensorSecurity	Tokentrust AG	Ultraviolet Consult DOO	Solutions Spa
Sprint Corporation	Symbridge LLC	Technology Ltd	TomTom International B.V.	UnifabriX	Virtasant
Spyderbat	Symphony	TensorWorks	Torch Consulting Group	Union.ai	Virtual Power Systems
Squarespace, Inc.	Communication	TenxCloud	Toyota Tsusho	UnionTech Software	Visa Inc.
StackHawk	Services LLC	TeraSky	Corporation	Technology Co., Ltd.	Vodafone Group Plc.
Stacklet	Synax GmbH	Ternary	Traceable	Uniserver	VoerEir AB
Stackwatch Inc	Sync Computing	Tetrate.io	Traceroute42	Unisys	Volkswagen
Starburst Data	Synechron, Inc.	Teuto.net Netzdienste	Traefik Labs SAS	Unity Technologies	Aktiengesellschaft
Stark & Wayne LLC	Syngenio	GmbH	Trail of Bits	UpCloud Ltd	
State Farm Mutual	Synopsys, Inc	Texas Instruments	Translucent Computing	Upbound	<b>W</b>
Automobile Insurance	SysEleven GmbH	Incorporated	Transposit Corporation	Upsolver Data, Inc.	WSO2 Inc.
Company	Sysdig, Inc.	Thales SA	Transwarp Technology	Utilidata	Wallarm
Steamhaus		The 4th Paradigm	(Shanghai) Co., Ltd	UtilityAPI	Walmart Inc.
Stellate	<b>T</b>	Technology Co., Ltd	Travelers		Wanclouds Inc.
StepZen, Inc.	TDT AG	The Constant Company,	Traveling GmbH	<b>V</b>	Wandelbots
Sterlite Technologies	TELUS Corporation	LLC / Vultr	Trend Micro Incorporated	VA Linux Systems Japan	Wargaming.net Limited
Limited	TL Consulting Group	The Foundry	Trilio Data	K.K.	WattCarbon
StorPool Storage AD	TLM Partners	Visionmongers Limited	True B.V.	VES LLC	Wavelabs
Storm Reply GmbH	TO THE NEW	The Guild	Truepic, Inc.	VEXXHOST, Inc.	Wayfair
Strata Identity	Tafi	The Medium	Turk Telekom <sup>®</sup> nikasyon	VNC Automotive Limited	We.Trade Innovation DAC
Stratascale	Tangem AG	The Qt Company Oy	A.S.	VSHN AG	WeHealth Solutions PBC
Strategic Blue	Target Corporation	The Scale Factory Limited	Turnium Technology	ValueCloud	WeScale SAS
Stratox Cloud Native	Tata Communications	Thebes Cloud	Group Inc	Valve Corporation	Weaveworks Inc.
StreamNative	Limited	Thnk	Tuxera Inc.	Vapor IO	Webera, LLC
Structsure, LLC	Teal Communications, Inc.	Thought Machine Group	Twitter Inc.	Vattenfall Eldistribution	Wegmans Food Markets
Styra Inc	Tech Mahindra Limited	Limited	Tyk Technologies Ltd.	AB	Wellington Management
Successive Technologies	Technology Innovation	ThoughtWorks, Inc	<b>U</b>	Vaxowave	Company, LLP
Sumo Logic, Inc.	Institute	Thunder Software	UBS AG	Veea Inc.	Western Digital
Super Micro Computer,	Tectonic Labs Ltd.	Technology Co. Ltd.	ULAK HABERLESME A.S.	Vega Cloud Inc	Corporation
Inc.	Telaverge	Tick42	UMB AG	Vela	Wevr
SuperOrbital, LLC.	Communications	Tidelift, Inc.	UNIBERG	Velocity	WhaTap Labs Inc
Superblocks	Telechips, Inc.	TietoEVRY	US Navy	VeriSilicon, Inc.	WhiteSource Ltd.
Supercritical	Telecom Italia Mobile	Tigera, Inc.	USAA	Vertiv	Whitestack LLC
Suzhou Beyondcent &	(TIM) S.p.A.	Timescale	UWS Inc.	Viable Data	WhizUs GmbH
Software Co., Ltd.	Temporal Technologies Inc	Timesys Corporation	Ubiquitous AI Corporation	VicOne Inc.	Wind River Systems, Inc.
(BoCloud)	Tenable, Inc.	Timspirit		Vicom Infinity, Inc.	Windmill Engineering

Wingtecher Technology Co., Ltd.  
Winning Health Technology Group  
Wipro Limited  
Wistron Corporation  
Witekio Holding  
Wowjoy Technology  
Wuhan Lotus Technology Co.,Ltd

## X

Xcalibyte  
Xenit AB  
XenonStack Inc.  
Xevo Inc.  
Xi'an Tieke Jingwei Information  
Technology Co.,Ltd. (CARS)  
Xilinx Inc  
Xopero Software

## Y

YLD! Limited  
Yahoo Japan Corporation  
Yazaki Corporation  
Yellowbrick Data  
Yotascale

## Z

ZEDEDA, Inc.  
ZTE Corporation  
Zebrium, Inc.  
Zeeve Inc  
Zelarsoft LLC  
ZenHub  
Zenlayer Inc  
Zerto, Inc.  
Zettabytes, Inc.  
Zilliz  
Zoi  
Zoss Team, LLC  
ZutaCore

## In memoriam: Shubhra Kar

This year, we lost our dear friend, colleague, and a true champion of the open source community. Our CTO, Shubhra Kar, passed away suddenly while he was with his entire LF family at our first in-person, all-hands gathering since before the pandemic.

Those who had the honor to work with him will know, he was a special leader and a wonderful human being. Above all, Shubhra was the kind of leader who quickly passed the credit for accomplishments to his team over himself. His humble spirit and everpresent smile was admired by all around him. He was so proud of the world class team he had built here, and did that in part with engineers who followed him from one organization to another throughout his career.

We also knew Shubhra as a selfless leader—one who was more interested in

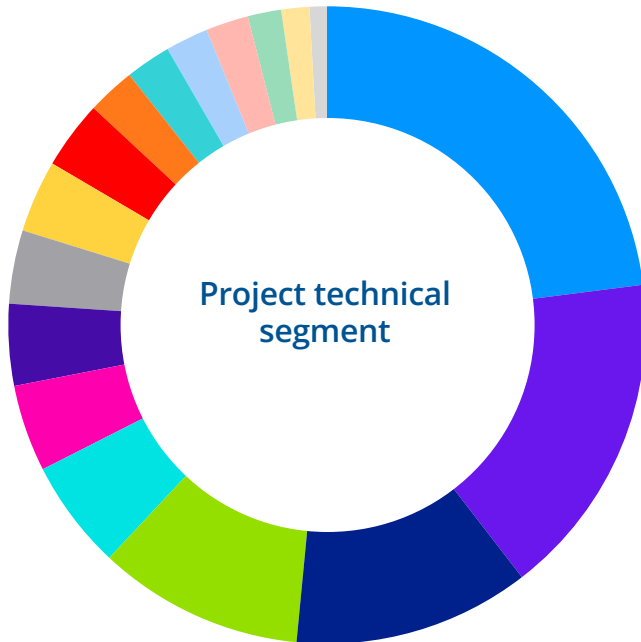
the work than the reward. At the same time, he was incredibly ambitious—wanting to build a platform that would not only transform The Linux Foundation but support open source development communities around the world. This was the week his team unveiled significant new enhancements across the LFX platform. It was a project he led from vision to reality, after many—even members of his own team—had told him the path to success was impossible. He was a transformational leader that has left his legacy here.

While he was passionate about his work and his team, he loved his family even more. In fact, his children were often spotted behind him during video calls throughout the day. He was a fantastic husband and father, and we are so grateful for his wife, son, and daughter sharing him with us.

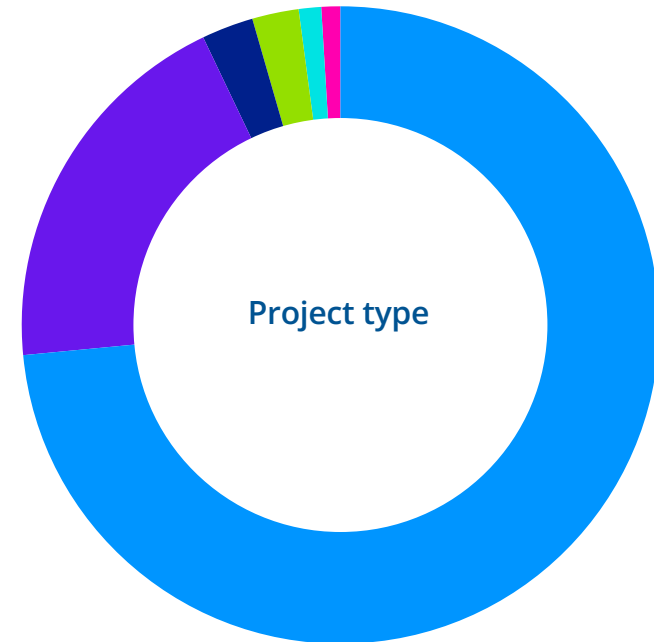


“Shubhra was a special leader and a wonderful human being. He always passed the credit for accomplishments to his team over himself. His humble spirit and constant smile were admired by all around him. He was so proud of the world-class team he had built. Most of his engineers had followed him from one organization to another—a true testament to the type of manager Shubhra was.”

## Serving over 986 open source project communities



- Cloud, Containers, & Virtualization **23%**
- Networking & Edge **16.5%**
- Web & Application Development **12%**
- AI, ML, Data, & Analytics **10.4%**
- Cross-Technology **5.6%**
- Privacy & Security **4.4%**
- IoT & Embedded **4.1%**
- DevOps, CI/CD, & Site Reliability **3.7%**
- Blockchain **3.7%**
- Open Source & Compliance Best Practices **3.5%**
- System Administration **2.4%**
- Linux Kernel **2.3%**
- System Engineering **2.2%**
- Storage **2.2%**
- Open Hardware **1.7%**
- Safety-Critical Systems **1.4%**
- Visual Effects **0.9%**



- Open Source Software **73%**
- Open Standard / Specification **19%**
- Open Data **3%**
- Open Hardware **2%**
- Peer Network **1%**
- Open Governance Network **1%**

# Innovation with an evolving Linux kernel

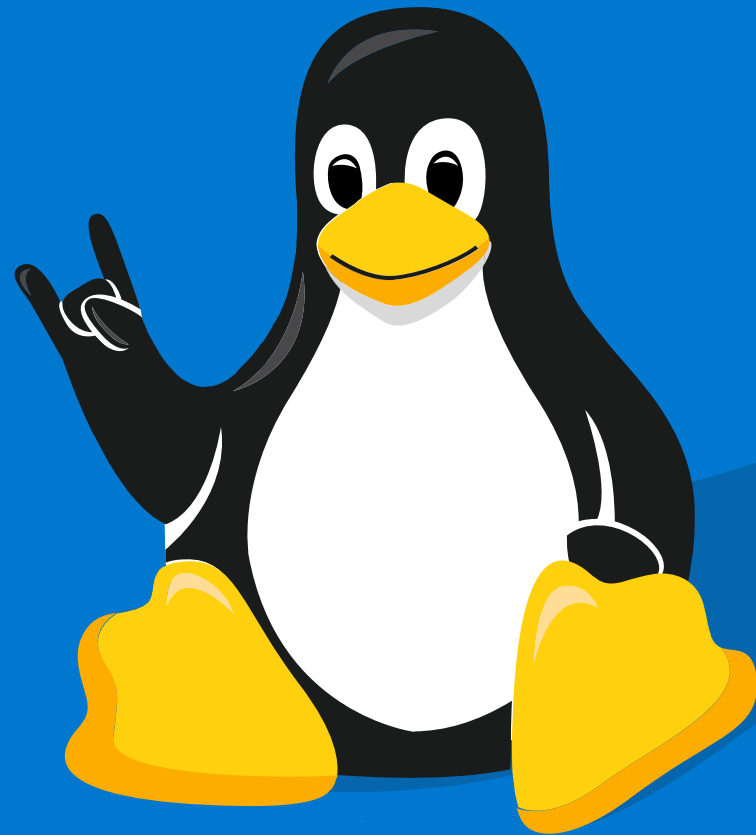
In tandem with security, nurturing open source innovation to create a better world is at the heart of Linux Foundation activities. Last year, we celebrated the Linux kernel's 30th birthday. In 2022, Linux remains among the top three global open source projects in terms of development velocity. Each release is the result of the work of thousands of contributors worldwide and from a wide variety of organizations. The kernel community actively maintains a steady flow of innovative improvements to expand the footprint of Linux and improve its capabilities.

Attendees at the [2022 Linux Plumbers event](#) in Dublin discussed a future Linux that is faster, more versatile, and more secure, but also an increased desire to improve regression testing methodologies to reduce the number of bugs introduced into the code with new commits. A new kernel regression tracking

system, [regzbot](#), led by developer Thorsten Leemhuis, is currently in early testing.

It's exciting to see that the first Rust modules are now slated for rollout in Linux 6.1, marking the start of a new journey toward memory safety.

We're also excited to see developers showing how the Linux eBPF subsystem runtime is turning into a utility tool that goes beyond package filtering to adjust process scheduling and make accommodating new input devices easier. New features, such as `io_uring`, will make Linux much faster by eliminating many system calls back to the kernel. Considering that most open source projects have a healthy lifespan of a decade or less, the speed at which Linux accelerates its innovation is all the more remarkable.





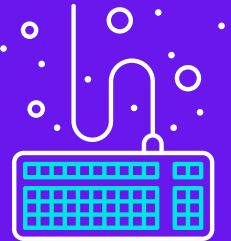
# Fostering growth, quality, and velocity

There are over  
**850 active open source projects**  
being hosted by the  
Linux Foundation.



**52M+ lines of code**

are generated every  
week by our project  
communities, up  
13% year over year.



**17K global organizations**  
contributed to  
Linux Foundation  
open source projects  
in 2022.



The Linux Foundation  
open source community  
contributed to over  
**3.2 million project builds**  
in 2022.

**827K developers actively contribute**

to Linux Foundation  
projects, resulting in a  
12% increase in 2022.



In 2022, the Linux  
Foundation acquired  
**321 new members.**



**Active member contributions increased 13%**  
in FY22, and  
148K were by new  
contributors.



LFX Security detected  
**264K code vulnerabilities**  
in 2022, aiding faster  
fixes by developers.

**10,700 applications for LFX Mentorships**  
were received in 2022.



**135K developers enrolled** in training  
courses in 2022  
and earned **26K certifications**,  
an increase of 15%.



Events hosted by  
the Linux Foundation  
had a total of  
**188K attendees**,  
an increase of 120%  
from the previous year.



**\$3.3 million**  
in funds were raised  
this year through  
LFX Crowdfunding.

## Celebrating the innovators

Throughout history, innovation has abounded during times of crisis or adversity. This past year was no exception. We continued to serve and grow our communities as we welcomed new projects such as PyTorch and launched Linux Foundation Europe and its OpenWallet Foundation.

We also saw sparks of innovation aiming to change the world, from tracking conflict minerals to providing broadband to poor and remote communities to creating open source technology for animal tracking as part of endangered species conservation efforts. Here's a roundup of the innovation from 2022... and here's to the project innovators!



## Innovation with a global impact

### **Saving wildlife: Peace Parks Foundation and OpenJS Foundation**

#### The Peace Parks Foundation

is leveraging OpenJS-hosted technologies like Node-RED, Electron, jQuery, Lint, and Moment to fight poaching in African national parks. Using a network of cameras that monitor endangered wildlife, they have created a low-cost, scalable system that identifies poachers and notifies local police in realtime.

The monitoring system relies heavily on Node-RED, a low-code programming language for event-driven applications. Node-RED is built on Node.js, making it ideal for running at the network's edge on low-cost hardware and in the cloud. OpenJS technologies enable organizations like the Peace Parks Foundation, which have limited resources, to fight poachers and protect endangered ecosystems at scale.

### **OpenCollar animal tracking and the Zephyr real-time operating system**

The OpenCollar Initiative is a conservation collaboration for designing, supporting, and deploying open source tracking collar hardware and software for wildlife monitoring projects. OpenCollar integrates LoRa, GSM, Bluetooth LE, and GPS technologies for a seamless wildlife monitoring solution based on the Zephyr real-time operating system. By making the hardware and software open source, the OpenCollar Initiative aims to attract and inspire talented students, researchers, and tech-savvy conservationists to develop tracking systems that are more customizable to accommodate the needs of various animals.

The OpenCollar Initiative started with the design and deployment of elephant tracking collars and has



PHOTO BY GERAN DE KLERK: UNSPLASH

since expanded. It now provides field-tested solutions for tracking rhinos, lions, cheetahs, wisents, wild dogs, and other animals.

► <https://www.zephyrproject.org/portfolio/opencollar/>

► <https://www.smartparks.org/opencollar-io/>

## Data modeling for climate change: OS-Climate

[OS-Climate](#) is an open source collaboration community that is building data and software tools to drive climate change mitigation and action. Founded to accelerate the global investment shift toward green technologies, infrastructure, and business practices, OS-Climate is helping stakeholders across industries align on sustainability goals. This alignment allows them to accelerate the adoption of new business models and take action to meet the targets outlined in the Paris Climate Accords.

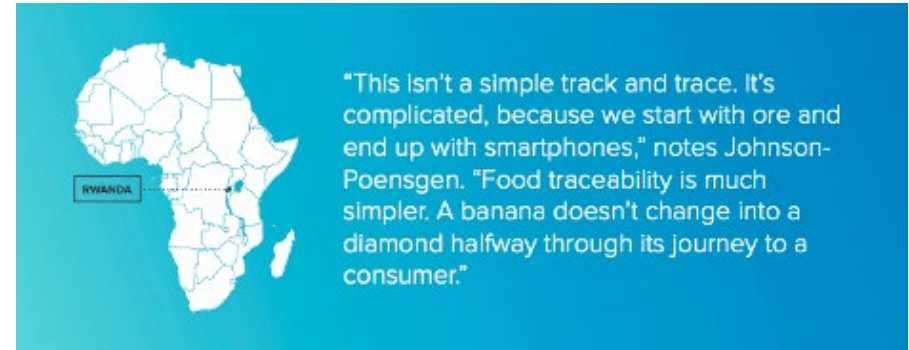
By aggregating the best available data, modeling, and computer science, OS-Climate is helping organizations prepare for a future

built on climate-friendly economic practices. They are working to develop an AI-enhanced physical-economic model that functions like an operating system and enables powerful applications for climate-integrated investing.

## Open charging for electric vehicles: EVerest (LF Energy)

As the demand for electric vehicles (EVs) continues to grow, LF Energy's EVerest project is developing an open source software stack for EV charging infrastructure. The EVerest project aims to speed deployment, ensure interoperability, and avoid stranded infrastructure for EV charging solutions. Developed with modularity and customizability in mind, EVerest works with all types of fast public charging, including smart charging, DC charging, bidirectional charging, and even emergency energy backups, for use during blackouts.

By leveraging all the advantages of open source for the EV charging world, EVerest is driving e-mobility



**Circular's blockchain-based system: The first ever mine-to-manufacturer traceability solution for the conflict mineral.**

innovation and adoption. In the future, the project will focus on providing new features for local energy management, PV integration, grid-friendliness, and more.

## Mine-to-manufacturer traceability of a conflict mineral: Circular (Hyperledger Foundation member)

[Circular's](#) blockchain-based system provides much-needed provenance for tantalum and is the first ever mine-to-manufacturer traceability solution for the conflict mineral. Using Circular, manufacturers can ensure that tantalum ore purchased in Rwanda is mined, transported, and

processed under OECD-approved conditions and without slavery or child labor.

Tantalum is one of the rarest chemical elements in our solar system, and there is a growing demand for it in a variety of industries. It is also a conflict mineral, meaning that a portion of its supply comes from warlords in the Congo who enlist enslaved people and children to mine it. The OECD, the U.S., and the E.U. passed regulations to improve its traceability, but there has not been a way to accurately track tantalum from mine to manufacturer—until now. Using Circular's traceability solution, which is built using [Hyperledger Fabric](#),



manufacturers and governments can ensure that rare-earth elements such as tantalum are ethically and sustainably sourced.

## Employee and student health verification: Cardea

### LF Public Health's Cardea project

is a decentralized, open source, privacy-preserving solution for sharing health data. Initially built to support health data sharing for COVID-19 tests and vaccinations, the Cardea project has since expanded, with use cases in employee and student health verification and drug testing.

The underlying architecture of Cardea is optimized for sharing privacy-sensitive data. Individuals can submit health data as tamper-proof digital credentials with consent-based sharing of specific data. This makes it perfect for universities and organizations that rely on a paper-based method to verify the health requirements of students and employees. Cardea can verify the health credentials of individuals in a convenient, digital, and privacy-centered way.

## Improving network access for underserved communities: Magma

The Magma project is helping rural and underserved communities gain better access to Internet and LTE networking. Using policy-rich network edges and simple fabrics, the Magma project's broadly applicable design provides flexible, scalable, and low-cost networking solutions for use in various low-service areas. First Nations communities across North America can now control their Internet access using private LTE networks powered by Magma, thereby providing support for critical communications and cultural resources.

## Securing open source software: OpenSSF

The Open Source Security Foundation (OpenSSF) brings together government and industry leaders to improve the state of open source software security. Several targeted initiatives were released by the OpenSSF in 2022, including education courses, best practices, and an open source

summit in Washington, D.C., that gathered government and industry representatives to discuss action and investment in open source security.

Cross-industry conversations facilitated by the OpenSSF led to the launch of a comprehensive mobilization plan outlining 10 streams of investment to improve the state of open source software security. OpenSSF has also funded security teams and projects in a variety of critical open source projects and released novel tooling to enable secure software development. With the support of more than 95 members, the OpenSSF is taking actionable steps to secure the open source software powering our world.



OSS North America 2022

# Welcoming the PyTorch Foundation

In September, we welcomed **PyTorch** as a new project under the Linux Foundation, and we formed the PyTorch Foundation. Since its initial release in 2016, over 2,400 contributors and 180,000 organizations have adopted the PyTorch ML framework for academic research and production environments. And, within the last year, PyTorch counted over 65,000 code commits and was one of the world's five fastest-growing open source software communities, alongside the Linux kernel and Kubernetes.

PyTorch is one of the world's most important and successful machine-learning software projects. We are grateful to the team at Meta for trusting the foundation with this project and to our founding members from Amazon Web Services, AMD, Google, Microsoft, and NVIDIA.

In the coming year, we look forward to building upon the success that PyTorch has already established with the AI and ML community. Artificial intelligence and machine learning remain key technologies in open source, and we know that the neutral home of the Linux Foundation will bring in even more diverse contributions to the PyTorch community. By creating a neutral home for PyTorch, we open up possibilities for further collaboration, innovation, and growth. We are excited to offer training, certification, and access to our LFX platform to PyTorch maintainers and contributors.



**Linus Torvalds (left), the creator of the Linux kernel, met with Soumith Chintala (right), the creator of PyTorch, at Open Source Summit Europe this year in Dublin.**

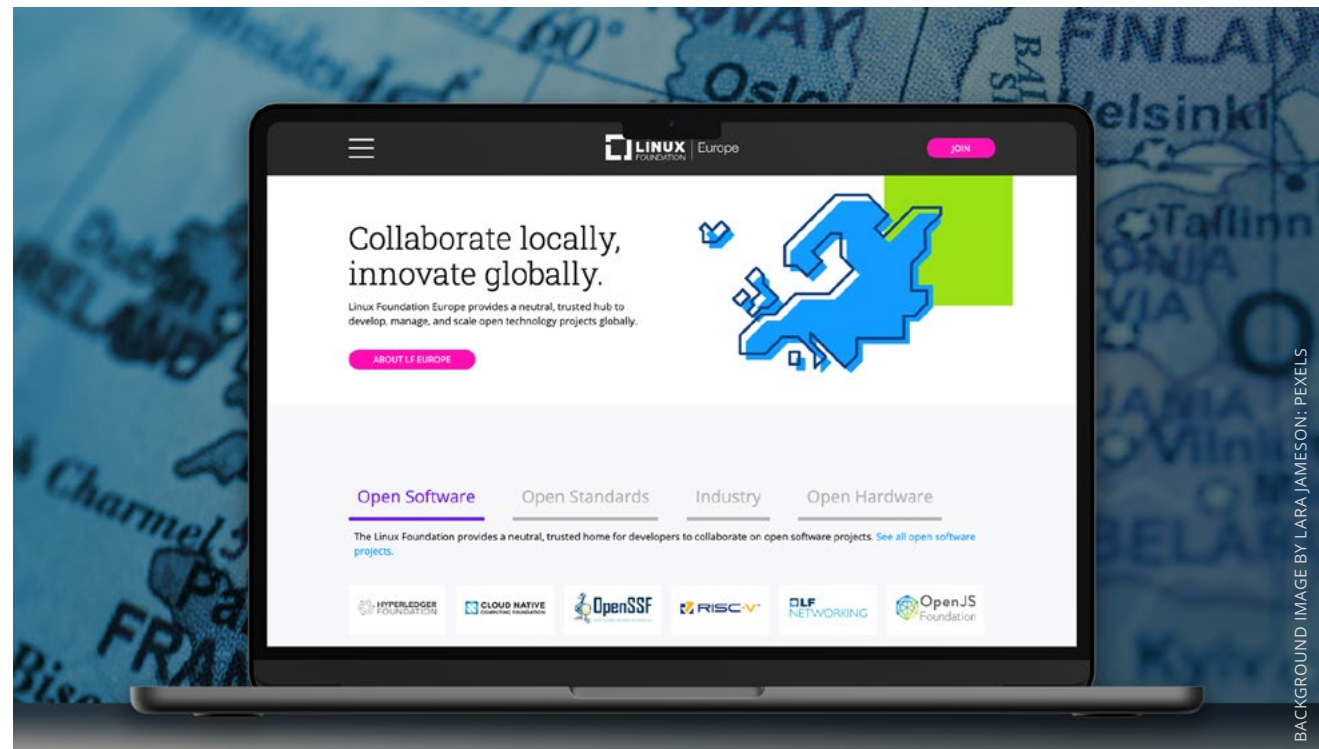


**Mark Zuckerberg initially announced the PyTorch Foundation on his Facebook page.**

# Investing in European innovation: The launch of Linux Foundation Europe

As the pace of digital transformation is accelerating in Europe, we realized that we needed to establish a presence in the region and promote the role of open source as a critical competitive differentiator. By planting roots in the European open source community, we are manifesting our vision to help promote the ideals of collaborating locally to drive open source innovation globally and provide a neutral space for open source innovators with a European bent.

In September, at Open Source Summit Europe in Dublin, Ireland, we officially launched [Linux Foundation Europe](#) with over 15 founding members. It is a Brussels-based non-profit that will be led by General Manager [Gabriele Columbro](#), a native-born Italian and long-time proponent of the European open source ecosystem.



BACKGROUND IMAGE BY LARA JAMESON: PEXELS

The foundation's mission is to accelerate the growth of open collaborative efforts focused on challenges and opportunities faced by all European constituencies. Linux Foundation Europe will provide individuals in the public and private sectors with an

on-ramp so that European projects and companies can collaborate and succeed on a grand scale.

Jim Zemlin, the executive director of the Linux Foundation, described the regional opportunity:

*We see different regions worldwide saying, '...we want to have our own digital community and big digital economy. We want to create new jobs, spur innovation regionally because of our region's special circumstances, or because people here understand each other and*



*collaborate more quickly.’ And so, you have this balance where the free, organic, global innovation engine is open source.*

Europe is home to a thriving community of open source contributors—from individuals to enterprises to governments—who deliver innovation that positively impacts the region and the world. Today, policymakers widely recognize open source as a unique tool for achieving ambitious Europe-wide goals, such as the digital commons and digital sovereignty. According to Columbro, “*The LF is already in Europe. More than a third of our members are from Europe, split evenly across regions. So why are we launching a European branch of the Linux Foundation? The first and foremost reason is that Europe is a unique region that includes a supranational entity (the E.U.) that aligns goals and defines a collaboration framework that crosses borders. And we realized there was a need to support this type of collaboration. It’s a pleasure to focus on Europe, an area that I think*

*has major potential for innovation leadership through open source. We want to ensure that we enable collaborations that can start here, in Europe, but then go to a global scale.*”

During the launch, we published our study with Scott Logic, [World of Open Source: Europe Spotlight 2022](#), which describes the state of open source across Europe. At the Summit, Hilary Carter, VP of Research at the Linux Foundation, said, “*This study shows that open source remains an apolitical key to fostering the digital commons, enabling innovations that can originate in Europe and become de facto standards used worldwide.*”



OSS EU Dublin



## OpenWallet Foundation: Advancing interoperability in digital wallets

As announced at Open Source Summit Europe in Dublin, the mission of the [OpenWallet Foundation](#) (OWF), LF Europe's first project, is to develop an open source engine to create secure and interoperable multi-purpose wallets that anyone can use to build solutions.

The OWF aims to set best practices for digital wallet technology through collaboration on open source code that anyone can use as a starting point for building interoperable, secure, and privacy-protecting wallets.







Less than two months into its launch, LF Europe announced its first hosted project, Sylva.

A collaboration between leading European telcos and vendors (Deutsche Telekom, Ericsson, Nokia, Orange, Telecom Italia, Telefonica, and Vodafone), Sylva is designed to create a new, open source production-grade telco cloud stack within Europe. Sylva's common cloud software framework and adjacent reference implementation will reduce fragmentation of the cloud infrastructure layer for telecommunication and edge services and build on top of existing open source projects to provide implementations and extensions.

Specific goals of the Sylva project include the following:

- ▶ Release a cloud software framework to prioritize requirements, develop solutions to be integrated within existing open source components, and produce production-grade solutions to be leveraged within commercial products.
- ▶ Develop a reference implementation of this cloud software framework and create an integration and validation program to accelerate the adoption of network functions within the cloud.

Learn more about Sylva at <https://gitlab.com/sylva-projects/sylva>.



IMAGE BY KAREN UPPAL; UNSPLASH

## Software supply chain security

The Linux Foundation spent a large part of 2022 working on building a community around the urgent task of securing our open source software (OSS) supply chain, which is important to society and repeatedly in the news.

This section includes more information on the Open Source Security Foundation (OpenSSF), OpenChain, SPDX, and other cybersecurity activities at the Linux Foundation.





## Engaging the public sector on open source software worldwide

Throughout 2022, the Linux Foundation has been at the heart of several important conversations concerning the open source software (OSS) community and the sustainability of the ecosystem. Many of our worldwide engagement efforts have been focused on educating public and private sector leaders about open source software, including its security. Specifically, we have focused on three key priority areas:

1. Improving security and reducing systemic risk in the OSS ecosystem,
2. Closing talent shortages through improved training and educational initiatives, and,
3. Imparting the value of openness and the importance of the community.

This has included presentations, responses to requests for information, and more informal discussions with cybersecurity leaders in the U.S., Singapore, Japan, the U.K., the E.U., and elsewhere.



BACKGROUND IMAGE BY GERD ALTMANN: PIXABAY



# OpenSSF

The [OpenSSF](#) is a cross-industry collaboration that brings leaders together to improve OSS security through targeted initiatives, education, and best practices. Throughout 2022, OpenSSF membership increased to 95 members. Premier members include 1Password, AWS, Atlassian, Capital One, Cisco, Citi, Coinbase, Dell Technologies, Ericsson, Fidelity, GitHub, Google, Huawei, Intel, IBM, JFrog, JPMorgan Chase, Meta, Microsoft, Morgan Stanley, Oracle, Red Hat, Snyk, Sonatype, VMware, and Wipro.

## 2022 highlights

► In January 2022, the U.S. White House, along with leaders and experts of many U.S. federal agencies, convened an important cross-section of the open source developer and commercial ecosystem to identify the challenges in the OSS supply chain and share ideas on how to

mitigate risk and enhance resilience. Both the Linux Foundation and OpenSSF participated in this meeting. As a follow-up, the OpenSSF hosted the [Open Source Software Security Summit II](#) in May, bringing together over 90 executives from 37 companies and U.S. government leaders to reach a consensus on critical actions to improve the resiliency and security of OSS.

► During Summit II, the OpenSSF released the [Open Source Software Security Mobilization Plan](#) and announced \$30 million in pledges to improve OSS security. The Mobilization Plan outlines 10 streams of investment to rapidly advance well-vetted solutions to make immediate improvements to OSS security worldwide and build a strong foundation for a more secure future. Throughout 2022, the OpenSSF community has acted

on the Mobilization Plan and will continue to do so into 2023 and beyond.

► OpenSSF launched the [Alpha-Omega Project](#). The “Alpha” portion improves global OSS supply chain security by working with project maintainers to improve the security posture of their projects. The “Omega” portion systematically looks for new, as-yet-undiscovered vulnerabilities in open source code and fixes them. Alpha-Omega issued a total of \$1.5 million in [grants](#) to the OpenJS Foundation in support of Node.js, the Eclipse Foundation, the Python Software Foundation, and the Rust Foundation. For example, the funding to the Rust Foundation is for enhanced security, including a threat model of the Rust ecosystem and an assessment of the security of the Rust build/deployment infrastructure.<sup>1</sup>

► [Sigstore](#) has continued to see massive contributions and adoption to sign, verify, and protect OSS, emphasizing improving the integrity of the software supply chain and reducing the friction developers face regarding implementing security within their daily work. In June 2022, software developers, DevOps engineers, security engineers, and software maintainers could take the new free course on [Securing Your Software Supply Chain with Sigstore](#).

► In developers of critical open source projects’ pursuit of encouraging the wider adoption of multi-factor authentication (MFA), the OpenSSF Technical Advisory Council publicly supported, in strong terms, the various efforts to increase the use of MFA in various organizations.<sup>2</sup> The Securing Critical Projects Working Group (WG) coordinated the distribution of

<sup>1</sup> <https://openssf.org/blog/2022/09/13/alpha-omega-project-announces-over-1-5m-in-grants-to-critical-open-source-projects-and-new-omega-analysis-toolchain/>

<sup>2</sup> <https://openssf.org/blog/2022/07/20/openssf-supports-movements-toward-multi-factor-authentication/>



hundreds of codes for free MFA tokens to developers of the 100 most critical open source projects in 2021–2022 in what was known as the “[Great MFA Distribution](#).”

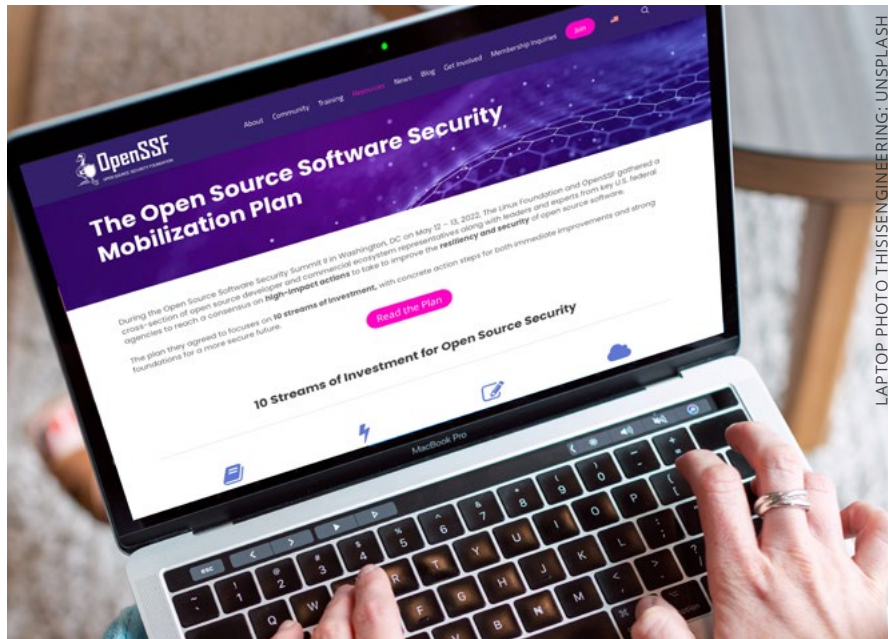
- ▶ The Best Practices for Open Source Developers WG increased awareness and education of security best practices through improvements in its free [Developing Secure Software Training Course](#). This is now available through the Linux Foundation Training & Certification platform, on edX, and on various organizations’ Learning Management Systems, and it has had over 8,000 enrollments. The course was updated this year to address the attacks that have recently become more prominent (per the CWE Top 25 and OWASP Top 10), as well as adding material to cover topics such as securing systems that use machine learning. It also released [Concise Guides](#) on Developing More Secure Software and Evaluating Open Source Software and provided an npm Best Practices Guide for those using the popular npm package manager. The OpenSSF Best Practices badge now has over 5,000 participating projects and over 850 passing projects.
- ▶ The Best Practices WG released new [Scorecards](#) features, such as a GitHub Action and REST API, added security checks, scaled-up scans of the open source ecosystem, and badges. Over 1,600 repositories use Scorecards to incorporate best practices into their software development lifecycle for continuous improvement.
- ▶ The Vulnerability Disclosures WG unveiled the next evolution in improving open source coordination of vulnerability disclosures by crafting a new guide focused on the security researcher or Finder persona with a [Guide for Security Researchers to Coordinate Vulnerability Disclosures with Open Source Software Projects](#).
- ▶ A key component of the Mobilization Plan is using a software bill of materials (SBOM) as a foundational building block to improve the security posture of the open source ecosystem known as [SBOM Everywhere](#). The SBOM Everywhere Special Interest Group (SIG) sprang up under the Security Tooling WG, and its first effort was to fund work on an SPDX Python library to support SBOM creation and processing.



OpenSSF General Manager Brian Behlendorf, second from right, appears alongside executives from the Linux Foundation, IBM and Microsoft.



Open Source Security Summit II



LAPTOP PHOTO THISISENGINEERING: UNSPLASH

Security is always a primary concern and priority for companies and projects, and when there is a significant dependency on open source, it can cause anxiety.



OpenSSF Day, OSS NA 2022, Austin

- The Security Tooling WG also released Fuzz Introspector. Many development workflows have come to rely on fuzzing, an automated technique for finding bugs by feeding unexpected inputs into software with the intent to trigger crashes or other problems. Fuzzing plays an important role in vulnerability discovery. However, today fuzzing often hits roadblocks (“blockers”) that prevent effective fuzzing of some code areas. Fuzz Introspector provides actionable insights for developers to identify fuzzing coverage blockers so they can be resolved, with the goal of (1) improving projects that use fuzzing and (2) improving fuzzers themselves (by helping tool developers understand current problems).<sup>3</sup>
- The OpenSSF Supply Chain Integrity WG continues to work on refining the Supply chain Levels for Software Artifacts (SLSA) (pronounced “salsa”). This is a checklist of standards and controls to prevent tampering,

improve integrity, and secure packages and infrastructure. A draft is already public, and work continues to refine it for a “version 1.0” release. The working group also began work on the complementary Secure Supply Chain Consumption Framework (S2C2F) to further develop and continuously improve the S2C2F guide. This guide outlines and defines how to securely consume OSS dependencies into the developer’s workflow.

- The OpenSSF added two new WGs. The [Securing Software Repositories WG](#) “provides a collaborative environment for aligning on introducing new tools and technologies to strengthen and secure software repositories.” The [End Users WG](#) “represents the interests of public and private sector organizations that primarily consume open source rather than produce it.”
- OpenSSF hosted [OpenSSF Days](#) in Austin and Dublin at both

<sup>3</sup> <https://openssf.org/blog/2022/06/09/introducing-fuzz-introspector-an-openssf-tool-to-improve-fuzzing-coverage/>





OpenSSF Day, OSS 2022 Europe



OpenSSF Day, OSS 2022 Europe

Open Source Summits North America and [Europe](#), bringing together the open source community to discuss the challenges, big-picture solutions, ongoing work, and successes in securing the OSS supply chain. It is also hosting upcoming OpenSSF Days in China and Japan.

► OpenSSF GM Brian Behlendorf [testified](#) to the U.S. House of Representatives Committee on Science, Space, and Technology about the work being done within the OpenSSF and broader OSS community to improve the security and trustworthiness of OSS.

## Maintainer's POV



*"I am a maintainer for Sigstore's Rekor and Cosign projects. I've also been working on making the public Rekor and Fulcio services generally available. There were a few reasons I chose to become involved. First, I found the mission of Sigstore compelling, and I wanted to work on a project that I thought was focusing on important and fulfilling work.*

*Supply chain security is a huge problem, and there's a lot of work to be done; I thought Sigstore could have a huge impact. I also liked that it was an open source project to make security easier for everyone. The other major reason I wanted to get involved was the community. The Sigstore community has been so welcoming and fun to work with, and it really made my Sigstore experience a positive one."*

—Priya Wadhwa, Software Engineer, [Chainguard](#)

## OPENCHAIN

The OpenChain project's core mission is to build trust in the supply chain. The ISO/IEC OpenChain Specification 5230:2020 is the International Standard for Open Source Compliance and builds trust in that domain.

The next step is identifying the key requirements of a quality open source security assurance program.



IMAGE BY PETE LINFORTH: PIXABAY

In October, we released version 1.0 of the OpenChain Security Assurance Specification, which results from over one year of work throughout the global OpenChain community. It applies to an open source management activity related to security compliance. We regard this as adjacent but different to license compliance.

Initially, the scope of this specification is limited to ensuring that an organization vets open source with regard to known publicly available security vulnerability issues (e.g., CVEs, GitHub dependency alerts, and package manager alerts). The security assurance specification's scope may grow over time based on community feedback.

We will proceed to the ISO/IEC JTC-1 PAS submission with an estimated completion date of mid-2023. In the meantime, our security assurance specification is ready for market adoption as a de facto standard.



## Software Package Data Exchange (SPDX)

One key issue in improving software supply chains is improving software transparency through SBOMs. The Linux Foundation has been a key player in this effort through its development of Software Package Data Exchange (SPDX), including work to make it an ISO standard in 2021.

Work is ongoing to develop SDPX version 2.3. SPDX 2.3 includes improved interoperability with other exchange formats, including adding fields to record the purpose of a package and adding support for more hash algorithms. SDPX 2.3 also adds new relationship types (to explain links between elements further), new time information fields, and added ways to refer to external materials.



## Related security activities at the Linux Foundation

Each Linux Foundation project is responsible for developing secure software for its own users, as projects such as OpenSSF cannot rewrite all their software. However, the Linux Foundation works to help its foundations and projects to achieve this, including sharing materials developed by other groups. Some foundations, such as the Cloud Native Computing Foundation (CNCF), have their own groups that specifically focus on security issues for their domain. We intend to continue to encourage collaboration between foundations and projects as we work to counter attackers.



## Internet Security Research Group (ISRG)

ISRG's Let's Encrypt project provides free, automated TLS certificates to over 300,000,000 websites. The project continues to thrive, with an excellent record of security and stability. This year, Let's Encrypt spearheaded a new industry feature that makes early certificate renewal seamless and automated. This feature will improve the agility and resilience of Let's Encrypt for the billions of people who rely on it every day.



PHOTO BY MAREK PIWNICKI: UNSPLASH

ISRG also operates a privacy-preserving metrics service called Divvi Up. This project aims to dramatically improve the privacy of data collected by web and mobile applications by aggregating and anonymizing it. In 2023, Divvi Up expects to finalize its underlying protocols as an industry standard and bring on initial subscribers.

Prossimo is the third project run by ISRG. It focuses on bringing memory safety to the Internet's most critical infrastructure. The project made significant code contributions over the past year to improve memory safety on the Internet, ending the year with Rust support being merged into the Linux kernel and completing a memory-safe NTP client and server implementation.

## LF Research: Measuring the impact of open source innovation

Since launching in 2021, LF Research has published a suite of in-depth reports exploring all aspects of open source. Using best practices in empirical methodologies, LF Research offers deep data analysis and a richer perspective into the community's current trends, challenges, and opportunities, delivering actionable insights that support future open source strategy formation.





## 2022: A year of insights

Thanks to the participation of developers, community leaders, and member organizations in the research development process, initial LF Research publications provide new evidence to support the open source innovation opportunity and create an exciting new channel to engage stakeholders. The scope, reach, and impact of open source project communities is all around us, captured by LF Research deliverables and accessible on the newly designed LF Research home page.

During the past year, we have published more than two dozen reports and research newsletters, each of which describes how open source drives innovation and adds value.

### Focusing on people: Maintainership and mentorship

Among our core and project-focused research efforts are new studies exploring our most important resource: The people at the helm of open source project communities. These people include maintainers, who not only make critical decisions that impact security, velocity, and innovation in open source but whose participation in mentorship and other volunteer programs helps to nurture the committers and maintainers of tomorrow.

The Linux Foundation has long valued broadening the understanding of open source contributor dynamics, notably with the recent [FOSS Contributor Survey](#) report in partnership with

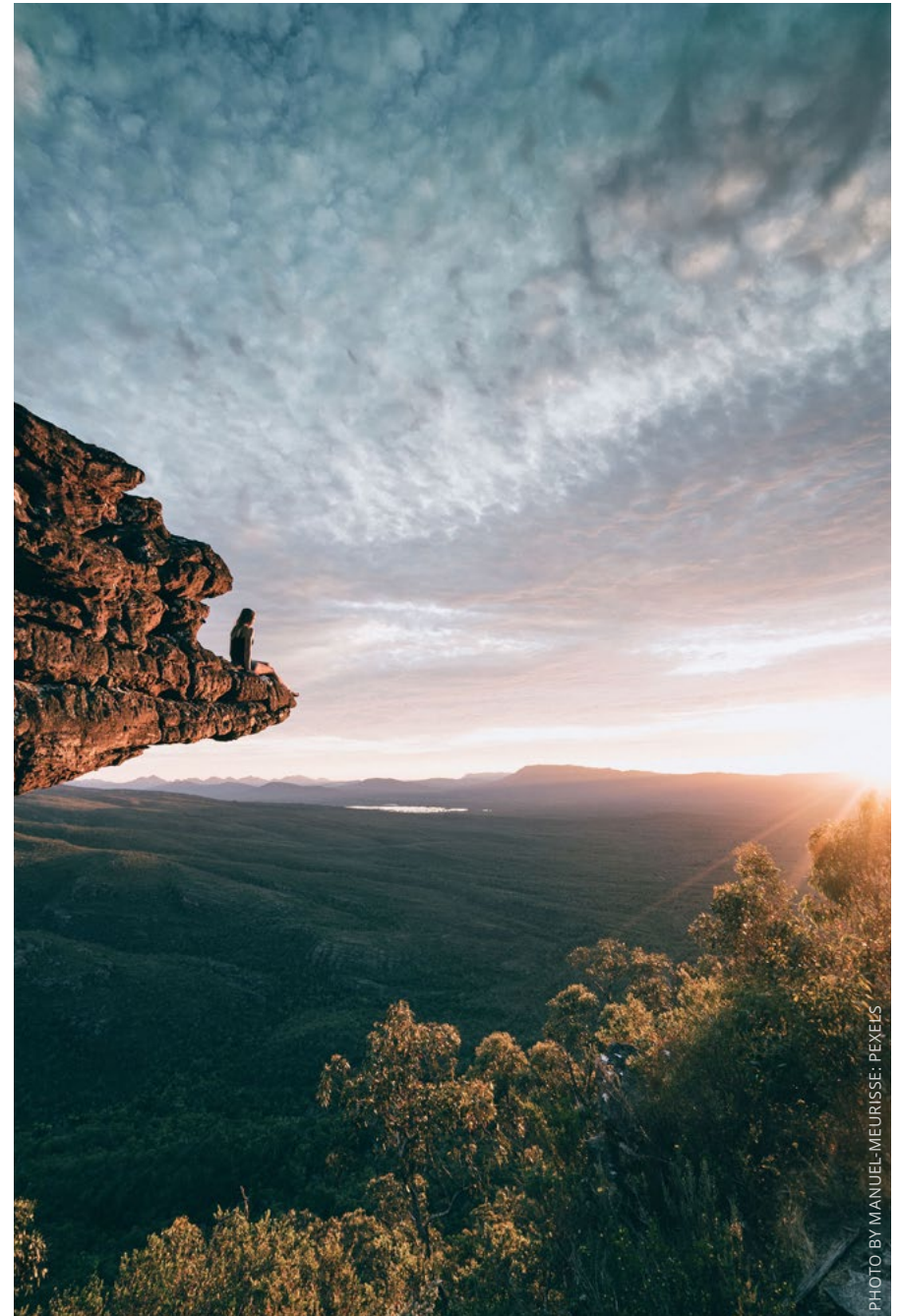


PHOTO BY MANUEL MEURISSE: PEXELS

the Laboratory of Innovation Science at Harvard (LISH) and the 2021 report on [Diversity, Equity, and Inclusion in Open Source](#). The key findings from these reports inspired further research into the critical role that open source developers play in securing software supply chains and creating and sustaining high-impact innovations and communities.

In 2022, LF Research launched several maintainer- and committer-centric research studies to explore how we can better support the “super coders” across open source project communities. In the process, we hope to inspire a new cohort of participants to follow in their footsteps, learning, growing, and thriving along the way. Below are a few examples of people-centric research.

► [Addressing Cybersecurity Challenges in OSS](#): This study, launched in partnership between LF Research, the OpenSSF, Snyk, the Eclipse Foundation, CNCF, and the CI/CD Foundation, iden-

tifies security challenges in OSS. The project began with a series of candid interviews with OSS maintainers and contributors. Thanks to the involvement of many survey distribution partners, insights were derived from more than 500 survey respondents. The result is a deep dive into critical software security development challenges, including at the organizational level, where policies requiring security protocols are in short supply and dependencies are often not effectively managed.

► [Critical Maintainers in Open Source: Motivations, Community Dynamics, and Challenges \(4Q2022\)](#). What makes a successful maintainer? Can a set of best practices be identified and codified, and how can the open source community best support their implementation? A current study on “critical maintainers” is set to answer these questions and more. This project will reveal insights derived from a series of qualitative interviews

conducted with 25 maintainers and significant project contributors at the helm of the most critical open source projects, many of which were identified in the Census II report published in collaboration with the LISH. The findings reveal maintainer motivations, describe how their communities and projects function, identify the problems they experience, and share valuable lessons learned.

► [Mentorship in Open Source: Exploring the Intrinsic, Economic, and Career Values of Open Source Mentorship Programs \(4Q2022\)](#). This upcoming report investigates how mentorship programs influence the recruiting, onboarding, and nurturing of the next generation of open source developers, some of whom will go on to become future project maintainers. It explores challenges related to the succession of open source maintainers, explains how we can improve the health of OSS projects by increasing diversity within our developer commu-

nities, and demonstrates the myriad benefits (and some of the challenges) associated with mentorship programs for mentees and mentors alike.

Encouragingly, we see clear patterns in how successful projects and their maintainers recruit and manage contributors, structure project governance, address security practices and challenges, and nurture overall project health.

## Focusing on priority issues: Core research projects

Core research examines all strategic issues of importance across the Linux Foundation. Below are the highlights from 2022.

► [World of Open Source: Europe Spotlight 2022](#). In this inaugural, geographically focused study, the Linux Foundation and its partners examine the priorities and challenges of open source specific to Europe. It describes the “state of open source” across the European continent,

examining the current activity levels through consumption and contribution, inhibitors, motivators, and opportunities.

► [The 10th Annual Open Source Jobs Report](#). This report contains practical information on the state of open source talent that employers may use to guide their hiring, training, and diversity awareness efforts. It also provides IT professionals with clear, unbiased insights into the most marketable skills.

► [Census II of Free and Open Source Software—Application Libraries](#). Produced in partnership with the LISH and OpenSSF, Census II is the second investigation into the widespread use of Free and Open Source Software (FOSS). The report provides insights to identify the most common FOSS packages at the application library level. This facilitates prioritizing resources to address security issues in the most widely used software. The Census II utilizes 500,000 aggregated data observations of FOSS in production applications at

thousands of companies, thanks to our Software Composition Analysis partners Snyk, the Synopsys Cybersecurity Research Center, and FOSSA.

► [The State of SBOM and Cybersecurity Readiness](#). Produced in partnership with SPDX, OpenChain, and OpenSSF, this research reports on the extent of organizational SBOM readiness and adoption and its significance in improving cybersecurity throughout the open source ecosystem. The study follows in the wake of the U.S. Administration's Executive Order on Improving the Nation's Cybersecurity and the disclosure of the most recent and far-reaching Log4Shell security vulnerability in Log4j. Its timing coincides with increasing global recognition of the importance of identifying software components and helping accelerate the widespread implementation of cybersecurity best practices to mitigate the impact of software vulnerabilities and security development gaps and challenges. In our sample, it was found that

90% of organizations have started their SBOM journey.

## People-powered innovation within industry verticals

As every vertical industry becomes increasingly software-defined, LF Research has an important role to play to illustrate the impact of OSS within this transformation. Recent studies illustrate the specific role that sector leaders and decision-makers play in creating shared value for all industry competitors. The two reports below highlight experiences from the energy and motion picture industries.

► [Paving the Way to Battle Climate Change: How Two Utilities Embraced Open Source to Speed Modernization of the Electric Grid](#). This inaugural energy report describes how two large European distribution and transmission systems operators, the Netherlands' Alliander and France's RTE, adopted and contributed to three significant LF Energy projects, SEAPATH, CoMPAS, and OpenSTEF, to make



Of organizations using SBOMs today,  
**74% produce AND consume SBOMs.**

**#1 ACTION:**  
**Get a vulnerability reporting system**  
in order to better secure your software supply chain.



When producing SBOMs...  
**#1 BENEFIT:**  
**Developers better understand dependencies.**



When consuming SBOMs...  
**#1 BENEFIT:**  
**Better support for compliance and reporting.**



From [The State of Software Bill of Materials \(SBOM\) and Cybersecurity Readiness report](#)

their electrical substations more modular, interoperable, and scalable and alleviate the challenges associated with less predictable renewable energy sources. It provides a pathway for others in the energy sector to follow to speed up the digitalization of our world's power systems.

► [Open Source in Entertainment: How the Academy Software Foundation Creates Shared Value](#). Everyone loves a good story! This research project tells the story of the formation of the Academy Software Foundation—how it came to be, where it came from, what it has achieved so far, and where it aims to go next. It is a story about engineers and leaders who collectively generate value by developing critical open source software that powers many entertainment, gaming, and media industry productions and the open standards needed for growth. It is a powerful example of competitors collaborating on open source projects.

► [The State of Open Source in Financial Services Report 2022 \(4Q2022\)](#). Produced in partnership with FINOS, Scott Logic, Wipro, and GitHub, the second annual release of this report explores the state of open source in the financial services sector. It identifies current levels of consumption and contribution of open source software and standards in this industry and the governance, cultural, and aspirational issues of open source among banks, asset managers, and hedge funds.

### Focusing on technology trends: Research from Linux Foundation projects

In the reports in partnership with Linux Foundation projects, we examine the hottest trends in tech and how the communities behind open source software development and open standards are prime innovators, force multipliers, and continual disruptors.

► [AI and Data in Open Source](#): As with other industries, OSS adoption in the AI field has increased the use of open source in products and services, contributions to existing projects, the creation of projects fostering collaboration, and the development of new technologies. This report reviews critical challenges in the open source AI ecosystem, discusses common characteristics across AI and data projects, and presents the role of the LF AI & Data Foundation in empowering innovators and accelerating open source development.

► [The Carbon Footprint of NFTs: Not All Blockchains Are Created Equal](#): Produced with Palm NFT Studio and the Hyperledger Foundation, this report lays out key climate-related barriers to NFTs and suggests some concrete strategies for embracing and building on the exciting innovations that NFTs enable. Adopting these strategies may unlock new opportunities for global collaborations and

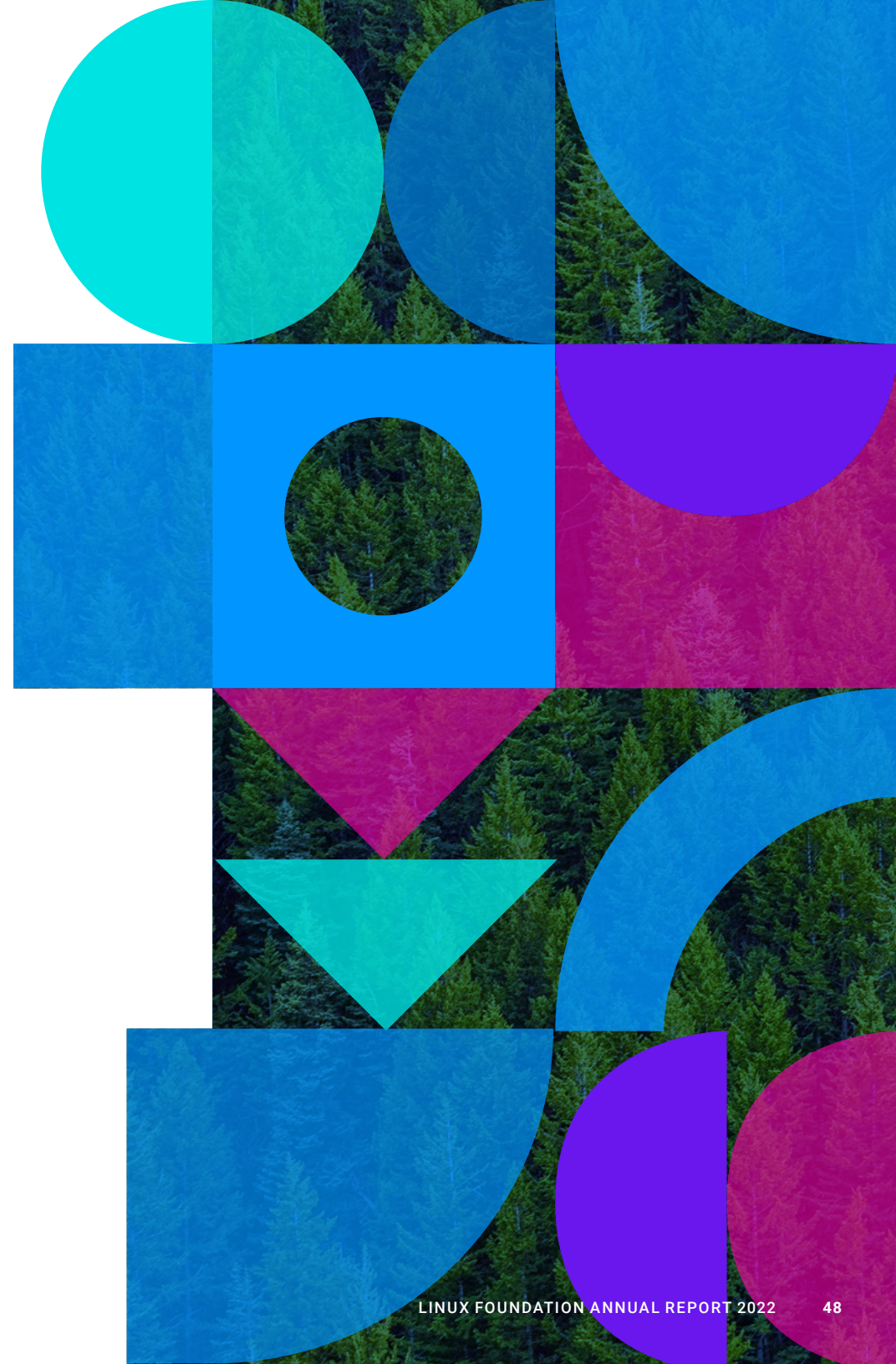
partnerships for impact through responsible and potentially beneficial approaches to climate solutions.

From telling the story of how open source is transforming the motion picture industry to exploring standards and best practices to create more secure software supply chains, 2022 solidified the role of LF Research to provide data-driven insights that broaden the understanding of the impact of open source projects worldwide. We would like to thank all those in the open source ecosystem who participated in our research efforts this year. Your contributions have helped LF Research collectively build and grow a valuable “knowledge network” for all stakeholders across the Linux Foundation community.



# LFX

Supporting data-driven open source project growth and enabling digital transformation.

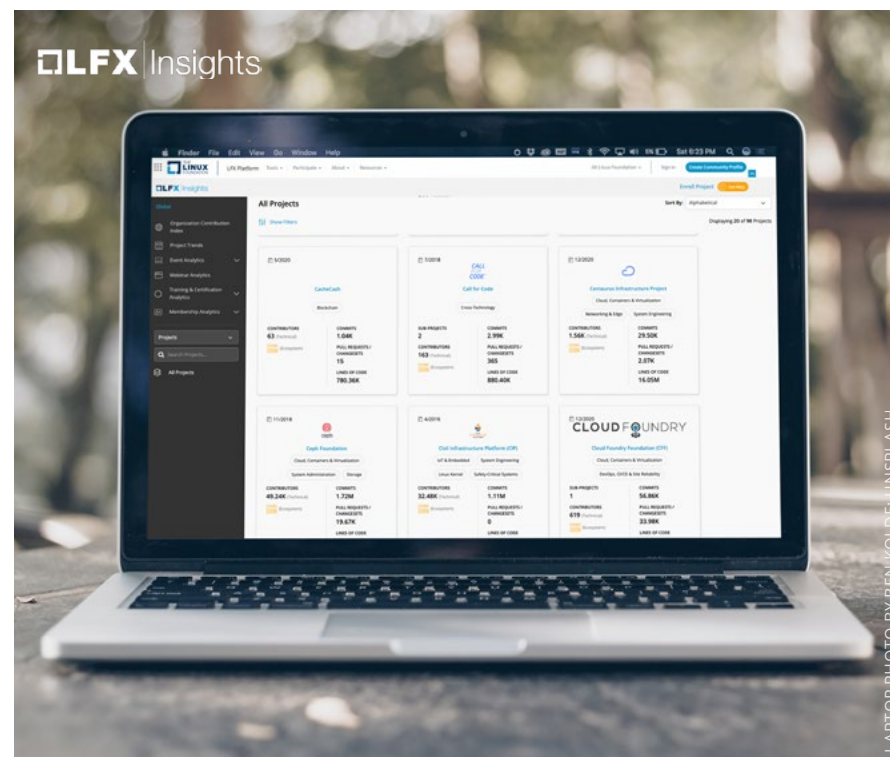




According to the Business Research Company, the global open source services market is expected to grow from \$24.63 billion in 2021 to \$30.57 billion in 2022 at a compound annual growth rate (CAGR) of 24.1%. Open technologies are mission-critical, and so is the need to manage an enterprise's open source presence, including code contributions, project participation, governance roles, and legal processes such as Contributor License Agreements. Securing the open source supply chain and all of the projects incorporated in company infrastructure and products is crucial in deciding which open source projects to support. Organizations require accurate and detailed metrics on community health to make informed decisions on which open technologies to consume and invest in.

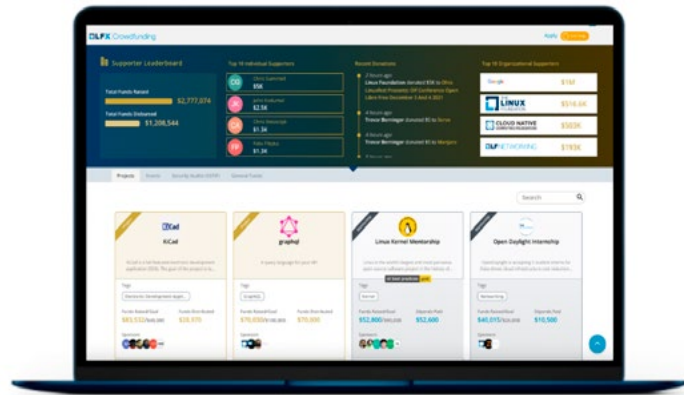
For open source projects, foundations like the Linux Foundation have become the medium for cross-platform collaboration and building sustainable project technologies and communities. To best support the 500K+ contributors and the organizations supporting them, we created LFX—a modular, extensible, and API-driven digital toolkit to grow, manage, secure, and build open source technologies. Already, 750+ open source projects have been onboarded to the LFX platform, leveraging the data sources and tools the developer communities already use.

In building these tools for open source project communities, we helped drive our digital transformation. LFX has enabled us to have better integration across all of our services (events, training, certification, projects, and IT) and automate or reduce the complexity of many day-to-day responsibilities.

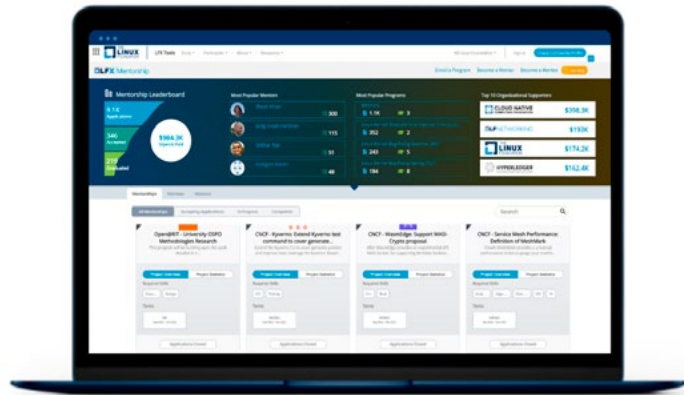


“Organizations require accurate and detailed metrics on community health to make informed decisions on which open technologies to consume and invest in.”

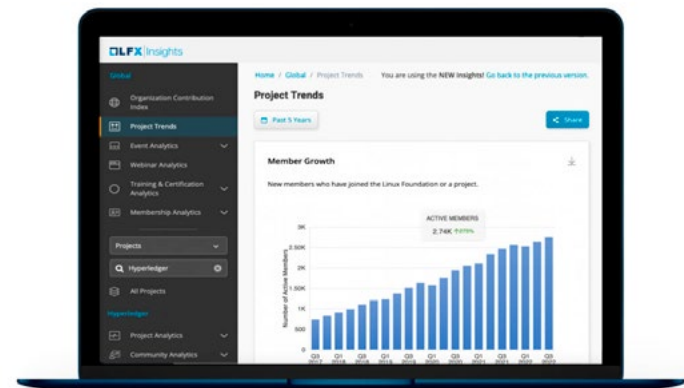




LFX: Crowdfunding



LFX: Mentorship



LFX Insights: Project Trends

## In 2022, the LFX team:

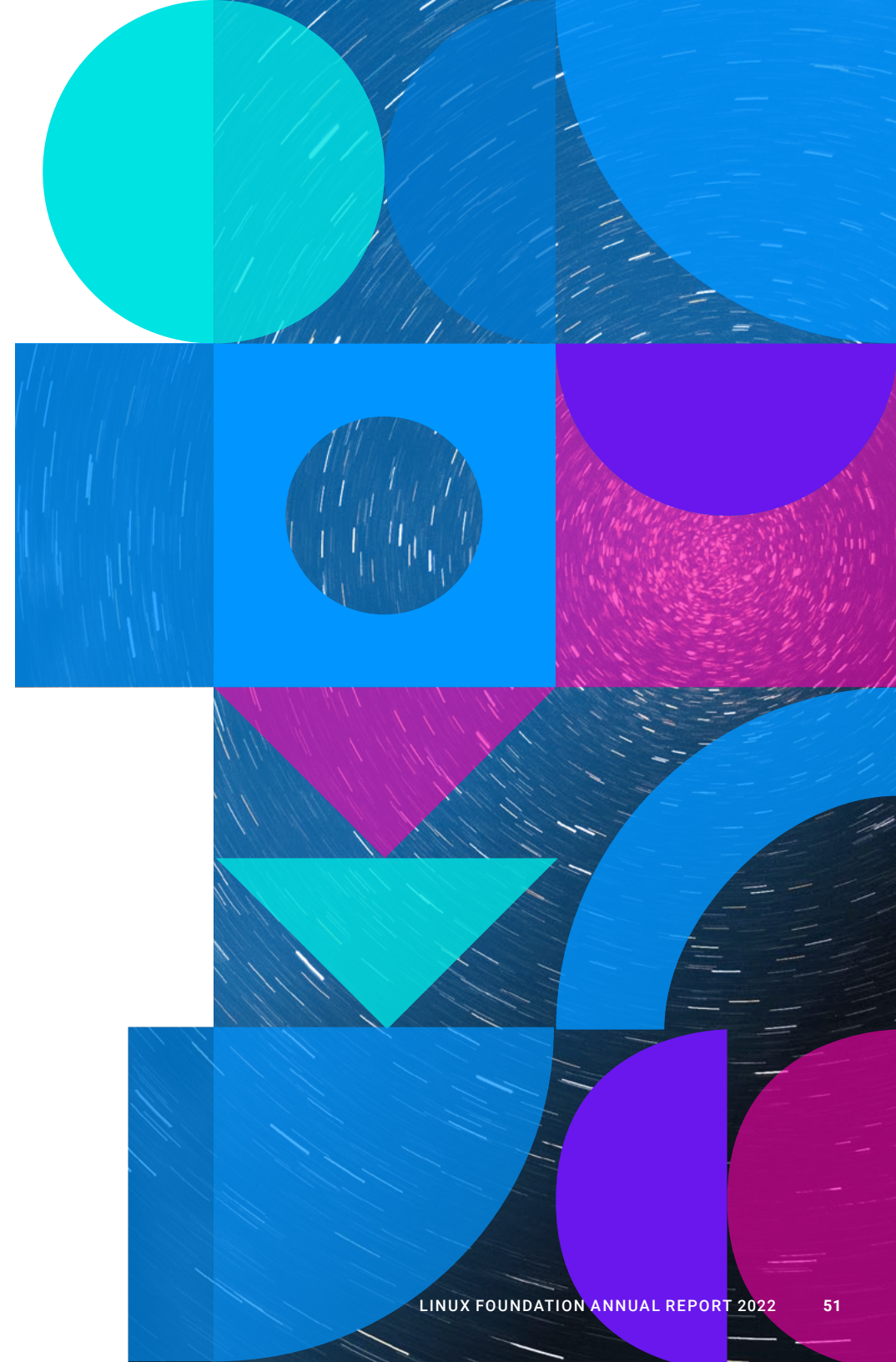
- ▶ Released the second version of [Insights](#), which provides a contextualized view of project ecosystems, including contribution trends and analytics.
  - ▶ Introduced the ability in [Individual Dashboard](#) to collect and display maintainer badges simply by connecting a GitHub account.
  - ▶ Released the first version of Community Management to help projects build healthy and engaged communities.
  - ▶ Launched a new Open Source Program Office (OSPO) dashboard for managing employees in [Organization Dashboard](#), where you can better visualize your entire open source project investment and impact.
  - ▶ Made substantial improvements to meeting and committee management in Project Control Center (PCC), a unified control plane for managing open source project operations.
- ▶ Completed the cross-platform integration and migration to a data lake infrastructure.

What can you expect from LFX in 2023? In addition to supporting more connectors like StackOverflow, Twitter, and StackShare, launching the next version of Mentorship, and introducing searchable community profiles, we are working with OpenSSF on the Risk Assessment and Data Sharing projects as a part of the [OSS Security Mobilization Plan](#). We will also be opening up Project Control Center to community members, and, most importantly, onboarding open source projects that aren't hosted at the Linux Foundation to Insights.

Learn more about LFX at [lfx.linuxfoundation.org](https://lfx.linuxfoundation.org).

## Mentorship and diversity

We're committed to making a difference. We believe that, by empowering people, offering enriching learning opportunities—structured and unstructured—and helping to build diverse communities that develop open source code, we can improve the state of the open source ecosystem. We aim to make it healthy and sustainable for future generations.



## LFX Mentorship

We started LFX Mentorship in 2019 with just three new developers. We have come a long way since then.

We continue to get feedback on our programs and improve them based on that feedback. We started offering unpaid mentorships this year based on the feedback we received to enable participation by individuals who cannot receive stipends. This also allows us to scale the program further without additional funding. We are exploring offering short-term mentorship programs to meet the needs of developers with limited time and those wanting to focus on a specific area or educational need.

As we look back at the year, LFX Mentorship will wrap up 2022 with more than 30 new Linux kernel developers and more than 240 new open source developers

across all LFX projects. CNCF leads this group, with over 104 graduates.

In 2022, we received 6,852 applications, the vast majority coming from outside the United States.

Our mentorships primarily went to younger applicants. This is expected, as mentorships aim to benefit those early in their careers, and the vast majority of applicants are relatively young.

We enjoyed great geographic diversity across our mentees, with a high concentration of participants coming from India. By launching Linux Foundation Europe and working to expand in other regions, we hope to increase geographic diversity even further.

Mentorships are useful for engineers of any education level. Understandably, our mentors concentrated on serving



Open Source Summit North America, June 2022

undergraduate students, who are most likely to seek internships and other opportunities that further their chances of employment upon graduation.

The Linux Foundation seeks to mentor engineers and students from a wide array of socioeconomic backgrounds. We are pleased to report that more than 70% of our mentorship program participants this past year were from low socioeconomic

backgrounds. Open source developers can counter income inequality, and LFX Mentorship certainly contributes to that ideal.

We continue to work on increasing applications from women and people whose races are historically underrepresented in technology. Diversity comes in many forms, and diversity in LFX Mentorship is important. It creates widely acknowledged benefits within the open source community,

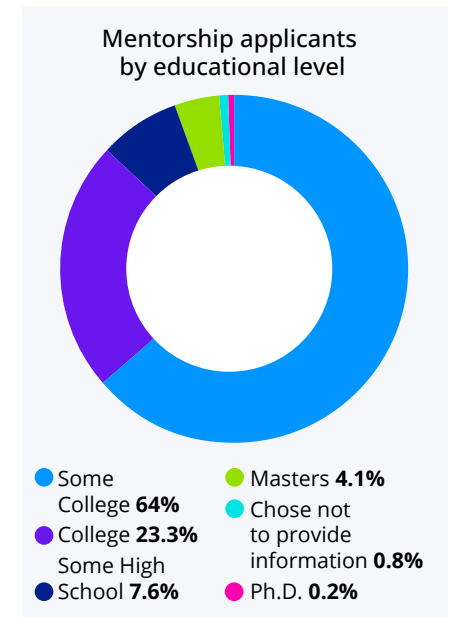
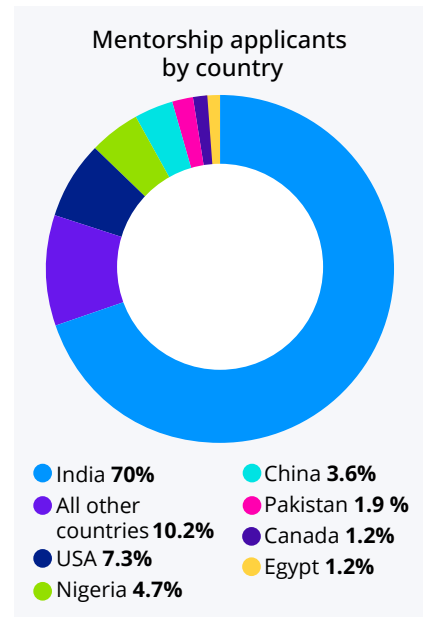
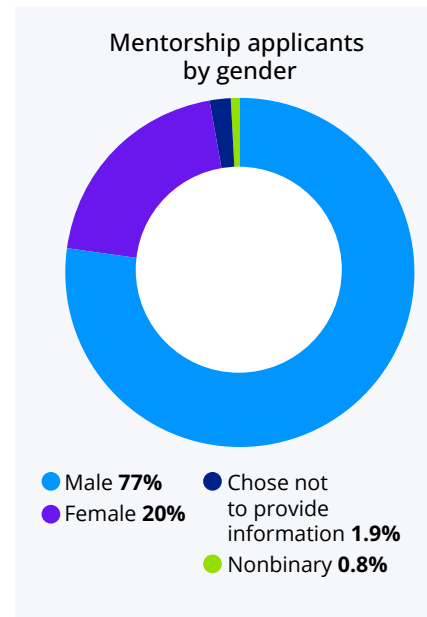
and it brings opportunities to a greater range of people. While we've seen some improvement in the participation of women since the program's inception (17% of applicants in 2019 compared with 20.1% of applicants in 2022), we'd like to see a more significant increase in 2023.

In summary, we are proud of the work accomplished by LFX Mentorship thus far and the opportunities it has created for a diverse set of folks around the globe. We are striving to improve in various ways and look forward to sharing more next year on what we hope to accomplish in 2023.

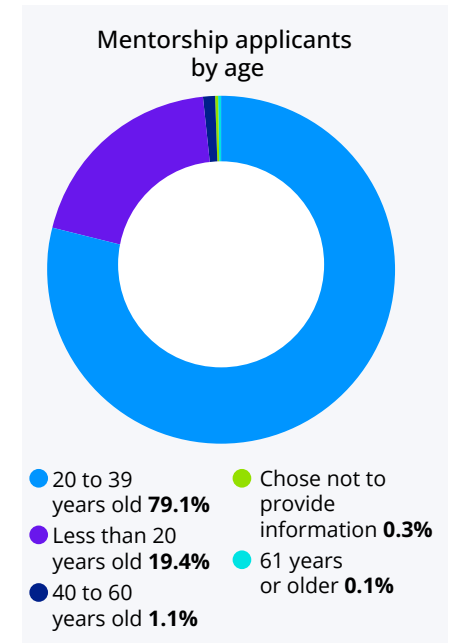
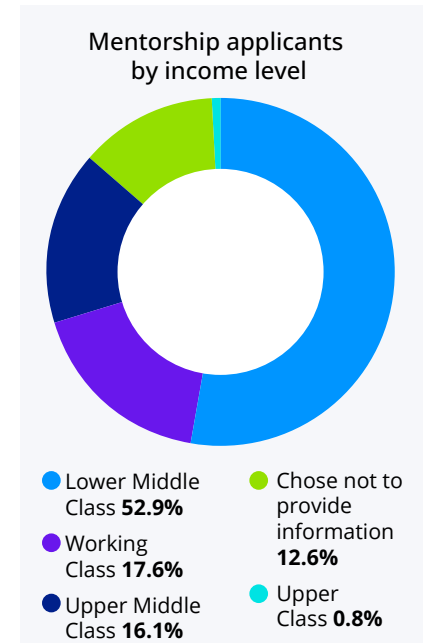
We thank all our mentors for taking the time to share their knowledge and expertise. Your contributions are invaluable, and your leadership is foundational.

## Mentorship and Events

The LFX Mentorship and LF Events teams continued their collaboration with open source community experts in 2022 to



provide unstructured, free, and accessible online education and learning opportunities through the [LF Live Mentorship Series](#). The series provides expert knowledge and valuable interactive discussion across various topics related to the Linux kernel and other OSS projects. A total of 12 sessions were held throughout the year, with an average live attendance of 100 people per session. Included in these was a five-part series on Rust. This is a timely resource as Rust grows in popularity and







Open Source Summit North America, June 2022

becomes a supported language in the Linux kernel 6.1 release. We thank the Rust maintainers for taking the time to provide this valuable resource.

In January 2022, we held our first [LFX Mentorship Showcase](#) to connect our graduates with prospective employers from our member companies. In this virtual event, 28 mentees shared their accomplishments with other attendees and attending employers. There are many open

source jobs, and employers are always looking for talent. Additionally, this event allowed us to thank our mentors, who shared their knowledge to train this new talent. Some of our mentors do this in their spare time, helping others with no expectation of thanks. We hope to make this an annual event and are already planning for the next mentorship graduate showcase to be held in January 2023.

In-person speed mentoring sessions returned at our flagship Open Source Summit North America and Europe conferences this year, where over 40 community members sat down with community veterans to ask questions and receive mentorship on technical, community, and career topics.

*“If you want to walk far, walk together.”*

As we talk about the stats and numbers, let's not lose sight of the big picture. It's all about the following:

- ▶ Making a difference and empowering people by offering enriching learning opportunities, both structured and unstructured.
- ▶ Paying them to learn while making the resources available for free and accessible to all.
- ▶ Developing new talent and making it available to the open source ecosystem.

- ▶ Helping to build diverse communities that continue developing open source code to keep our ecosystem healthy and sustainable.
- ▶ It is a long road, and we plan to walk together with the graduates, mentors, and experts in our communities for many years and many miles (or kilometers).





## Diversity, equity, and inclusion efforts

A richness of diversity—including people from all walks of life, cultures, countries, and skin colors—is crucial for developing sustainable and thriving open source communities. People from diverse backgrounds contribute fresh and inventive ideas. This creates a rich ecosystem that is inclusive and welcoming to everyone.

Creating diverse communities requires active effort and a dedication to engineering inclusive spaces.

We are proud to use our own events as a way not only to create these inclusive spaces but as opportunities to help build the diversity and inclusivity of the open source ecosystem. To achieve this, we have many diversity and inclusion initiatives that we undertake across our events, including the following:

- ▶ Policies against all-male panels and speaker line-ups.
- ▶ Free childcare at events.
- ▶ Nursing rooms, pronoun stickers, all-gender restrooms, and prayer rooms.
- ▶ D&I special events at our conferences, such as the Women & Nonbinary in Open Source Lunch (Open Source Summit), Better Together Diversity Lunch (Open Source Summit), and EmpowerUs Reception (KubeCon + CloudNativeCon). These events celebrate diversity and provide opportunities for networking and collaboration among people with shared life experiences.
- ▶ A strongly enforced code of conduct across our events. This clarifies that the Linux Foundation and its project communities provide a harassment-free experience for participants at all of our events, whether they are held in person or virtually.



Open Source Summit North America, June 2022

- ▶ Applying for CHAOSS project D&I badges to showcase our events as ones that take D&I seriously.
- ▶ Ongoing outreach to invite and encourage more diverse speakers at events—we're proud to share that.

In addition, the Diversity Empowerment Summit micro conference at Open Source Summit North America and Europe creates a space for participants to share D&I stories, best practices, insights, and lessons learned. It

included over 20 sessions this year, along with allyship workshops.

### Grace Hopper Conference

One important way the Linux Foundation [helped to build diversity and inclusion this year was by supporting the Grace Hopper Celebration \(GHC\)](#). Together, the OpenJS Foundation, OpenSSF, LF Training & Certification, CNCF, Hyperledger Foundation, and RISC-V teamed up at GHC to support and encourage



Open Source Summit North America, June 2022

more women and nonbinary technologists to contribute to open source projects.

Anna Jung, Senior ML Open Source Engineer at VMware and GHC 22 Open Source Co-Chair, said, "Reflecting back, I am so grateful to the open source community for being part of the Grace Hopper Celebration, especially Open Source Day. Open Source Day was only possible because 60+ project maintainers/contributors, 70+ mentors, and 15+ speakers volunteered their time to be part

*of the event. Because Open Source Day is a hackathon, participating in Open Source Day takes considerable time and effort, especially for projects and mentors. Therefore, I am thankful to them for being true leaders in the movement to increase diversity in open source. They collectively helped thousands of attendees, and, in less than 7 hours, there were more than 100+ contributions made to open source, mostly from women in tech."*

Ambika Sharma, Principal Data Product Manager at U.S. Bank and GHC22 Open Source Co-Chair, said, "Open source was loud and proud at GHC22! We're grateful for the community coming together to welcome, celebrate, and elevate more women to take their first steps into the world of open source software. The Linux Foundation had a pivotal role in making open source center-stage at GHC22, and we are grateful for their partnership. Five of the 27 projects that participated in Open Source Day were from the Linux Foundation. Two board members of the Linux Foundation were speakers and shared advice on building careers in open source—Nithya Ruff and Sarah Novotny. The Linux Foundation hosted a wonderful Happy Hour at GHC22 in Orlando, bringing the open source community together. Here's to celebrating the next generation of open source contributors and advocates."

Shagun Bose, SWE at Intuit and Grace Hopper Open Source Co-Chair said, "The Open Source community is so welcoming and supportive! One of my favorite moments from the day was when multiple representatives and mentors from different projects responded to a concerned participant asking whether she could keep contributing post-event. It was a small moment, but it illustrates beautifully how events like these can support and enable new contributors to confidently take their first step and forge lifelong connections within the community."

## Open Hardware Diversity Alliance

[The Open Hardware Diversity Alliance \(OHDA\)](#) is a RISC-V incubating project. It aims to bring together the open hardware community by providing programs and networking opportunities and encouraging the participation and professional advancement of women and other underrepresented groups. In 2021, OHDA hosted sessions on diversity at Open Source Summit. It continues to provide RISC-V diversity scholarships as well as free online training.

## Open Mainframe Project diversity efforts

The Open Mainframe Project aims to ensure that diversity is integral to the project and technology landscape. Sharing the [importance of belonging in the tech ecosystem](#), promoting [neurodiversity in the workplace](#), and giving staff and community members a place to share their struggles and [personal experiences for Asian American and Pacific Islander Heritage Month](#) are all part of the Open Mainframe Project. The project has provided an open conversation about DEI that is honest and raw. Through the “Making Our Strong Community Stronger” collaborative initiative, Open Mainframe has hosted several webinars, engaging with over 1,000 registrants, presentations, and blogs focused on diversity, equity, and inclusion.

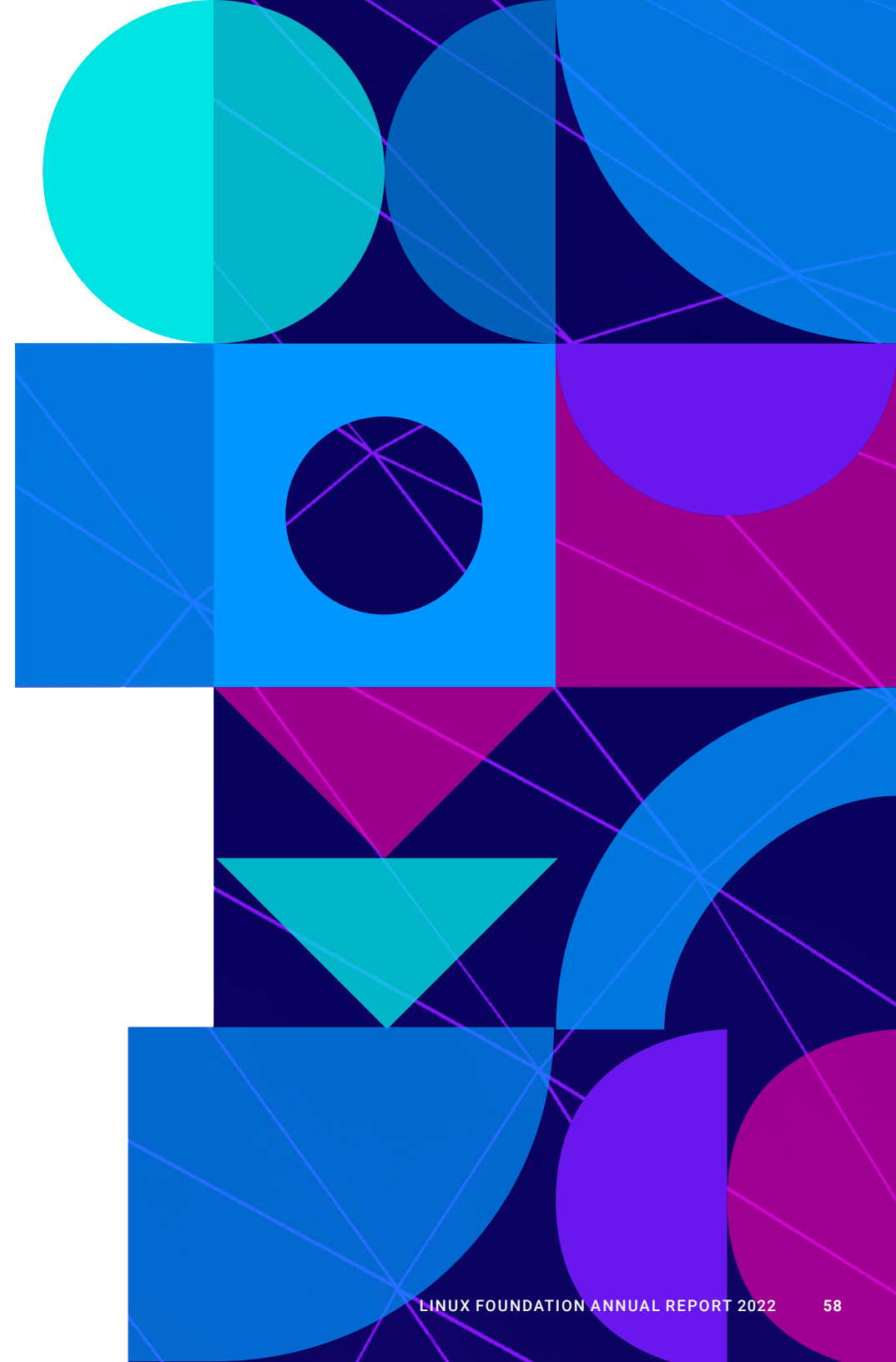


Open Source Summit North America, June 2022



## Investing in training and certification

The demand for experienced open source talent has never been greater. Although organizations have navigated a pandemic, the great resignation, and uncertain economic times, the need to bring innovative and secure products, services, and systems to market is even greater than the demand.





## Leveraging learning to support talent acquisition and retention

How do organizations manage their open source talent shortage while meeting their business needs? Hiring managers need to recruit technical professionals with proven and verifiable skills **and** invest in the growth and professional development of their current team.

The Linux Foundation works with organizations that are facing these challenges and strives to help technical professionals across the world gain the hands-on training and performance-based certifications they need to demonstrate their talent and advance in their careers. To date, more than 2.3 million individuals have enrolled in free training courses, and nearly 55,000 professionals worldwide have achieved technical and verifiable certification.

In 2022, our Training & Certification team launched more than 25 new offerings in high-demand technical areas, including cloud, cybersecurity, artificial intelligence, DevOps, and other emerging technologies. We currently host nearly 100 online courses, deliver over 20 instructor-led courses, and offer more than a dozen exams.

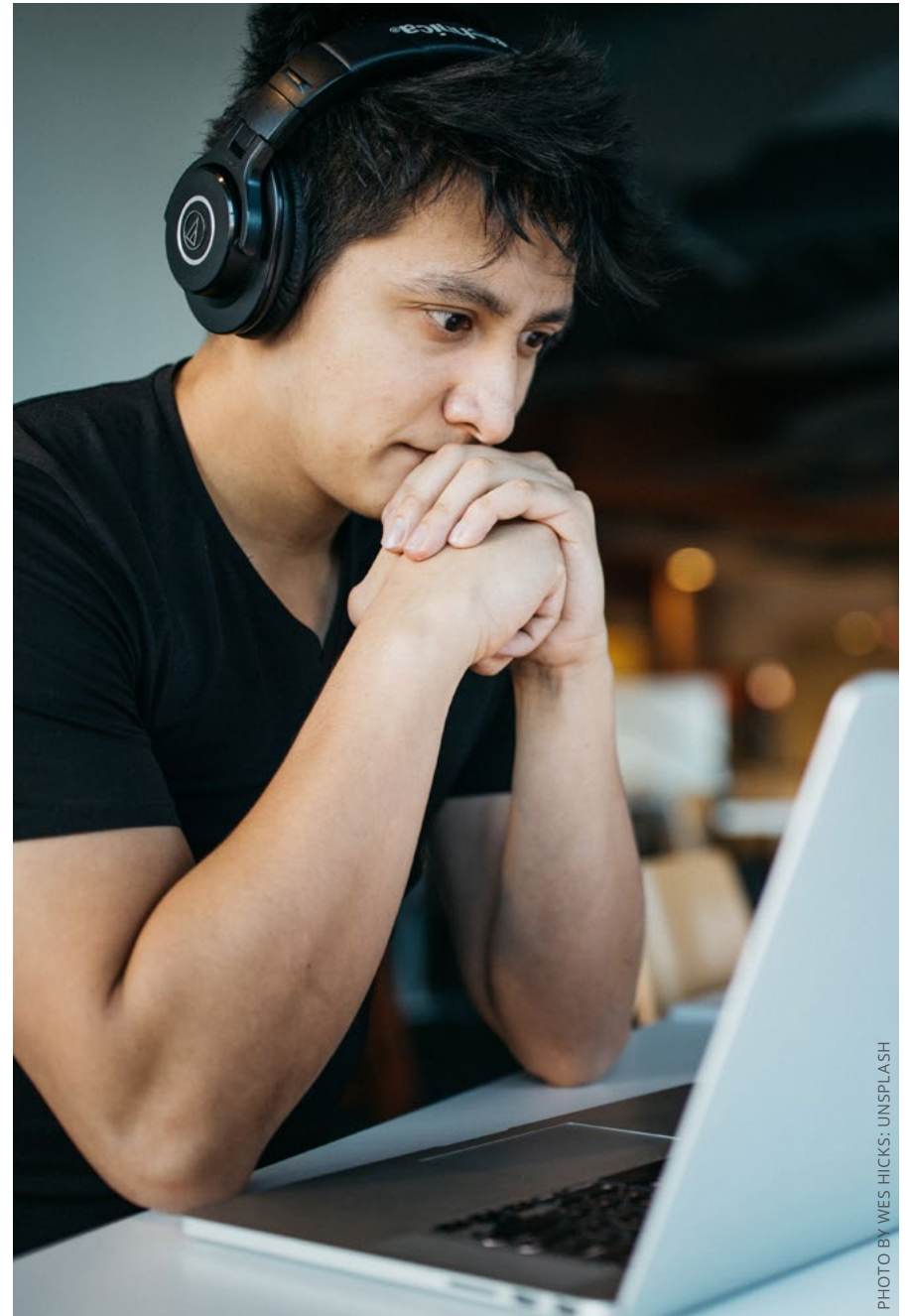


PHOTO BY WES HICKS: UNSPLASH

## New courses in 2022



- ▶ Antitrust for Open Source Project Communities
- ▶ Building Applications with RISC-V and FreeRTOS
- ▶ Data and AI Fundamentals
- ▶ Developing Secure Software
- ▶ Ethics for Open Source Development
- ▶ Foundations of RISC-V on Assembly Programming
- ▶ Fundamentals of Quantum Computing
- ▶ Getting Started with Self-Sovereign Identity
- ▶ Git for Distributed Development
- ▶ GitHub Supply Chain Security Using GitGat Foundations of RISC-V on Assembly Programming
- ▶ Green Software for Practitioners
- ▶ Implementing Open Source License Compliance Management
- ▶ Introduction to Backstage: Developer Portals Made Easy
- ▶ Introduction to DevSecOps for Managers
- ▶ Introduction to Istio
- ▶ Introducción a Linux (Spanish version)
- ▶ Introduction to Protocol Buffers 3
- ▶ Kubernetes and Cloud Native Essentials
- ▶ Linux for Cloud Technicians Developing Secure Software
- ▶ Linux for Cloud Technicians Essentials
- ▶ Linux System Administration
- ▶ Linux System Administration Essentials
- ▶ Linux Tools for Developers



PHOTO BY KETUT SUBIYANTO: PEXELS

- ▶ Microcontroller Applications with RISC-V
- ▶ OSS Development: Linux for Developers
- ▶ PyTorch and Deep Learning for Decision Makers
- ▶ Securing Your Software Supply Chain with Sigstore
- ▶ Software Engineering Basics for Embedded Systems

## Certifications and credentials

This year, we updated the Linux Foundation Certified System Administrator exam, developed a new certification for Linux Foundation Certified Technicians, worked with CNCF to create the Prometheus Certified Associate, and launched a new credential series called SkillCreds to support niche areas, such as Vim, Bash, Git, YAML, and Helm.

## Scholarships

In 2022, the Linux Foundation directly awarded 500 scholarships for free training and certification to individuals worldwide in memory of Shubhra Kar, the Linux Foundation's CTO. Hundreds more were awarded via non-profit partnerships, including Blacks in Technology, TransTech Social Enterprises, and Women Who Code.

## 10th Annual Jobs Report summary of findings



### Organizations need to retain and recruit open source talent

Our [10th Annual Open Source Jobs Report](#) was published in June 2022.

Hiring managers find that talented open source professionals are in even greater demand than in previous years. Closing the talent and skills gap requires top-level recruitment incentives and aggressive upskilling and certification of existing talent, which will have the added impact of supporting retention efforts.

### Additional key findings include the following:

- ▶ **A significant shortage of qualified open source talent:** Approximately 93% of employers report struggling to find sufficient talent with open source skills.
- ▶ **Certifications hit new levels of importance:** Approximately 90% of employers stated that they would pay for employees to obtain certifications, and 81% of professionals plan to add certifications this year. This demonstrates the weight these credentials hold.
- ▶ **Cloud's continued dominance:** Cloud and container technology skills remain the most in-demand this year, with 69% of employers seeking hires with these skills and 71% of open source professionals agreeing that these skills are in high demand.
- ▶ **Cybersecurity concerns are mounting:** Cybersecurity skills have the fourth-biggest impact on hiring decisions, as reported by 40% of employers, trailing only behind cloud, Linux, and DevOps.

## Events

This year finally allowed us to return to global locations to reconnect with many of our community members we haven't seen live since 2019 and meet new ones.

*"I don't think anything replaces the face-to-face meetings and the personal connections that you get when you're in the same room or same place with people."* – Annamie Paul



## Returning to our global community

Europe's reopening allowed KubeCon + CloudNativeCon Europe (and 14 co-located events) attendees to reconvene live, and over 7,000 did, in Valencia, Spain, this May.

After several smaller European events throughout the summer, Open Source Summit Europe, Hyperledger Global Forum, Linux Plumbers Conference, Kernel Maintainer Summit, KVM Forum, Linux Security Summit, and several other events were able to return in person for the first time since 2019 in Dublin, Ireland. It has been truly amazing to see the excitement and enthusiasm that our communities have had as we've been able to return to in-person events.

With Japan's recent reopening, we are ecstatic to return to Japan in December with Open Source Summit Japan, KubeDay Japan, SODACon, and Open Compliance Summit.

Across 230 in-person, virtual, and hybrid events in 2022, we gathered over 92,000 attendees from 176 countries and over 12,000 organizations.

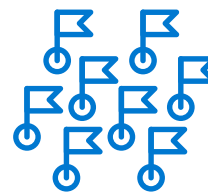
We received over 7,900 speaking submissions across these events. Over 830 program committee members reviewed these submissions, resulting in 4,416 open source community leaders delivering over 3,000 talks across these events to an audience around the world.

### ATTENDANCE ACROSS 2022 EVENTS



**92,000**  
**attendees**

230 in-person, virtual, and hybrid events in 2022



**12,000**  
**organizations**



**176**  
**countries**

### SPEAKERS AND CONTENT



**7,933**  
**submissions**



**836**  
**Program committee members**



**4,354**  
**speakers**



**3,079** talks across  
**271** tracks

### TRAVEL FUNDING

We provided just under \$1.2M in travel funding in 2022 to attend career-changing events:



**289 diversity travel scholarships (\$636,730)**

**77** In-person and **27** Virtual Diversity Registration Scholarships awarded



**246 need-based travel scholarships (\$471,209)**

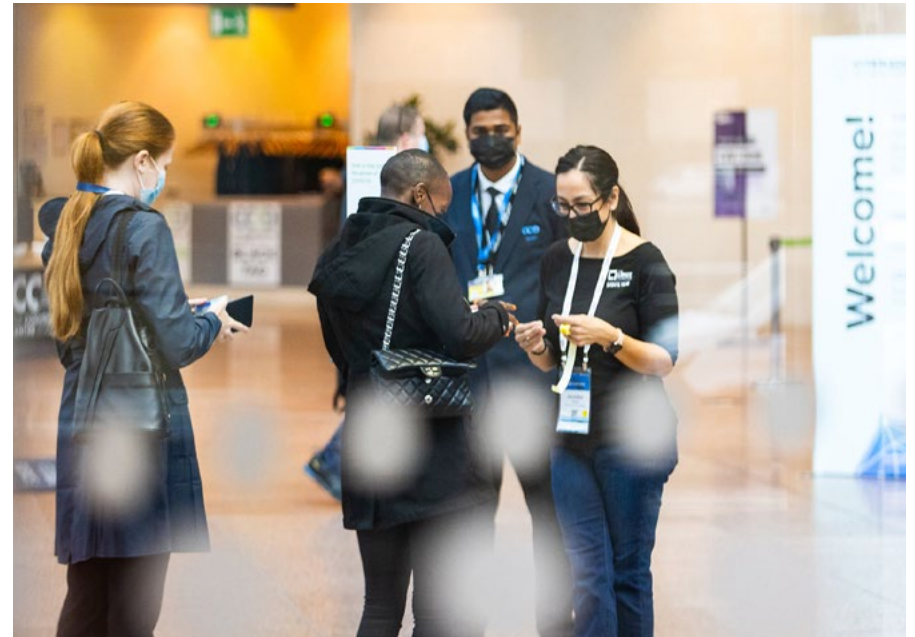
**44** In-Person and **21** Virtual Need-Based Registration Scholarships awarded

## Looking forward to 2023

We know the effect of COVID-19 may continue to shape our event plans as we move forward into 2023, and we expect the economic headwinds to do so as well. We will continue to evolve and reshape our event offerings to provide the greatest benefit to as many people as possible, in as many ways as possible, through these times.

“As a first-time attendee, the OSS NA exceeded my expectations. The keynotes. The session speakers. The quantity of rich content—from everything open source to DEI and mentorship. I loved every minute of it.”

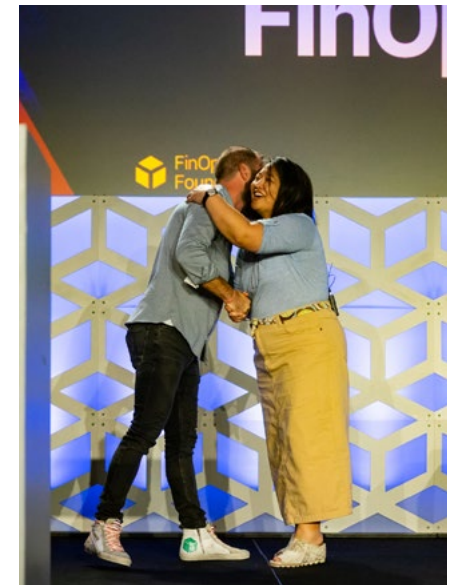
“One of the most important events about Open Source! Many interesting projects! Loved it.”



Open Source Summit, Dublin 2022



Open Source Summit North America, June 2022



# Innovation in telecommunications and the edge

Massive global demands for data consumption drive the need for digital transformation—with tight security, strong infrastructure, and scalable architecture—it is crucial to deliver data across networks.





# Open source networking: Reshaping global connectivity for five years and counting



Linux Foundation Networking (LFN) software and projects provide the foundations for network infrastructure and services across service and cloud providers, enterprises, vendors, and system integrators that enable rapid interoperability, deployment, and adoption. We are the nexus for collaboration and enable people across the world to access networking innovations and achieve their digital transformation goals.

LFN is now in its fifth year as an umbrella organization, and its maturity brings deeper cross-community collaboration, with major integrations between building blocks underway across the entire stack—from the core to the access and edge—between ONAP and ORAN, Akraio and Magma, Anuket and Kubernetes, Nephio and EMCO, and many others.

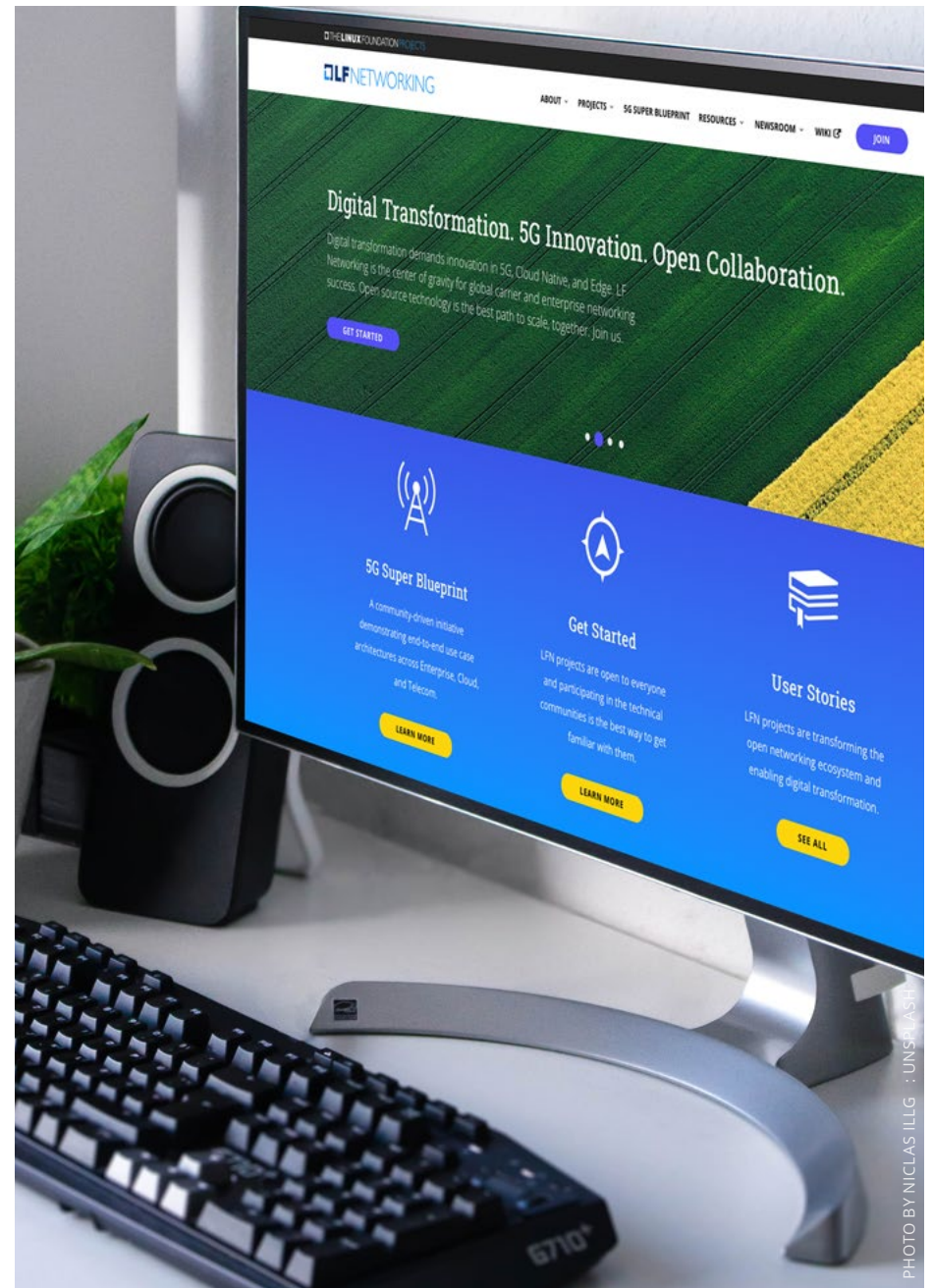


PHOTO BY NICLAS ILLG : UNSPLASH



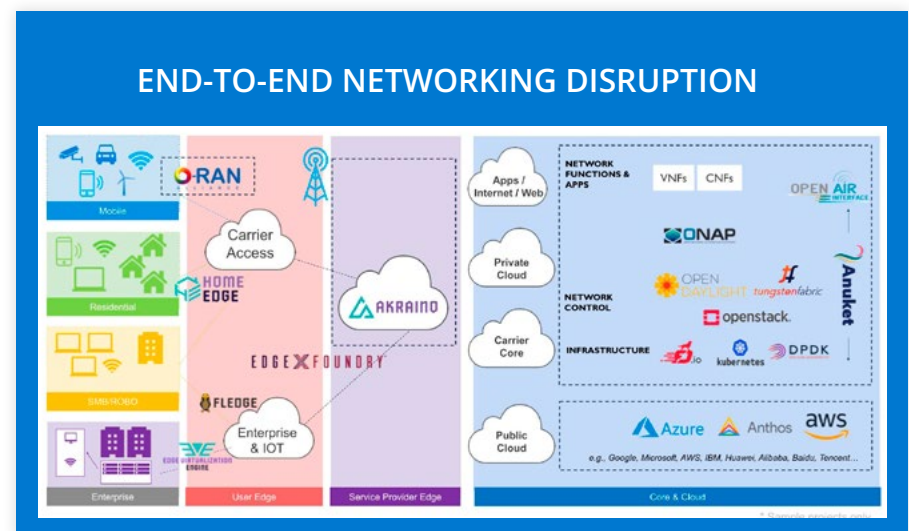
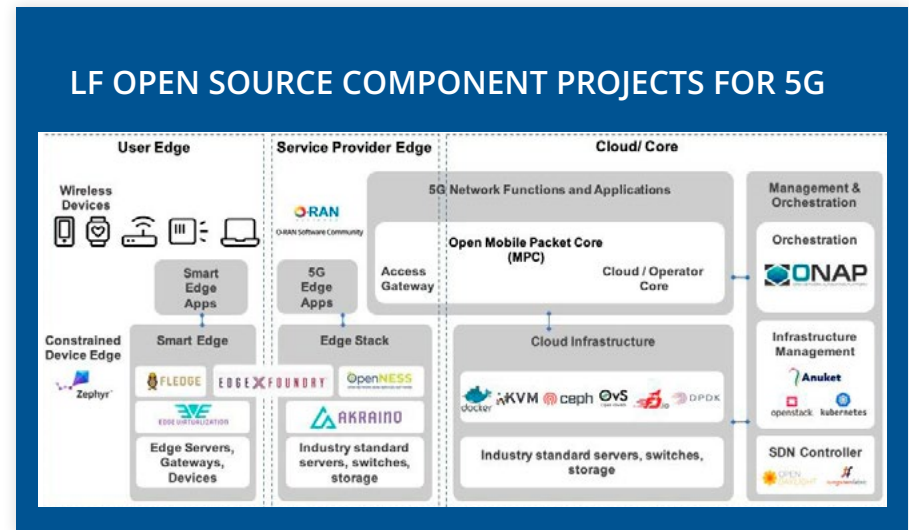
# 5G Super Blueprints: Enabling integrated, accelerated cross-stack 5G use case deployments

A centerpiece of open integration is the 5G Super Blueprint initiative—a community-driven integration and proof of concept involving multiple open source projects that enable end-to-end use cases demonstrating implementation architectures for end users. Intending to accelerate deployment (e.g., from six months to six weeks), the 5G Super Blueprint provides the framework for implementing real-world use cases in the open.

Integrating multiple open source projects and umbrellas (such as LF Edge, Magma, Nephio, CNCF, O-RAN Alliance, and Linux Foundation Energy) with a full-stack framework for underlying infrastructure and application layers across the edge, access, and core, this initiative is a true “Integration and Interoperability” framework across the ecosystem. Specific use cases include fixed wireless, mobile broadband, private 5G, multi-access, IoT, voice services, network slicing, and more (many of which are now in active production deployment). In short, the 5G Super Blueprint is a vehicle for collaborating and creating end-to-end 5G solutions.

Currently, the U.S. government is the leading user of these blueprints across all major case studies, including Static Transport Slicing, Distributed DOS, and Factory Visual Inspection.

Another example of the 5G Super Blueprint comes from a Japanese enterprise customer who collaborated with LFN member organization Aarna Networks to leverage the 5G SBP. The collaboration delivered a Radio Access Network (RAN) core and single pane of glass for an enterprise customer to view, orchestrate, configure, and manage private 5G mobile broadband and IoT deployment.



## FROM POC TO PRODUCTION

As open source networking solutions become more ubiquitous, 2022 saw even more LFN use cases come to life, with **new user deployment stories** published from several carriers, including Spark (New Zealand), Tigo (Guatemala), and Orange (France), as well as vendors and SIs, such as Aarna Networks, Netgate, Equinix, Intel, and Pantheon. Increasing industry organizations are now reaping the benefits of open source technologies in production, saving on CAPEX, OPEX, R&D, and more.

Looking ahead, the LFN ecosystem will increasingly integrate across even more touchpoints, such as the metaverse, Open RAN, and AI / ML. We're also excited about the following tangible networking industry shift into the enterprise that is already coming into

fruition: The L3AF project, which Walmart donated to the Linux Foundation in 2021 with the support of other leading tech companies and enables Kernel Function as a Service with lifecycle management of eBPF networking application programs. Similarly, the EMCO project, which was new in 2021, helps organizations (including enterprises) to securely connect and deploy workloads across public clouds and edge locations, with end-to-end inter-application communication enabled. Join us on this journey and see where the open source networking ecosystem goes in 2023.

[www.lfnetworking.org](http://www.lfnetworking.org)

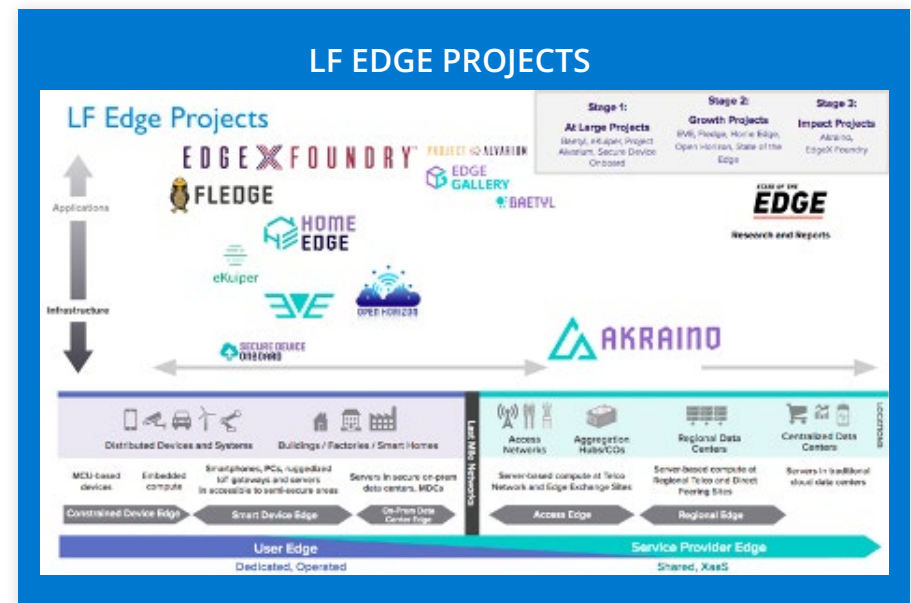
## LF EDGE

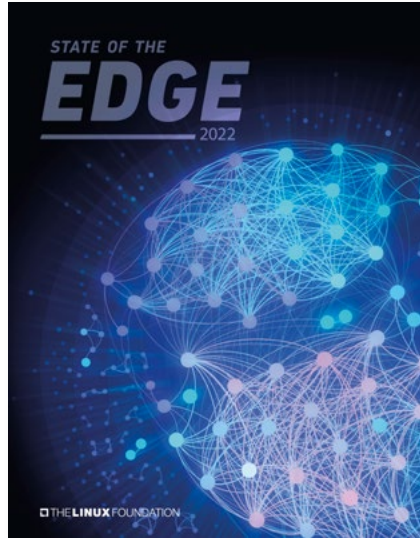
### Edge and IoT now mandating open source frameworks: A market four times the size of cloud computing

As defined by the 2021 State of the Edge Report, 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 a natural extension of cloud computing

and estimated by analysts to be at least four times the size of cloud computing, the edge cloud construct is increasingly a key enabler for the "Fourth Industrial Revolution," in which the widespread deployment of IoT, global sharing economy, and increase of zero-marginal-cost manufacturing deliver unprecedented communication-driven opportunities with massive economies of scale.

Now in its third year as an umbrella organization, LF Edge has become the center of gravity for





some of the world's most impactful open source edge computing projects, including EdgeX Foundry and Akaino—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 sector verticals, including telecommunications, cloud, IoT, industrial IoT, retail, AI / ML, factory floor, and smart home.

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, driven by EdgeX Foundry and Akraino, is more crucial than ever. The key impacts of LF Edge in 2022 are evidenced by the robust set of Akraino blueprints in deployment, EdgeX's 10M+ container downloads, and the project's tenet publications, [State of the Edge Report](#), and the LF Edge Taxonomy, along with a diverse set of new use case deployments. The highlights include the following:

- ▶ At the 2022 Olympic Games in Beijing, Tencent and China Unicom created a multi-access edge computing platform to track and analyze real-time traffic data based on Akraino's [Connected Vehicle Blueprint](#).
- ▶ Retailers use [EdgeX Foundry](#) to combine POS, RFID, Weight Scale, and Computer Vision data to alert associates in real time, improving self-checkout efficiency and saving costs.

- ▶ [UC Davis and Opus One use Fledge](#) to create safer wine-making conditions via a multi-node wireless sensor network to produce world-class wine.

The [Mayflower Autonomous Ship leveraged](#) Open Horizon components and successfully sailed across the Atlantic Ocean unmanned.

- ▶ Project Alvarium provides [trust-worthy sustainability](#) reporting and validated carbon emission measurements for organizations that accurately track their carbon footprint.

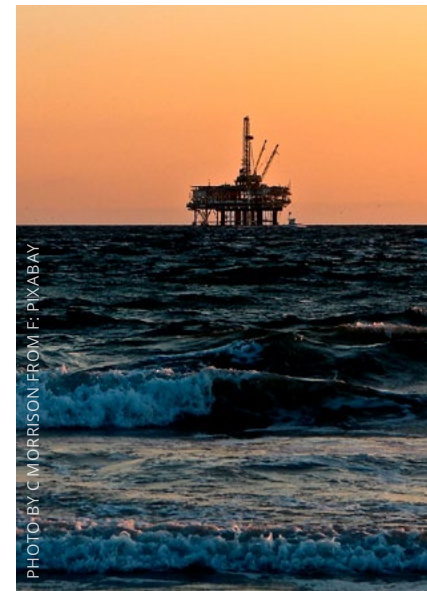


PHOTO BY C. MORRISON FROM P. PIXABAY

## US GOV OPS

Accelerating Open and Secure Innovation

Founded in 2020, the U.S. GOV OPS project is an umbrella for OS projects initiated by the U.S. Department of Defense (DoD).

The first project under the umbrella is the Open Programmable Secure 5G project, which develops a secure, end-to-end, open source architecture for 5G wireless networks. The resulting architecture will address DoD operational and security requirements. DARPA sponsors the project, which utilizes the U.S. Navy as a management agent.

Notable successes include the following:

- ▶ Development of an ONAP use case that enables security for network slices.
- ▶ A new project proposal based on DDoS mitigation technology.
- ▶ Contribution of use cases and technology to LFN 5G Super Blueprint.





In partnership with Google Cloud, we announced the formation of project [Nephio](#) on May 3, 2022. Nephio enables cloud native automation and the management of 5G networks across multiple edge locations. With over 50 supporting organizations, Nephio has grown two-fold since launching.

Momentum for Nephio in its first year is strong. With developers and representatives from over 25 major service providers and vendors, Nephio hosted its first in-person [Nephio Technical Summit](#) in the Bay Area during the summer. Nephio held a follow-up event at ONE Summit in November, with an even stronger show of support. The [Technical Steering Committee](#) is actively discussing strategies, a roadmap, and operations of cloud native automation in the telecommunication world.

#### [Learn more about Nephio](#)

and become part of this effort to enable the efficient and on-demand consumption of cloud and edge resources, opening new opportunities for the telecom industry.



Created by Microsoft, Software for Open Networking in the Cloud (SONiC) is an open source network operating system based on Linux that runs on over 100 different switches from multiple vendors and ASICs. Since it launched, SONiC has grown rapidly, with over 50 leading organizations collaborating to build a vibrant NOS community.

SONiC joined the Linux Foundation in April 2022. Since then, the new Governing Board comprises luminary leaders from major companies that have contributed to SONiC since its development. The project has also grown from mainly powering datacenter



**DPDK Userspace in Arcachon, France 2022**

scenarios to powering bare metal, AI and gaming, enterprise, and now edge and 5G scenarios. With an active and vibrant ecosystem, SONiC is now ready to handle almost all scenarios with the network switch. The community has also participated in the Open Networking Day with SONiC, OCP Summit, and ONE Summit this year.

More information about SONiC, including how to join, is available on the [SONiC website](#).



The strong and passionate DPDK community met in person once again in September 2022 for DPDK Userspace in Arcachon, France. While in-person attendance was lower than pre-COVID-19 numbers, with 37 onsite, another 102 folks joined virtually, and the session recordings are available for on-demand viewing. The event also featured a hackathon to address zero-day issues and bug fixes.

Contributor strength has grown by 11% yearly, and the DPDK blog features more community developers. The project changed its release cycle from four to three releases per year and currently supports a Long-Term Support (LTS) release. The community also published a user story outlining how SmartShare Systems used DPDK to improve customers' WAN bandwidth from 1GB to 10GB; however, DPDK enabled up to 100GB of bandwidth.





In 2022, the Magma community underwent a transition to becoming a full-fledged community-run project under the auspices of the Linux Foundation across all governance functions. It is now a fully functioning open source community working to bring modern software networking techniques to take on the challenge of rural Internet access.

Magma issued its first major release since moving to the Linux Foundation—Magma 1.8—which brings multi-architecture containerized AGW to the market. The addition of new Arm partner systems to the test list makes the project accessible to both Arm and x86 solutions.

Magma is seeing new deployments that enable a better connection across rural parts of Africa, as well as within the U.S. Open, monthly meetings ("Magma 5G: All You Need to Know") are in full swing, alongside an updated blog

cadence. The group is looking at contemporary Mobile Packet core projects for integration with LFN 5G Super Blueprint.



eBPF is in its second year at the Linux Foundation, working toward strengthening governance and community structure. The year 2022 brought an approved budget, updates to the Charter and Project-Progression Policies, the kick-off of the marketing committee, and the ability to accept new projects into the foundation.

The project sponsored the live stream of the following two events in the year's second half: Linux Plumbers Conference 2022 and Kubecon + CloudNativeCon's eBPF Day.

The group is working on updating its website and growing the developer community in 2023.



The O-RAN Software Community (SC) is a collaboration between the O-RAN Alliance and the Linux Foundation with the mission to support the creation of software for the RAN. The RAN is the next challenge for the open source community. The O-RAN SC plans to leverage other Linux Foundation Networking projects while addressing performance, scale, and 3GPP alignment challenges.

With a focus on cross-collaboration, ORAN-SC is now more fully integrated across the open networking stack, as it finalized its ONAP Interface testing, leveraged SMO using ONAP modules for synergy, and implemented Anuket's xTesting tool.

The community issued its F and G releases and welcomed a new AI / ML framework project driven by the member organization Samsung.



DENT, an open source network operating system utilizing the Linux Kernel, Switchdev, and other Linux based projects, made significant strides in 2022. Its DENT 2.0 release, "Beeblebrox," added 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.

In addition, Amazon deployed 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 successful Mini-Summit, "NOS for the Distributed Edge: a DENT Mini Summit," co-located with ONE Summit in November, with over 70 attendees.

The next DENT release, due out in Q1'23, will include updates to consistency configuration and 802.1x features.

## Innovation in web, cloud, and DevOps

We remain focused on innovative solutions that continuously improve the software supply chain, making cloud native ubiquitous, and growing a sustainable continuous delivery ecosystem that fosters vendor-neutral collaboration across industries and organizations.

# OpenJS Foundation

People are the heart of the OpenJS Foundation, as they bring fresh ideas and innovations to keep our community a safe and neutral home for JavaScript.

Security issues have always been a part of the Internet, but they are now on a larger scale and directly impact more people than ever before.

This year, we set out to strengthen the security and sustainability of the OpenJS projects to improve the software supply chain and increase our security contributions and collaboration with security communities and JavaScript maintainers.

Node.js was the first open source community onboarded to the OpenSSF's Alpha-Omega Project to support these efforts. This project has been ongoing since the summer, and we've been recapping the progress in our [monthly Node.js Security Reports](#).

We continue to build our OpenJS Security Working Group led by the Cross Project Council (CPC).

The CPC sets the technical and project governance strategies for the foundation. Through these efforts, we hope to reduce the risk and achieve ambitious security goals for all our OpenJS projects.

"JavaScript technologies are often highly interconnected, so it's great to see how maintainers support maintainers at the OpenJS CPC," said Joe Sepi, Open Tech Program Director at IBM, and Chairperson of the CPC.

Our footprint in testing and automation continues to grow. Joining other frameworks such as Appium and Mocha, we welcomed [Jest](#) earlier this year, the most popular testing framework contributed by Meta. Jest currently has over 17 million weekly downloads, and companies of all sizes, including Amazon, Google, Meta, Microsoft, and Stripe, use it.

OpenJS also added a new technical solution in JavaScript development with the [Urban Computing Foundation](#) (UCF). To continue this impactful work, we announced the formation of the Open Visualization Collaboration Space, a place within OpenJS to neutrally govern the most comprehensive and widely adopted visualization libraries based on JavaScript and WebGL. We welcomed UCF members Foursquare, HERE Technologies, Joby Aviation, and Uber as new members of the OpenJS Foundation. Open visualization technologies are vital to each of these companies' leadership positions in the market. By supporting the foundation, they are supporting the infrastructure and long-term growth of the key open source projects that they rely on.

To celebrate the great work in our community, we developed JavaScriptLandia, the OpenJS Foundation's supporter program. This year, our



"JavaScript technologies are often highly interconnected, so it's great to see how maintainers support maintainers at the OpenJS CPC"



Rachel Nabors, AWS, on The Human API, Building Your Project's Second Source of Truth.



Standards panel: Robin Ginn, OpenJS; James Snell, Cloudflare; Jordan Harband, Open Source maintainer; Christian Bromann, Stateful.

first-ever [JavaScriptLandia awards](#) showcased the work of our community leaders by highlighting their leadership and contributions to JavaScript. Matteo Collina and Bethany Griggs received awards this year for their strong leadership and dedication to growing our projects.

"Fastify just turned six, and the foundation has helped grow the adoption of this ecosystem to attract new contributors," said Matteo Collina, co-founder of Platformatic and director of OpenJS CPC.



**JavaScriptLandia**

The OpenJS Foundation continues to invest in diversifying our members. This year, we added three new women [board members](#) and participated in the [Grace Hopper Conference](#), the world's largest gathering of women technologists.

JavaScript is everywhere, including in 98% of the world's websites. Representing this enormous developer ecosystem is a humbling and awesome responsibility. The work of our maintainers matters, as they keep JavaScript safe and modern for those who depend on it.



## Bringing JavaScript users together through diversity among people and projects



### Matteo Collina

Matteo received the JavaScriptLandia award for Leading by Example. A strong technical leader helps others to grow, provides mentorship, and supports new contributors.

Matteo always tackles problems head-on and collaboratively. He recently co-founded the new company Platformatic, which joined the OpenJS Foundation as a silver member in September.



### Bethany Griggs

Bethany received the JavaScriptLandia Unsung Hero award for being a powerful force for Node.js behind the scenes. She puts in tremendous work on the release team for the project, but that work often goes unrecognized.

In addition to her service to the project, Beth volunteers on other OpenJS committees and makes herself available to help the foundation in various ways, including in the marketing and programming committees.



### Michał Gołębiowski-Owczarek

Michał is a staff software engineer for Sumo Logic, a contributor to various open source libraries, and a core team member of jQuery.

Michał has been leading an effort to update and modernize jQuery, which 77% of the world's top 10 million websites still use. Michał appeared in GitHub's README project for his work on jQuery.s.



### Joe Sepi

Joe has been a critical success factor in the OpenJS Foundation's Cross Project Council, leading efforts to support our key maintainers.

Joe ensures that the CPC progresses every week and dedicates time to guiding the technical strategy of the foundation and evolution of healthy governance policies.

# Cloud Native Computing Foundation

**The Cloud Native Computing Foundation** (CNCF) has been building the road ahead throughout 2022, creating a stable and sustainable, contributor-led springboard for the future as we continue to make cloud native ubiquitous.

CNCF is the vendor-neutral hub of cloud native computing, hosting 18 graduated projects, 34 incubating projects, and 74 sandbox projects, driven by over 168,962 contributors representing almost 200 countries.

Today, CNCF has over 830 members, making it one of the largest open source foundations in terms of member companies. Up to September 2022 (when this report was curated), we welcomed 108 new vendor members, an increase of 15% from 2021. Additionally, we saw a 12% year-on-year increase in end-user membership to 153.

## Contributor-led innovation

#TeamCloudNative, CNCF's vibrant and diverse community of doers, continued to expand and drive engagement across many initiatives in 2022. From the expansion of [Kubernetes Community Days](#) to cover eight regions across the globe to welcoming over 7,000 in-person attendees to KubeCon + CloudNativeCon Europe, 65% were there for the first time.



KubeCon + CloudNativeCon Europe 2022, Valencia

With a particular focus this year on cloud native security, [The Cloud Native Security Whitepaper](#), published in June by the TAG Security group, highlighted the importance of humans within security, concluding that it “is the mechanisms, processes, and intent by which humans and systems interact with and make changes to cloud native applications and technology.”

## Humanizing security

Building on the importance of humans in security, CNCF partnered with Sonatype to introduce Security Slam, which enables CNCF projects to improve their security posture while attracting new contributors through a fun and collaborative event leading up to KubeCon + CloudNativeCon North America 2022. The hugely successful Bug Bash brought developers together in a live, asynchronous, and





KubeCon + CloudNativeCon Europe 2022, Valencia



cooperative model to find and fix as many bugs as possible in open source projects. Meanwhile, [Fuzzing](#) continued in 2022, with 18 projects fuzzed continuously by the [OSS-Fuzz project](#) to uncover bugs.

Seven projects completed security audits, resulting in 132 security fixes and improvements, 45 common vulnerability exposure fixes, and 51 security tool builds. In addition, CNCF conducted several independent security audits throughout 2022 in strategic partnership with the Open Source Technology Improvement Fund. Additionally, we announced the inaugural [CloudNative SecurityCon](#), which will launch in 2023 and allow application developers and modern security experts to propose solutions that incrementally improve what already exists and make room for cutting-edge projects and advances in modern security approaches.

## Building the road ahead

Underscoring CNCF's dedication to innovation at all levels of the ecosystem, we hosted the inaugural [CTO Summit](#) at KubeCon + CloudNativeCon Europe 2022, bringing together 21 leaders from six different business verticals to discuss multi-cloud resiliency and how to achieve it. This was so successful that CTO Summits will appear at each KubeCon + CloudNativeCon.



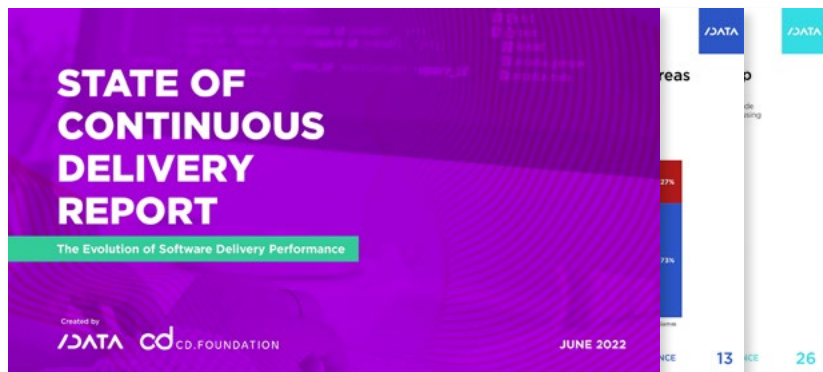
# Continuous Delivery Foundation

The [Continuous Delivery Foundation \(CDF\)](#) serves as the vendor-neutral home of the fastest-growing projects for Continuous Delivery (CD), such as [Jenkins](#), [Spinnaker](#), [Tekton](#), and [CDEvents](#). Its mission is to grow and sustain projects that are part of the broad and growing continuous delivery ecosystem. It fosters vendor-neutral collaboration between the industry's top developers, end users, and vendors to further CD best practices and industry specifications.

The year 2022 has been exciting for the CDF, as it has seen many

achievements. The community continued to shape the future of CD by making impactful contributions and kicking off new initiatives. One key initiative the community has been working on is interoperability in the CD ecosystem, resulting in a new project called [CDEvents](#), a common specification for CD events that brings an innovative approach to CD.

The CDF community started contributing to global improvements of the software supply chain by forming the [Software Supply Chain Special Interest Group](#) and the



**Moderator (left):** Fatih Degirmenci, CD Foundation. **Speakers (left to right):** Sarah Novotny, Microsoft; Hong Wang, Akuity; Isaac Mosquera, AWS; and Tim Jacomb, Kainos.

[Supply Chain Maturity Model Workstream](#), onboarding a new project called [Pyrsia](#), and completing a [Tekton Security Audit](#).

We hosted many events throughout the year, including the first in-person [cdCon](#), [CD Mini Summit](#), co-located with OSS Europe 2022, [CD Summit](#), and [Spinnaker Summit 2022](#), co-located with KubeCon

CloudNativeCon NA 2022. Furthermore, we launched the [CD Best Practices](#) website, allowing the collaborative development of CD best practices. We also published the third [State of the CD Report 2022](#), measuring the evolution of software delivery performance.

The projects within the CDF took part in global initiatives, such as [Google Summer of Code 2022](#)



and [Hacktoberfest 2022](#), with many individuals contributing to moving our projects and the overall CD ecosystem forward.

Our 2022 achievements have laid the groundwork for greater things in 2023. We look forward to driving the CD forward with our wonderful community!

---

*"We started CDEvents with the team at the Special Interest Group as we recognized the need for a common language across the tooling we use to produce software, from development through build, deployment, and operation."*

*The Continuous Delivery Foundation is the perfect home for the project. The CDF team shares our vision of interoperability, and they helped us to connect to a great community of maintainers, vendors, and DevOps practitioners.*

*Thanks to CDF in 2022, we hosted two events, [the CDEventsCon](#) and [the CDEvents Community Summit](#), where we could get together, share our work, and grow our community."*

**Andrea Frittoli, CDEvents maintainer, IBM**

---



## Communities building open source best practices

From creating OSPOs that help organizations in their consumption and contributions in enterprise FOSS to maximizing business value in their data-driven cloud spending decisions, Linux Foundation communities are leading the way in the development and dissemination of open source best practices.



## TODO Group (open source program offices)



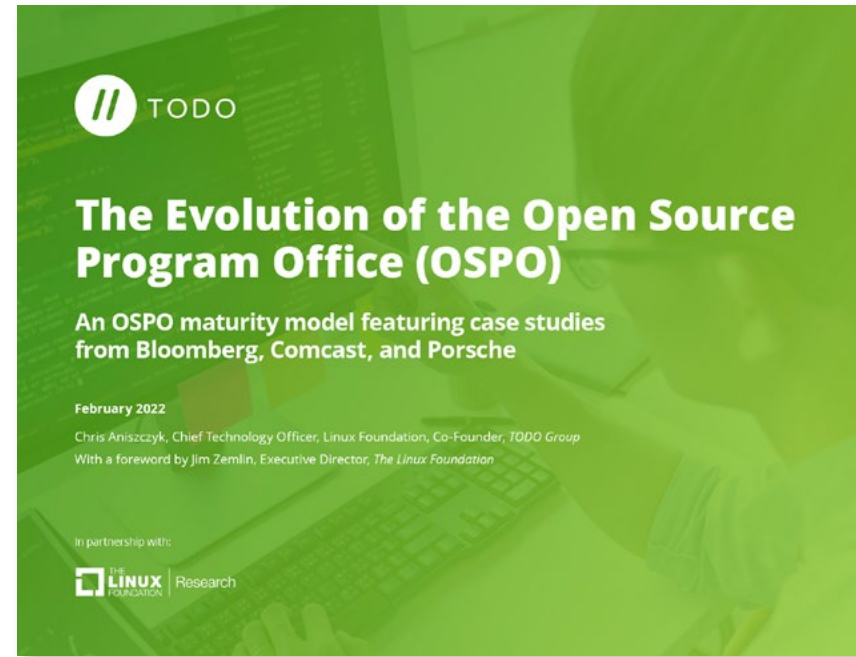
Adopting a strategic posture around open source is no longer optional. An [Open Source Program Office \(OSPO\)](#) is an open source catalyzer for [many organizations](#). An OSPO is a designated place where open source is supported, nurtured, shared, explained, and grown inside an organization. With such an office in place, organizations can establish and execute their open source strategies and policies with clear terms and responsibilities, giving their leaders, developers, marketers, and other staff the necessary processes and tools to make open source a success within their operations.

The [TODO Group](#) exists to support the adoption of OSPOs worldwide. This growing community of practitioners formed by open

source leaders from all industries and regions collaborates on best practices and tools to run effective OSPOs. During the last decade, the community has published numerous well-known guides, studies, courses, and toolkits.

The TODO Group began and collaborated with other projects on many initiatives in 2022, including the following:

- ▶ [OSPOlogy.live Europe](#): A cross-community effort and two-day convention to discuss the organization's open source challenges in Europe, seek advice from OSPO peers, connect OSPOs with open source communities, and collaborate on shared solutions (e.g., open source policies, tooling, standards, and community-building).
- ▶ [OSPO Local Meetups](#) supported in native languages: A forum for like-minded professionals to



share their knowledge and experience of OSPOs and open source management within specific regions. [Western Switzerland OSPO \(French speaking\)](#) was the first forum, launched in September 2022.

- ▶ The [OSPO Mind Map](#) project: An interactive mind map that schemes the main OSPO's responsibilities, roles, behavior, and team size within the ecosystem. The project can be found as part of the [OSPOlogy repo](#).

▶ [A Deep Dive into Open Source Program Offices](#): A whitepaper that includes OSPO characteristics, structures, roles, responsibilities, and challenges.

▶ [The Evolution of the OSPO](#): An OSPO study that shares an [OSPO maturity model](#), practical implementation from noted OSPO programs across regions and sectors, and a set of OSPO archetypes.





- ▶ **Outbound Open Source Guide:** A guide about contributing to or launching an open source project in the enterprise.

The TODO Group also continued to refine its existing work, including the following:

- ▶ **OSPology Global meetings:** Released season two of OSPO end-user use cases.
- ▶ **TODO Guides:** Best practices on how to start and advance in an OSPO.
- ▶ **Annual OSPO Surveys:** In collaboration with the Linux

Foundation, research to get an understanding of OSPO adoption.

- ▶ **OSPO Courses:** To build a comprehensive OSPO career path based on the many responsibilities of an OSPO in the future.
- ▶ **OSPO Landscape:** A landscape of the OSPO ecosystem to help organizations see how many OSPOs are out there and what tools can be used.
- ▶ **Awesome OSS Management:** A list of packages and projects built by the TODO Group community or helpful for managing OSPOs.
- ▶ **OSPO News:** TODO newsletter with OSPO trends, jobs, studies, events, and more.

- ▶ **OSPOCon Events:** Co-located in OSSummit NA, Europe, and Japan.

We encourage practice leaders or people considering setting up an OSPO to [join us](#). [Our doors are always open!](#)

## OSPO educational publications

In 2022, Linux Foundation Research released an ongoing series of reports published by Linux Foundation AI & Data's general manager Ibrahim Haddad, Ph.D., that explore fundamental topics of open source consumption and contribution within the enterprise.

These reports include the following:

- ▶ **A Deep Dive into Open Source Program Offices** (sponsored by the TODO Group).



- ▶ **A Guide to Enterprise Open Source:** A practical and systematic approach.



- ▶ **Releasing Internal Code into a New Open Source Project: A Guide for Stakeholders:** An overview of the process, identifying the critical elements that ensure the necessary tasks are properly captured and executed.





# FinOps Foundation: Advancing how organizations understand and value cloud usage



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 for cloud billing and operations.

FinOps is an evolving cloud financial management discipline and cultural practice that enables organizations to maximize business value by helping engineering, finance, technology, and business teams to collaborate on data-driven spending decisions.

According to Gartner, overall cloud investment will reach \$544 billion

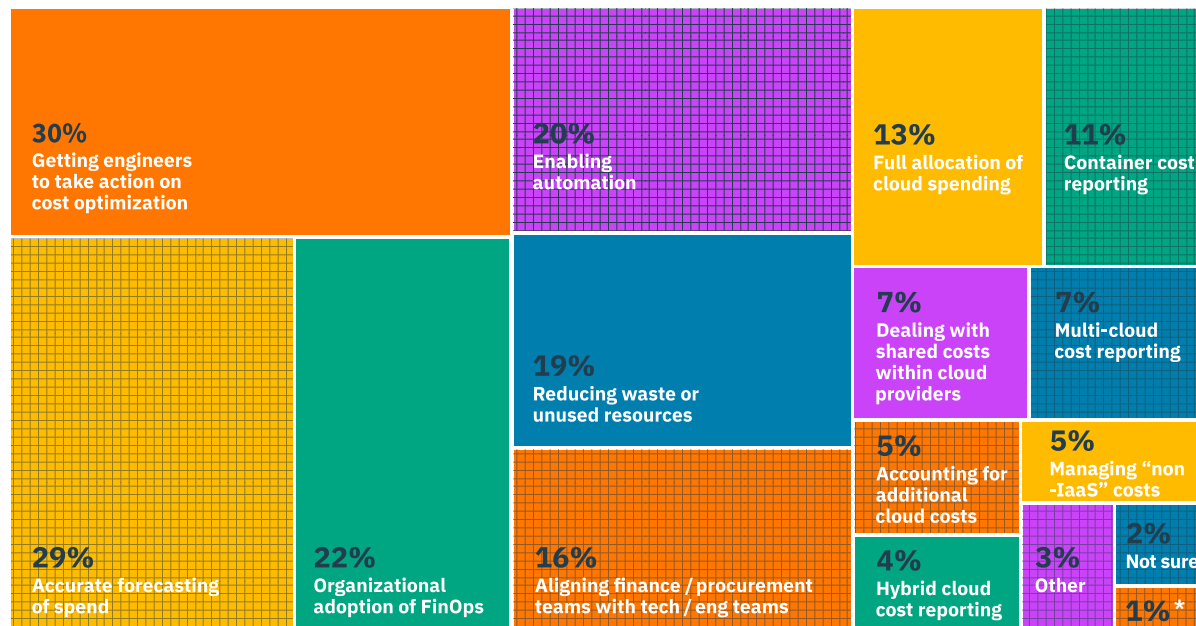
this year, an increase of 21% since last year. Enterprises continue to experience upward pressure to migrate to the cloud alongside downward pressure to operate efficiently, especially with economic uncertainty looming. The 2022 State of FinOps survey results (<https://data.finops.org/>) show that every major industry now practices FinOps across retail, financial services,

technology, manufacturing, and others, representing most of the Global 2000.

In other words, FinOps is here to stay, and thousands of global practitioners are challenging and strengthening best practices to keep up with increasing cloud spend and complexity.

## Gathering and inspiring FinOps practitioners from all types of organizations globally

The FinOps Foundation has seen significant growth in membership in 2022, as it now has 72 partner members (including Google, VMware, Accenture, Deloitte, and McKinsey) and over 7,000 community users, up from 47 partners and over 1,500 community users last year. A new End User Enterprise membership was launched in January 2022,



\*Multi-currency cost reporting

with Apple joining first, followed by Fidelity, JPMorgan Chase, AIA, and HERE.

Notable accomplishments by the FinOps Foundation and our community in 2022 include the following:

- ▶ Monthly Summit (our main community event) attendance averages 1,200 to 1,500 attendees who join to hear 10 to 15 speakers share best practices and stories over the open, two-hour Zoom event.

- ▶ The term “FinOps” has been mentioned in 8,533 articles since Sept 2022 (see the keyword comparison chart below).
- ▶ In January, we launched a new course and certification called FinOps Certified Professional. This intensive hybrid course has 40 to 50 hours of virtual instructor-led and self-paced training and a service and content contribution requirement to support the community.
- ▶ We launched our second [State of FinOps Survey](#), including a

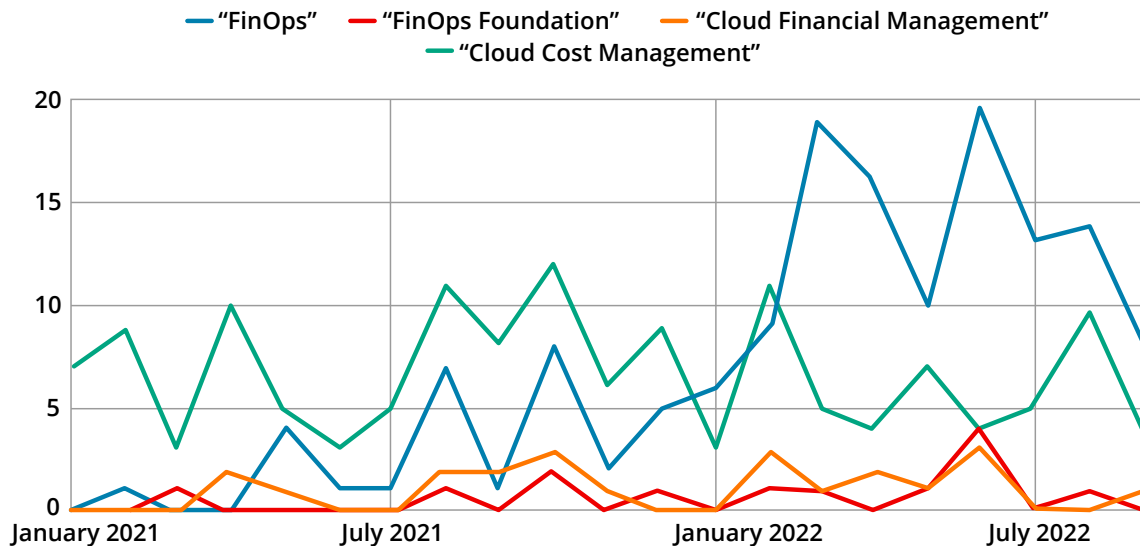
rich, data-driven visual analysis, putting us on track to deliver an annual report to benchmark and snapshot the state of the growing community.

- ▶ Our [FinOps Certified Practitioner](#) is on track to double the number of certifications completed this year compared with the previous year.
- ▶ In June, we completed our first in-person conference, FinOps X, in Austin, Texas. This conference sold every ticket and sponsorship slot. One of our attendees

noted, “This is trying to solve the problem together. How can we share knowledge, how can we be inclusive, and how can we rise the tides together?”—Aaron Edell, Global Head of Customer Cloud Intelligence & FinOps, AWS.

- ▶ The FinOps Foundation team grew from seven full-time equivalents (FTEs) to 15 FTEs in 2022.
- ▶ Innovation requires trying bold things, even with a cloud finance operating model. The FinOps Foundation launched a community board game this year that will be shared with our 17 global meetups from Ohio, Scotland, France, and Sydney.

## Keyword Mentions



## Increasing investments into our thriving community

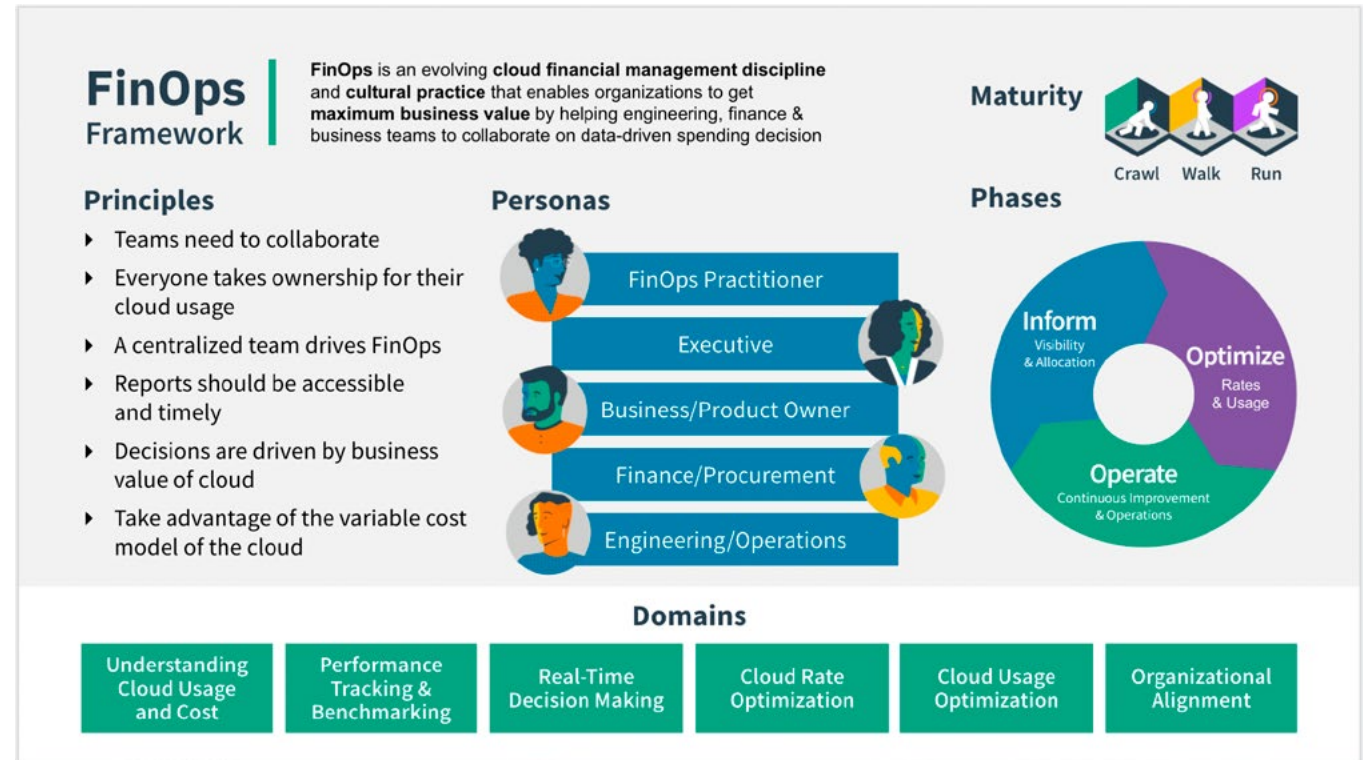
We’re incredibly proud of our two new community-driven programs, FinOps Ambassadors and FinOpsPod (our podcast is available on all major providers). Our 24 global ambassadors amplify our mission and influence

this ecosystem of enterprises, tooling, and hyperscalers. Alongside their efforts, our new podcast describes a day in the life of our practitioners from many walks of cloud life.

The FinOps Foundation continues to be the source for best practices around FinOps Adoption, FinOps Framework, and FinOps Practice Assessment. Our community working groups have doubled the project repository output with new FinOps playbooks on sustainability, variable forecasting, unit economics, the public sector, and more. The number of platform, tooling, and service providers, both commercial and open source, requesting FinOps certification has doubled since last year.

### Building upon our innovative momentum into 2023 and beyond

FinOps continues to be a supportive and inclusive place to learn, collaborate, and grow. In 2022, we launched a new training scholarship to ensure access for underserved demographics, and



\$93K has been awarded year to date. We launched a global mentorship program and received 54 applications.

We continue to encourage new voices in the community and strengthen diverse thought leadership via programs like the Women in FinOps virtual speaker series.

Our team believes that innovation requires an open mind and being observant and responsive to what our community and industry need to continue to adapt and evolve. We'll be keeping this mindset going into next year, welcoming every new opportunity that comes our way.

## Innovation in entertainment

Our communities are driving innovation in the development of open source software for the motion picture industry and for cutting-edge 3D games and simulations.



# 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.

An active, growing community supports ASWF. Total commits grew by 68.09% over the previous three years, and over the previous two years, a total of 80 organizations participated in code commits, 43 of which were new.

ASWF also doubled the number of hosted projects in 2022 with the addition of the following six new projects:

- **rawtoaces:** Contributed by the Academy of Motion Picture Arts and Sciences, the RAW to Academy Color Encoding Specification (ACES) Utility, or rawtoaces, is a software package that converts digital camera RAW files to ACES container files containing encoded image data, according to the ACES.
- **Rez:** Developed by Allan Johns as an in-house solution for Dr. D. Studios, Rez is an open source, cross-platform package manager that creates standalone configured environments for third-party and proprietary digital content creation software.
- **OpenAssetIO:** Developed by Foundry, OpenAssetIO is an open source interoperability standard between tools and asset management systems that



Spider-Man: Far From Home; courtesy of Imageworks

reduces the integration effort and maintenance overhead of content creation pipelines. It is the first project to enter the Linux Foundation in the sandbox stage.

- **OpenFX:** Contributed by the non-profit Open Effects Association, OpenFX is a popular open source plugin standard that allows interoperability between image-processing tools in the VFX industry.

- **Digital Production Example Library (DPEL):** Developed by the ASWF community, the DPEL project was born from the industry's long-standing need for production-grade sample content to thoroughly test hardware and software in development and ensure that it can scale to the demands of the film and TV content creation process. Assets hosted at DPEL include the American Society of Cinematographer's StEM2,



Image from Solo: A Star Wars Story. © and TM Lucasfilm Ltd. All Rights Reserved.

Animal Logic's ALab Phase 2, Intel's Volumetric Clouds Library, and the Noa character from Amazon Web Services (AWS).

- **Open Review Initiative:** This is a new sandbox project resulting from the efforts of the ASWF Review & Approval Working Group. The Open Review Initiative is building a unified open source toolset for playback, review, and approval of motion picture and related professional media, led by contributions from the member companies Autodesk, DNEG, and Sony Pictures Imageworks.

Additional highlights include the following:

► **Open Source in Entertainment:**

How the Academy Software Foundation Creates Shared Value: The ASWF's first research paper explores the evolution of open source technology in the modern filmmaking era, starting with digital visual effects and CG animated films, such as Toy Story, Terminator 2, and Jurassic Park.

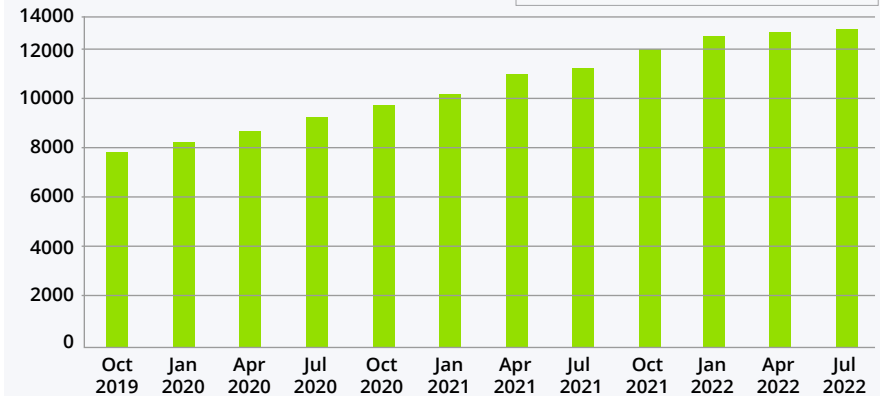
► **Summer Learning Program:**

Led by the Foundation's Diversity & Inclusion Working Group,

## Commits growth

The growth in terms of the aggregated count of total number of unique commits during the selected time period.

There has been a **growth of 6.09%** in total commits during the last 3 years.



the Summer Learning Program provided 19 BIPOC/Latinx participants with free access to an online learning platform designed to teach them practical skills to pursue technical careers in VFX/animation and matched them with a mentor from the ASWF community to further their professional goals.

► **New Governing Board succession plan:**

To foster inclusive representation across gender identity, race, and ethnicity, the ASWF adopted a new succession plan to increase representation at the highest levels.

## Open 3D Foundation and Open 3D Engine



As July 2022 marked the first-year milestone of the Open 3D Foundation and its anchor project, the Open 3D Engine (O3DE), the community celebrated significant growth and momentum. We welcomed [Epic Games](#), [LightSpeed Studios](#) (part of Tencent), [Microsoft](#), [OPPO](#), [Heroic Labs](#), and Kutztown University. Over 25 member companies are now part of this fast-growing family, including Adobe, AWS, Huawei, Intel, Kythera AI, Hadean, and Red Hat.

As today's world races faster toward 3D technologies, the Foundation provides a home

for artists, content creators, developers, and technology leaders to congregate and collaborate, share best practices, and shape the future of open 3D development. This thriving community is focused on making it easier to use and share 3D assets, and [O3DE](#) is the first high-fidelity, full-featured, real-time, open source 3D engine available to every industry.

Boasting over 500+ active online participants and nearly 200 authors of code, the community has experienced rapid growth over the last year, with almost 8 million changes to lines of code and a 70% increase in total commits. Entering the year with a \$1.16 million surplus, the Foundation has raised \$2.36 million in additional member commitments over the last year and doubled the number of stars, forks of the repository, and [Discord](#) users.



**Hadean provides the infrastructure and computational power that allows you to build, run, and monetise the metaverse.**

The community has also welcomed diverse participants, marked by an 80% increase in unique contributors and the election of Special Interest Group (SIG) leaders, including Huawei and Red Hat. Aliens Group, AWS, Brookhaven National Lab, Cro, Google, Rogue Rocket Games, Ubisoft, Warner Brothers, and Warpzone Studios have been among the top 10 creators of issues and pull requests, while

AWS, Baidu, Bytedance, Google, Microsoft, Netease, Tencent, and Ubisoft have ranked among the highest star followers.

O3DE software releases over the last year have focused on performance, stability, and usability enhancements, aiming to make it easier to build 3D simulations for AAA games and a range of other applications. Significant improvements in the





**Kythera AI** provides a flexible, scalable framework that integrates the whole range of AI features where other products offer just one or two.



**DIGIBL Studio**—Digital Basil Leaves is an innovative startup that aims to improve the traditional learning methods.

[22.05 release](#) included motion matching, a data-driven animation technique enabling the delivery of photorealistic experiences alongside installer validation, user-defined property support for the asset pipeline, and automated testing advancements. Release 22.10 brought new enhancements to ease team onboarding and collaboration, artist workflows, and multiplayer setup, alongside new rendering features and increased Terrain system performance.

The unique modularity of the Open 3D Engine is essential in enabling content creators to transform their visions into reality, especially as innovation in immersive experiences accelerates. Foundation members have been instrumental in shaping the engine through their contributions. As a key example, Kythera AI updated its binary AI gem, or plug-in, for the O3DE 22.05 release.

*"We believe that the vision of the Open 3D Foundation will be a huge enabler for the industry in general and a huge enabler for our*

*upcoming digital future with the metaverse. We wanted to be on board with that from the start and to help shape that future."*

**—Matthew Jack, CEO, Kythera AI**

Interoperability and portability of assets, visuals, and media scripting across development environments and engines is key to unleashing the creativity of artists and content creators around the globe. Epic Games' engagement is a testament to the Open 3D Foundation's significance.

*"The metaverse will require companies to work together to advance open standards and open source tools, and we believe the Open 3D Foundation will play an important role in this journey. With shared standards for interoperability, we're giving creators more freedom and flexibility to build interactive 3D content using the tools they're most comfortable with and to bring those amazing experiences to life in Unreal Engine and across other 3D engines."*

**—Marc Petit, VP of Unreal Engine Ecosystem, Epic Games**



Members are also collaborating on support for VR, AR, and MR through O3DE integration with [OpenXR](#), and advancing 3D graphics technology for mobile devices through the [Mobile Device Working Group](#) with strong support from some of the largest mobile device suppliers.

The broader community has also been prolific in its contributions. As a prime illustration, Matteo Grasso of DigiBL Studios made it possible to containerize and push O3DE projects to the cloud through O3DTanks.

In addition to launching the Under the Hood [Twitch series](#) and Tales from the 3rd Dimension [podcast series](#) to provide a stage for 3D developers, content creators, and tech leaders to share their insights, the Foundation hosted its flagship conference, [O3DCon](#), sponsored by AWS, in October with over 20 participating companies, including leaders from the C++ and Python communities. Content spanned various aspects of the Open 3D Engine and open source, including the importance of licenses, compliance, and their relation to 3D engines. Diversity activities

included a talk from the International Game Developers Association (IGDA) and a discussion with Amazon, IGDA, NVIDIA, Python Software Foundation, and Rochester Institute of Technology panelists. The Foundation also hosted a metaverse track at the conference comprising over 10 specialized topics spanning artificial intelligence; authentication; blockchain ledgering; cloud and infrastructure; currencies, edge network; financial services; media, 3D assets, and objects; simulation; and voice and immersive interfaces.

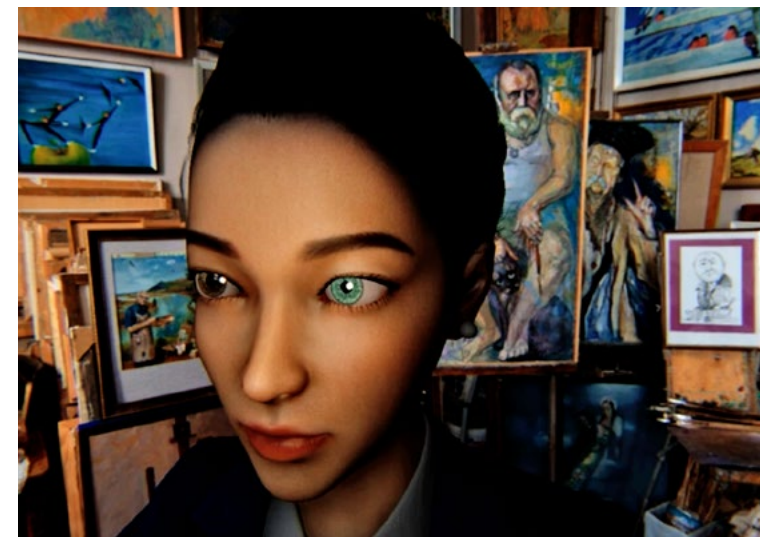
We look forward to an even more exciting year ahead.

*"It's truly exciting to see how the industry is responding to the real-time 3D needs of content creators around the globe, providing them with best-of-breed tools. As the Executive Director, I want to thank all of you for helping us grow this far!"*

**—Royal O'Brien, General Manager of Digital Media and Games, Linux Foundation and Executive Director, Open 3D Foundation**



**AWS for Games:** Transforming game workloads with purpose-built cloud services and solutions.



**Huawei Game Service** helps you build basic game functions such as achievements, leaderboards, and saved games at low costs.

## Making an impact on people and the planet

The Linux Foundation has been working to reimagine power systems across the globe. We're helping define emissions standards for software, providing digital infrastructure for food and agriculture, reducing barriers to developing treatments for rare genetic diseases, creating better ways to share data within and across borders, and developing tools to inform risk management and investment decisions to climate risk.

## LF ENERGY

The ongoing transition from centralized fossil-fuel generation to renewable and distributed energy resources is the most significant reimagining of power systems in over 140 years. The data indicate that we can mitigate approximately 75% of our planetary carbon emissions through energy and transportation electrification. We know that open source solutions will be crucial to those major shifts. By adopting an open source strategy that maximizes flexibility, agility, and interoperability to drive sustainability, we can develop innovative solutions to reduce our carbon footprint.

The Linux Foundation has several projects working on open source climate solutions. LF Energy is accelerating the transition to distributed clean energy by providing software tools to operate and manage energy systems.

OS-Climate, which focuses on finance and macro system

alignment of assets, is developing a data and analytics platform to close the \$1.2 trillion gap in financing and investment required to achieve the goals of the Paris Climate Accords. Many other LF projects are playing a substantial role in driving green initiatives: the Linux kernel in power management, the Green Software Foundation in driving sustainable software development, embedded Linux's work in edge interoperability, LF Networking in 5G, and the many efforts being carried out by LF AI & Data.

LF Energy has seen strong growth in 2022, adding dozens of new members. We welcomed Shell and Google at the Strategic level, bringing together the expertise of two leading companies in technology and energy. LF Energy members Cleartrace, M-RETS, and WattCarbon bring energy tracking and trading expertise.



IMAGE BY PIXABAY: PEXELS



Critical new projects also came into the Foundation in 2022. These new entrants include the Carbon Data Specification Consortium (CDSC), a standard specification to help define and track the carbon intensity of consumed energy and the carbon emissions associated with generated energy. Adding standards projects like CDSC and Super Advanced Meter provides new direction and opportunity for LF Energy.

[EVerest](#), an open source software stack designed to establish a common foundation for a unified EV charging ecosystem, also [joined the foundation](#).

These new initiatives are helping us solve climate change through open frameworks, reference architectures, and a support ecosystem of complementary projects.

We will need to do more than this to decarbonize. Mitigating climate collapse while ensuring economic prosperity will require us to network supply and demand through secure distributed hardware, data, and software.

The future energy grid will be built on open infrastructure platforms. The LF Energy stack and open networking projects can manage

and choreograph infrastructure resources using Software-Defined Networking (SDN) controllers that enable high-throughput data processing. This means more developers producing more code, which requires buy-in from industry, government, academia, and other stakeholders.

The growth experienced by LF Energy this year will accelerate as both the private and public sectors increase their investments in the energy transition toward decarbonization. The recent passage of the Inflation Reduction Act (IRA) in the United States provided crucial public sector support for green energy investments. The IRA is a welcome step toward realizing a more sustainable energy system, calling for a substantial increase in funding and the pursuit of clean energy sources. Implementation of the IRA and similar initiatives worldwide will require a reconception of the tech stack used by the power sector.

For the IRA, open source is essential to providing a transparent, consistent measure of performance that can animate the home energy efficiency deployment market. However, the value of open source for energy extends well beyond home energy efficiency performance. Meeting global decarbonization goals will require a massive digital transformation across all parts of the energy industry. A single organization cannot build the necessary technologies by itself; an open source collaborative development model that shares the burden is required for transformation projects like this. Open source also ensures uniform measurement standards, which proprietary approaches often struggle to deliver.

By adopting an open source strategy that maximizes flexibility, agility, and interoperability—both within the context of the IRA and in terms of other decarbonization efforts—the energy sector can learn to innovate at the speed of technology.





**Markus  
Mirz**

LF Energy's SOGNO project—which means “dream” in Italian and stands for “Service-based open source Grid automation platform for Network Operation”—is intended to accelerate the transition of energy production from centralized fossil fuel plants to more decentralized energy sources and storage devices. These decentralized elements will be integrated into power systems. SOGNO aims to provide a modular software solution for power system automation that is easily extendable and matches the speed at which new devices are being connected to the power system. SOGNO uses cloud and virtualization technologies to scale the number of connected devices.

Markus Mirz, Chief Engineer at Fraunhofer Digital Energy and Technical Lead of the SOGNO project, was part of the European H2020 project at RWTH Aachen. This project laid the foundation for SOGNO. Markus originally got involved to give back to society.

He helped bring SOGNO into LF Energy to ensure the project's future development and connect with the larger open source community. While the initial version of SOGNO was the outcome of a single research project, project code is now used by various contributors and end users in many research projects.

“Other contributors and I have appreciated the opportunity being part of the LF Energy community has provided in terms of enabling collaboration and exchange of ideas with other developers,” said Markus. “Another benefit of hosting the project in LFE is the support with marketing and other activities that are outside of the comfort zone of many developers, like legal questions that you should address when setting up a project.”



**Marco  
Möller**

One of the biggest obstacles to the mass adoption of electric vehicles (EVs) is a lack of compatibility and plug & play capabilities. The LF Energy EVERest project aims to tackle this and other global EV charging challenges. By utilizing a “code first” approach, the project aims to increase innovation tenfold in the EV sector.

EVERest wants to become the Android of electromobility and bridge the compatibility gap between the many vehicle manufacturers and charger producers. This would cut through incompatible standards and create global, open charging standards that all manufacturers could use. EVERest aims to impact all types of charging, including fast public charging, smart charging such as using solar energy to charge at home, DC charging, bidirectional charging, and emergency energy backups for electric blackouts.

Additionally, using EVERest will reduce CO<sub>2</sub>; development and

volume rollout can be accomplished much faster, using fewer resources and minimizing stranded assets.

The project originated with Marco Möller and his team at PIONIX. The idea of EVERest was sparked by one of PIONIX's previous consulting projects, where they learned how the complexities of the EV industry were making infrastructure build-outs more expensive and time-consuming.

“As commercial adoption continues to grow, many industry players are discovering significant overlap between their commercial projects. Eliminating overlaps is one of the benefits of working with an open source community,” said Marco. “LF Energy has provided a huge benefit in supporting the EVERest community with knowledge of open source best practices, legal and marketing support, and giving the project access to many exciting industry networking opportunities.”

# OS-Climate

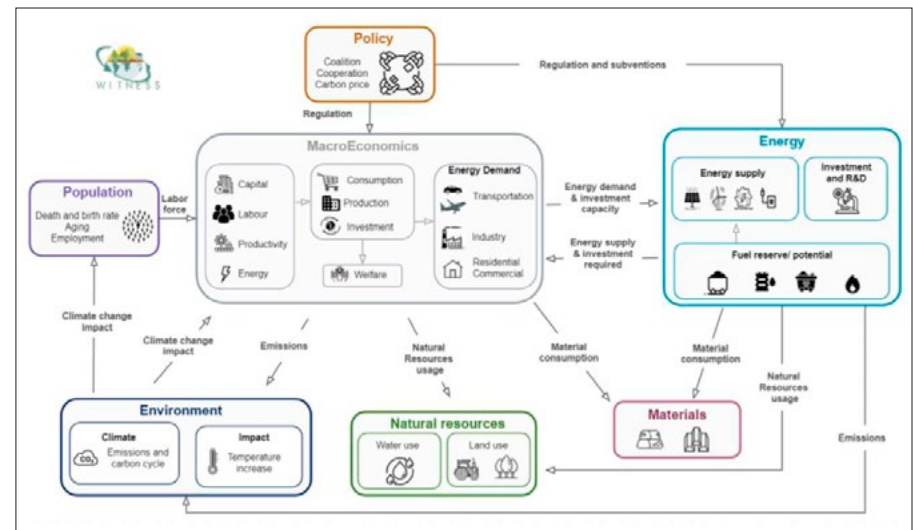


The Paris Agreement's goals of keeping global temperature rise below 2°C and enabling countries to adapt to climate change require an estimated investment of \$6.9T annually through 2030. Still, current investments of ~\$630B leave an immense gap. Investments are hampered by (1) a need for more transparent, climate-aligned analytical tools and (2) insufficient data. To accelerate the transition to net-zero and improve resilience, OS-Climate (OS-C) is creating a public data utility (i.e., Data Commons) that closes data availability, quality, and comparability gaps while building new analytical tools to inform risk management and investment decisions related to climate risk and opportunity across asset classes, sectors, and geographies.

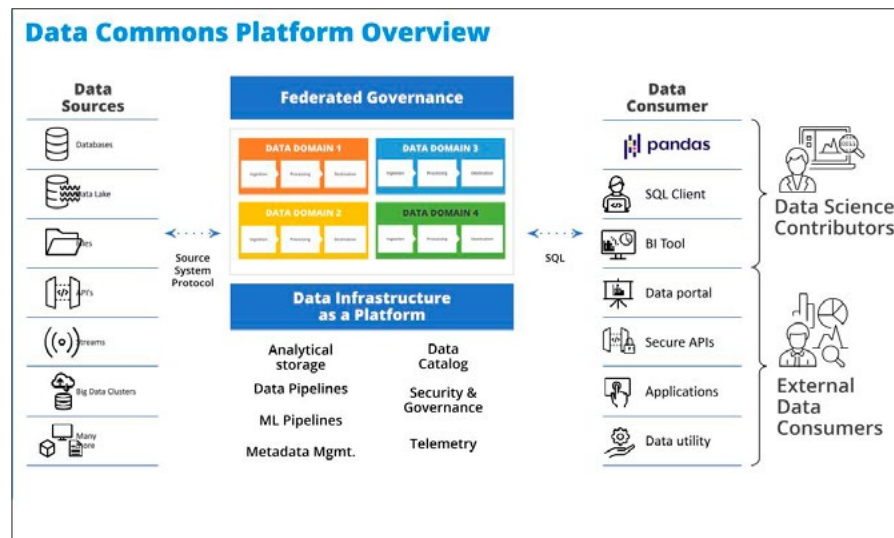
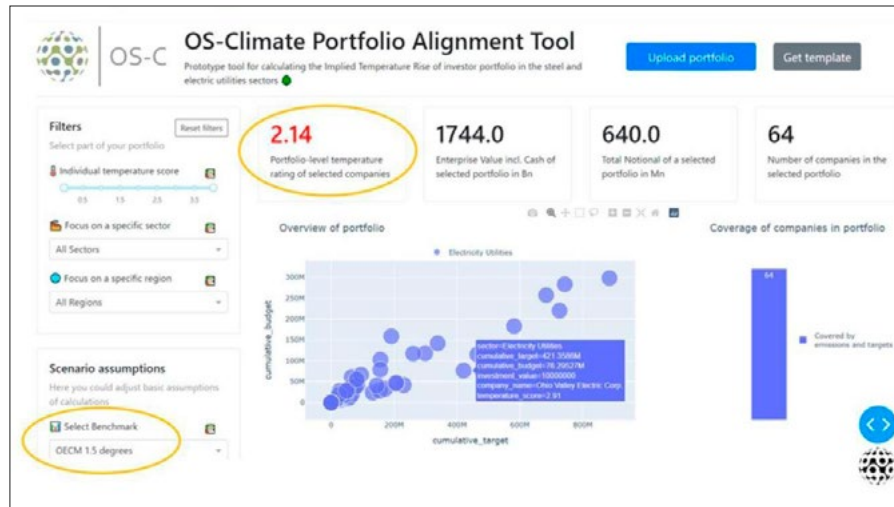
Recognizing that these solutions are too big for any organization to build, OS-Climate's Theory of Change is based on fostering a community of practice and action for open collaboration among financial institutions, corporations, academic institutions, non-profits, and governmental entities. Since January 2022, the size of OS-Climate's community has increased by 103.5%, and organizational memberships have increased by 15.8%. OS-C members own, manage, or provide custody services for more than \$60 trillion in assets globally. OS-C received two large data contributions from Riskthinking. AI and S&P Global, including data from more than 75,000 corporate reports and thousands of climate economic transition scenarios. The initial versions of three analytical tools were announced in July 2022: Physical Risk & Resilience, Transition Analysis, and Portfolio Analysis.



Chronic heat map



Transition Analysis: Witness model



The Physical Risk & Resilience tool connects asset location data to climate hazard models and vulnerability curves. Risk measurement includes not just the hazard value (i.e., flood depth) but also the associated asset vulnerability that determines the damage and disruption risk that those assets will face due to the hazard. OS-Climate gathers many climate hazards and vulnerability models in one place that can serve risk measurement use cases.

The Transition Analysis tooling (WITNESS and SOSTrades systems) allows organizations to (1) perform multiple transition scenario assessments, analyzing trade-offs / business cases, (2) optimize investments vs. objectives (e.g., what investment in energy production is needed to maximize economic development while minimizing emissions under resource constraints), (3) assess the value and impact of energy production technologies on resources, and (4) project the global economic evolution,

based on changes to policy, macro-economic impacts (e.g., capital, labor, production, energy, consumption, investment, welfare, and energy demand) alongside population, energy, materials, natural resources, and environmental variables. The tool will support companies in their decisions on funding transition projects to reduce global emissions. It will also enable asset managers and banks to reallocate finance and investment toward those companies and their projects.

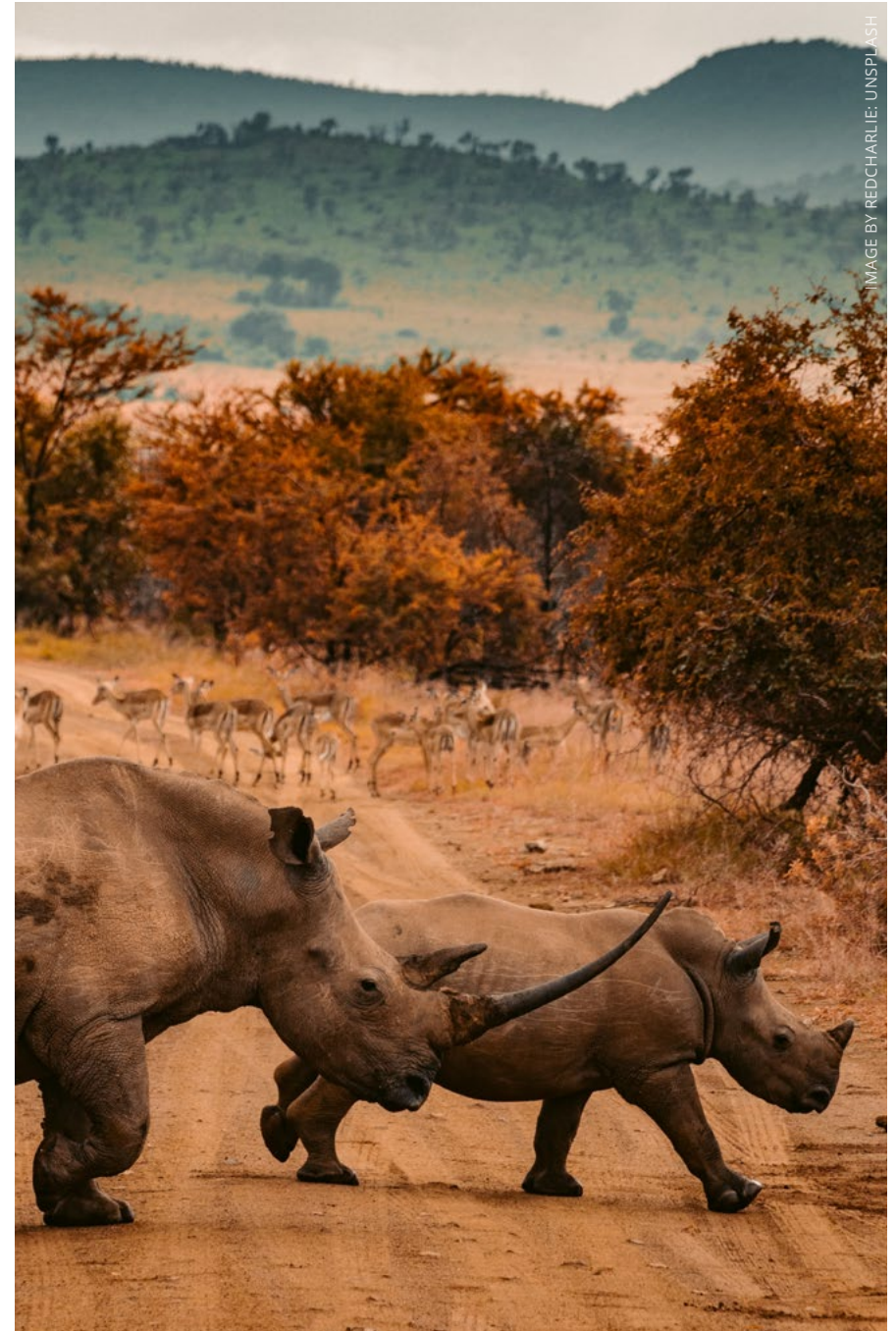
The Portfolio Alignment Implied Temperature Rise (ITR) tool evaluates how investment decisions can contribute to long-term climate goals—and whether the individual company and portfolio behavior exceed net zero budget expectations. The cumulative emissions relative to this budget at a global level inform what temperature outcome the world is likely to reach. As a result, the tool's mechanics are designed to compare forward-looking



emissions trajectories against benchmark climate scenarios and convert those cumulative emissions into a temperature outcome. The Portfolio Alignment Tool can support any sector-specific benchmarks to compare against financial institution portfolios. So far, the One Earth Climate Model (OECM) and Transition Pathway Initiative (TPI) benchmarks have been implemented.

OS-C's community continues to grow, and OS-C is gaining ground in driving climate-aligned investment decisions. Members and the broader sustainable finance community are using our data and tools to evaluate the physical risks of millions of assets in their portfolios, the carbon footprint of sovereign debt portfolios, and the transition strategies of real-economy companies and sectors. Finally, the Data Commons architecture fosters transparency and trust by managing climate and financial data like software code.

OS-Climate believes that our science-based models and methodologies, combined with our open source code, will provide a higher level of transparency and trust, helping address concerns like green-washing. As the community makes further enhancements to the analytic tools and our public data utility grows, regulators can better manage systemic risk related to climate. The broader sustainable finance community can also accelerate the “top of stack” development of innovative tools, investment strategies, and financial products.







Now in its second year as a Traditional-mode Specification program, the GSF has become a significant force in the Green Software ecosystem and is helping define emissions standards for software. The GSF achieved several milestones in that short period, adding 38 member organizations and nearly 800 participating members.

GSF has published its first production release of the Software Carbon Intensity (SCI) specification. This specification allows developers to calculate the rate of carbon emissions for a software system.

To bring the developer along on the carbon awareness journey, the GSF released its first Developer Training programs. These programs help developers put these green software principles into practice.

The GSF has created a coherent plan of engaging policymakers, industry verticals, and climate-action committees to ensure Green Software is included in the decarbonization agenda. This includes participation in COP-27 and software hackathons to demonstrate Green coding principles.



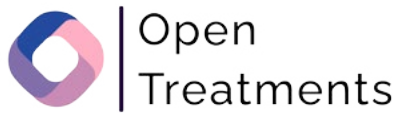
The AgStack project aims to provide digital infrastructure for food and agriculture as a “digital public good.” Just like the world of computing runs on Linux, the world of food will eventually run on AgStack.

The ultimate goal of AgStack is to enable the world’s food production to become more equitable, secure, sustainable, and profitable to producers and consumers alike.

Each day, more than 50% of our planet’s population is engaged in making our food. The sequence of work from seed to sow to harvest to processing to transportation to market is complex, fragile, and highly inefficient. Digitizing this workflow and making it more accessible, frictionless, and ubiquitous while ensuring neutrality, security, and data

integrity is the focus of the data infrastructure work at AgStack. The asset-registry project is a key step in that direction.

AgStack’s “asset-registry” project has been recognized (including through a grant by the German government) by much of the agriculture ecosystem as a “necessary innovation” for spatially indexing agricultural fields at the Earth scale. This would be especially valuable for small-holder farmers in developing nations. The project aims to leverage various open source tools, cryptography, and web service architectures to provide a public API for geo-registration and validation of agricultural fields. The use cases range from informing crop insurance claims to generating satellite data with a single address.



In March 2021, the Linux Foundation announced that it would be hosting RareCamp and the OpenTreatments Foundation. RareCamp is developing software platforms that reduce barriers to developing treatments for rare genetic diseases, regardless of rarity and geography.

[400,000,000](#) patients worldwide are affected by more than 7,000 rare diseases, but [more than 95%](#) of rare diseases do not have an approved treatment. New treatments are estimated to cost more than [\\$1 billion to develop](#).



The RareCamp open source project provides open governance for the software and scientific community to collaborate and create software tools to aid in creating treatments for rare diseases. With funding from the Chan Zuckerberg Initiative, OpenTreatments Foundation is using RareCamp's open governance infrastructure to collaborate and build a software product to count the number of patients diagnosed with rare diseases. The project is being built in collaboration with researchers from Macquarie University in Australia, software developers based in the U.S., and biotech institutions. Once released to the public, this software platform will catalyze the development of treatments for thousands of neglected rare and genetic diseases.



IMAGE BY LOUIS REED: UNSPLASH

# LF PUBLIC HEALTH



Linux Foundation Public Health (LFPH) hosts, supports, and nurtures open source technology to benefit digital health public goods and public health initiatives.

Founded two years ago during the global pandemic, the organization has become a go-to resource for governments and industry partners to get advice on the latest technologies. Our collaborative efforts have put the Linux Foundation into the international

arena of digital health public goods and the applicability of open source software for health, social services, and life sciences.

Since its launch in 2020, over 50 jurisdictions worldwide have trusted LFPH for unbiased, clear guidance on taking advantage of open source technologies within our program areas of exposure notification and COVID credentials. In 2022, we convened over 30 state public health authorities monthly in our Disease Investigative Technology Collaborative (DITC). National and global institutions such as the WHO, the CDC, the UN, and the E.U. have also invited LFPH to present at meetings, contribute to reports, and assist them in understanding this technology. LFPH has presented at over a dozen national and international health conferences in the U.S. and the E.U.

Meanwhile, LFPH projects and initiatives continue to grow.

The Global COVID Certificate Network (GCCN) and standard developments undertaken through the COVID Credentials Initiative (CCI) have transitioned to a project with the UN Development Programme (UNDP).

LFPH has grown our collaboration with other Linux Foundation initiatives to promote open source in new areas of digital health, such as:

- ▶ Artificial Intelligence (AI) and Machine Learning (ML)
- ▶ “Digital Twins” in healthcare
- ▶ Augmented Reality (AR)/ Virtual Reality (VR) and Digital Therapeutics
- ▶ International collaboration in health information exchange
- ▶ “Cloud native” efforts for electronic health records

As this Annual Report has highlighted, the Linux Foundation has been at the forefront of leadership and contribution to

open source security, and the healthcare sector has been no exception. LFPH, in conjunction with OpenSSF, has been developing tools and growing participation with medical device manufacturers and healthcare organizations to develop tools for securing medical devices critical for life safety and improving critical infrastructure protection in collaboration with the CISA, the FDA and industry groups.

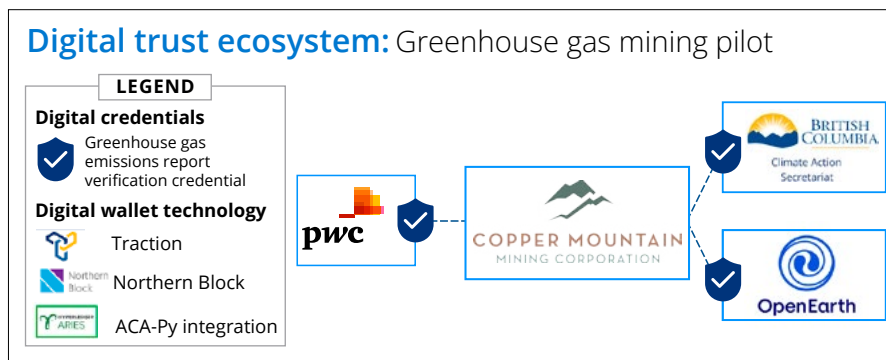
While COVID-19 is not going anywhere, LFPH is charting a path forward beyond the pandemic response. The pandemic has highlighted the need to overhaul digital health, virtual care, and the supporting public health infrastructure worldwide to create better ways to share data within and across borders. Open source software will deliver better health equity, security, and population health challenges.



## Climate change initiatives

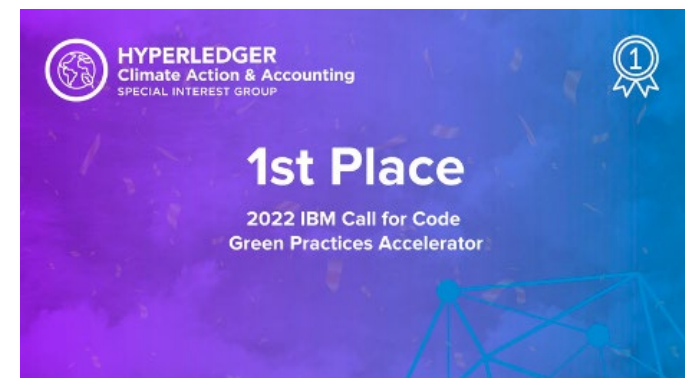
There is an active and growing movement across the Hyperledger community to leverage open source, enterprise-grade blockchain technologies to fight climate change. Below are two great examples, both tied to efforts to track and, eventually, reduce carbon emissions in the mining and oil & gas industries:

- The Energy and Mines Digital Trust (EMDT), established by the government of British Columbia, has been testing and refining their technology and governance through [multiple pilot projects](#) to demonstrate how sustainability reporting can be made more efficient and trustworthy. Two pilot projects explore reporting greenhouse gas emissions in the mining and natural gas sectors. These pilots allow participants to test sharing and receiving digital credentials that include verified GHG emissions data for a specific mine site or natural gas facility.



Because this is a pilot, the process depicted in this diagram does not satisfy or replace existing regulatory reporting obligations.

- In August 2022, IBM [announced](#) that the Reduce Methane Emissions with Supply Chain Tokens prototype built by members of Hyperledger's Climate Action and Accounting Special Interest Group (CA2SIG) was awarded first place in the 2022 IBM Call for Code Green Practices Accelerator. Each year, the IBM Call for Code challenge seeks the most creative and innovative solutions to help address issues of sustainability.





# Innovating with hardware, embedded, dependable, and IoT systems

The Linux Foundation fosters innovation by building communities for open hardware and real-time embedded systems and creating best practices for safety and confidential computing.





RISC-V membership increased by over 20% during 2021, with growth evenly distributed across North America, the E.U., and APAC. The contributions and commitments of the RISC-V community in 2022 include historic technical progress, industry innovation, and traction of commercial solutions.

This year's engagement in RISC-V work groups and committees has grown by 20% to roughly 10,000 individuals. RISC-V anticipates that, in 2022 alone, there will be over 12 billion RISC-V cores on the market.

RISC-V program highlights this year include the following:

► **New ratified extensions:**

After ratifying 16 extensions in December 2021, we are continuing to ratify six more extensions in 2022. These extensions include Vector, Bitmanip, Cryptographic, and Hypervisor, reflecting the accelerated traction of RISC-V as a highly compet-

itive architecture across the full computing spectrum.

► **New working groups:**

We formed groups to address topics like vector cryptography, ML/AI & graphics, automotive, and confidential computing.

► **Draft specifications:** We published drafts for RISC-V profiles, advanced interrupts, and an updated application binary interface to increase modular design opportunities and enable applications to migrate easily to RISC-V.

► **Developer board program:** In 2022, we launched a [developer board program](#) that provides RISC-V developers with the latest RISC-V hardware to support their software development projects.

► **Media updates:** Our media, social, web visits, and online presences continued to increase due to sharing content, coordinating amplification efforts



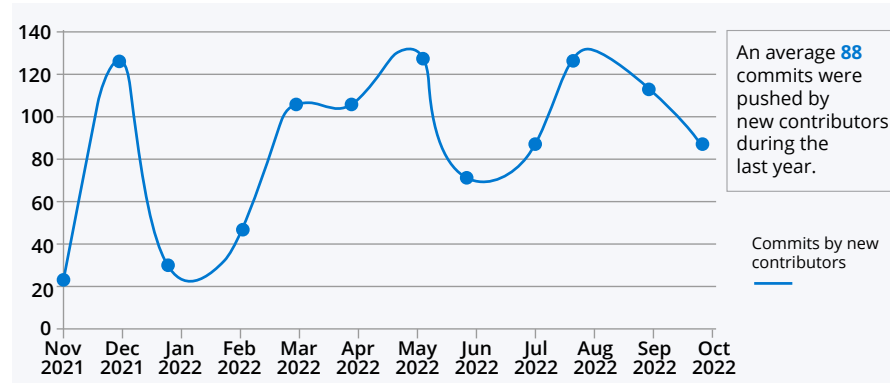
Krste Asanović, Board Chair, Chief Architect, SiFive.



2021 RISC-V Technical Awards.

## Commits by new contributors

The count of the total number of commits by new contributors. New contributors are defined as those who did their first code activity (commits/PRs/changesets) or submitted their first bug or resolved their first bug during the selected time period.



with the community, spreading ecosystem successes across events and online content, and focusing on the messaging and cadence of communications to strengthen conversations. We saw a sustained uptick in page visits to Specifications (up 10%) and Blog (up 17%). Very positive media coverage increased media by 17%.

- **New visibility programs:** The year 2022 saw the 2.0 launch of [RISC-V Exchange](#), hosting the hardware, software, services, and learning offerings in the RISC-V community.
- **New members & alliances:** We added dozens of new members from around the globe. Many members have upgraded to Premier level, including Beijing Institute of Open Source Chip, Futurewei, Haihe Laboratory of Information Technology Application Innovation,

Intel, Ministry of Electronics & Information Technology, Qualcomm, Rivos, Seagate, Synopsys, VMware, and a new RISC-V Alliance with the MIPI Alliance.

- **New in RISC-V learning:** [RISC-V Toolchain & Compiler Optimization Techniques](#) (LFD113x) currently has over 300 learners. We now have over 14,558 total learners across five online courses for RISC-V. We are also developing two new courses and a certification program in partnership with LF Training.
- RISC-V mentorships:** A total of 15 mentorships took place in 2022 on the LFX platform. This year also saw the launch of the first annual RISC-V Virtual Career Fair, providing general information about RISC-V, education for students looking for jobs, and an opportunity for RISC-V members to showcase their company and recruit students.



## OpenPOWER™

In 2022, The OpenPOWER Foundation continued to execute its long-term strategy of accelerating the development of the most open, mature, and high-performance CPU architectures by creating the necessary community tooling and initiatives to build a vibrant open source hardware ecosystem.

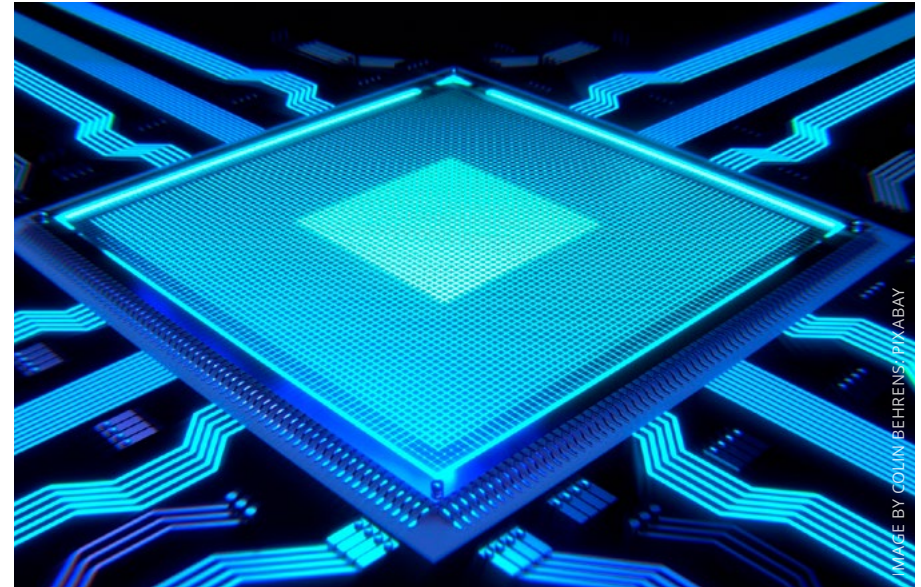
The OpenPOWER Foundation welcomed new members dedicated to expanding adoption of the POWER ISA, including Red Semiconductor, a startup focusing on developing a new POWER CPU and associated IP for others to consume, and 21Unity, a cloud software and hosting company building new POWER-based servers.

The foundation's LibreBMC SIG working group is continuing its development of the first fully open baseboard management controller (BMC). BMCs are typically stored in

servers for remote management applications and run proprietary software. The LibreBMC project delivers a fully open hardware stack based on POWER running openBMC software installed on OCP's open source DC-SCM module card.

The market opportunity of a fully open, secure BMC did not go unnoticed. One startup, Axiado, became a new member and is commercializing the LibreBMC solution as a new chip for hyperscalers, datacenters, and edge computing providers.

The foundation continued its push into open chip manufacturing with its sixth manufacturing run of the POWER-based Microwatt CPU core using a fully open process design kit (PDK) on Skywater Foundry's 180 nm process nodes. This program's success means they are looking to open more advanced process nodes soon, creating a low



barrier to entry and a potential avenue for dramatic increases in the experimentation and collaboration of hardware projects.

OpenPOWER is expanding its community-supported HUB providers globally and offers free remote access to POWER-based servers to enable developers working on porting software to access the POWER platform.





CHIPS Alliance continues to nurture and grow a robust hardware community as companies and universities look for ways to increase their participation in this new ecosystem. CHIPS currently has 40 international members. That number continues to grow as companies look for new ways to accelerate innovation and time to market by leveraging what has already been done and is available in the open source community. CHIPS is diligently working to become the trusted supplier and champion of open source

hardware, process design kits, and EDA tooling. During the last three years, CHIPS experienced a 132% increase in contributor strength (see table below).

Key highlights of the past year include:

- We participated in the keynote and panel at the 2022 Design Automation Conference in San Francisco, where open source hardware was the event's cornerstone. Democratization of hardware design is a key theme. Open source hardware, process

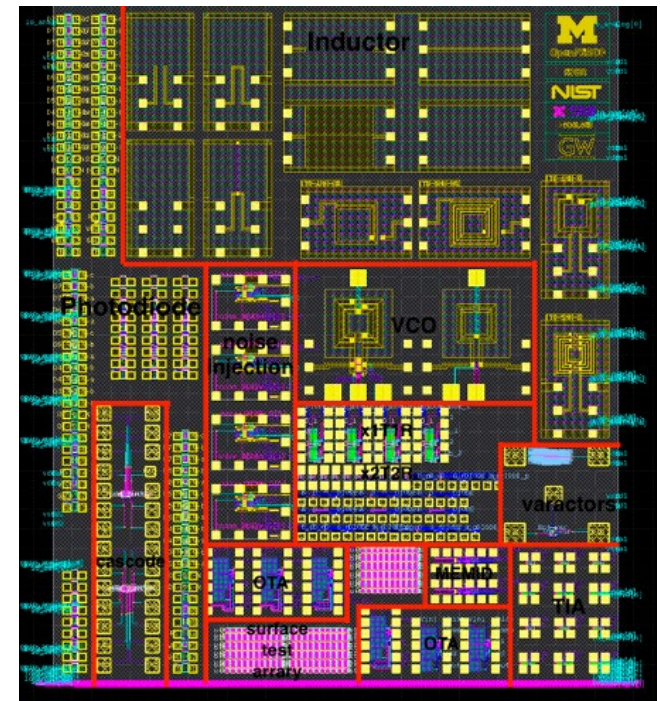
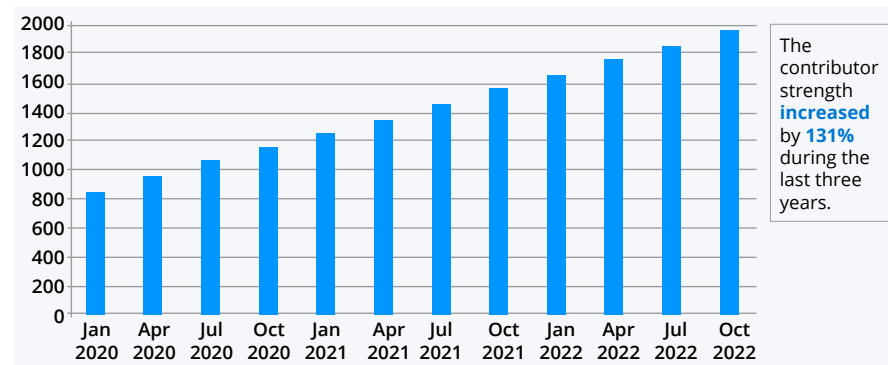
design kits, and EDA are foundational pillars.

- We presented four seminars on CHIPS Alliance and how open hardware is accelerating innovation and time to market.
- We led two technical seminars on CHIPS Alliance development activities.

- In conjunction with the University of Michigan, the analog workgroup accomplished three chip tape-outs using Michigan's open source analog design platform OpenFASoC and the DARPA-funded open source digital platform OpenROAD using the Skywater 130 open source PDK. Below is a picture of the generated layout:

### Contributor strength

The growth in the aggregated count of unique contributors analyzed during the selected time period. A contributor is anyone who is associated to the project by means of any code activity (commits/PRs/changesets) or helping to find and resolve bugs.



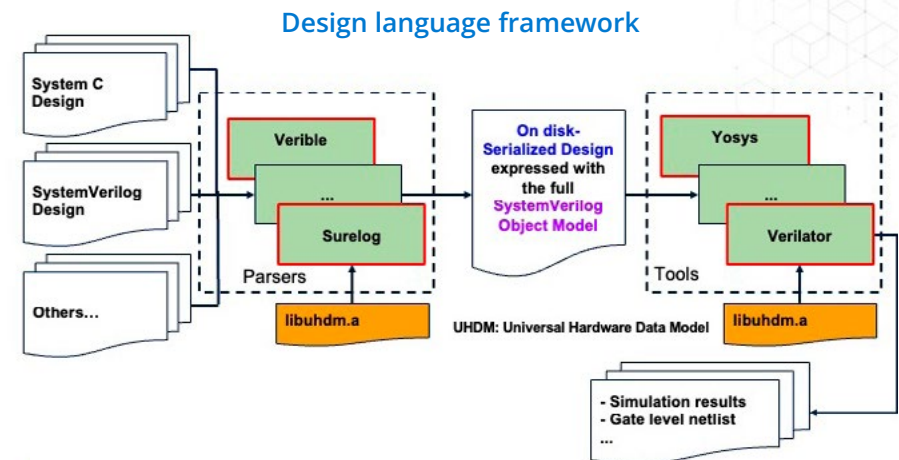
- We continued to evolve the CHISEL design language and compiler with several new releases.
- ▶ The F4PGA workgroup continues to make tremendous progress, expanding the synthesis, placement, routing, and timing of designs using open source tools across several vendor FPGA platforms. Some highlights of their activity include:
  - System Verilog support for the open source logic synthesis tool Yosys in the form of a plugin (repo: <https://github.com/antmicro/yosys-systemverilog>; <https://antmicro.com/blog/2022/02/simplify-ing-open-source-sv-synthesis-with-the-yosys-uhdm-plugin/>).
  - We donated F4PGA projects to the CHIPS Alliance organization.
  - We improved the F4PGA tool perf project (<https://github.com/chipsalliance/fpga-tool-perf>). The project

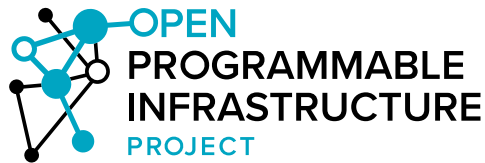
aims to continuously test various FPGA tools and generate reports presenting the results, including the runtime, quality of results, and resource usage. Recent work focuses on stabilizing the framework and parallelizing the tests.

- We enhanced the fpga\_interchange format support for the Xilinx Series 7 and UltraScale+ architecture FPGAs.
- We added initial support of the fpga\_interchange format to the vtr-verilog-to-routing (<https://github.com/verilog-to-routing/vtr-verilog-to-routing>) project.
- An ongoing effort is to consolidate the scripts and utilities that compose the F4PGA ecosystem. A Python package was created in [chipsalliance/f4pga](https://github.com/chipsalliance/f4pga) (<https://github.com/chipsalliance/f4pga>) to facilitate installation and version control of the utilities.

- ▶ There was evolution/broadening of the AIB chiplet protocol ecosystem with UCIE.
- ▶ In 2022, CHIPS championed several design languages and introduced a universal hardware data model (UHDM) as a central software framework for different language schemas enabling applications to access them via a common API. A high-level architectural representation of the system is below:

We look forward to another year of growth, contribution, collaboration, and excitement as we move into 2023.





Announced in June 2022, OPI will foster a community-driven, standards-based open ecosystem for next-generation architectures and frameworks based on data processing unit (DPU) and infrastructure processing unit (IPU) technologies. OPI is designed to simplify network, storage, and security APIs within applications to enable more portable and performant applications in the cloud and datacenter across DevOps, SecOps, and NetOps.

OPI will help establish and nurture an open and creative software ecosystem for DPU- and IPU-based infrastructures to support high-speed network capabilities and packet processing for applications such as 5G, AI/ML, Web3, and crypto. As various vendors offer more DPUs and IPUs, the OPI Project seeks to help define the architecture and frameworks for the DPU and IPU software stacks that can be applied to any vendor's hardware offerings.

The project intends to:

- ▶ Define DPU and IPU
- ▶ Delineate vendor-agnostic frameworks and architectures for DPU- and IPU-based software stacks applicable to any hardware solutions
- ▶ Enable the creation of a rich open source application ecosystem
- ▶ Integrate with existing open source projects aligned to the same vision, such as the Linux kernel
- ▶ Create new APIs for interaction among the elements of the DPU and IPU ecosystem, including hardware, hosted applications, host node, and the remote provisioning and orchestration of software

With several active working groups, initial technology contributions will come in the Infrastructure Programmer Development Kit ([IPDK](#)), an open source framework of drivers and APIs for infrastructure offload and management that runs on a CPU, IPU, DPU, or switch.



In addition, [NVIDIA DOCA](#), an open source software development framework for NVIDIA's BlueField DPU, will be contributed to OPI to help developers create applications that can be offloaded, accelerated, and isolated across DPUs, IPUs, and other hardware platforms.

For more information, visit <https://opiproject.org>; start contributing here: <https://github.com/opiproject/opi>.



Automakers have become tech companies with the advent of connected and autonomous vehicles, but lengthy production cycles hinder them from innovating at the speed of the tech industry. Many automakers have started incorporating open source software and Automotive Grade Linux (AGL) to keep pace with new technology and emerging trends to enable more rapid, agile development.

With over 150 members, including 11 automakers, AGL unites the automotive and tech industries around a shared software platform to reduce the fragmentation that has plagued the automotive industry for decades.

AGL-based infotainment systems are available globally in Toyota, Lexus, and Subaru vehicles. More should appear over the coming years, as many AGL members have

already integrated the AGL platform into their production plans.

### AGL 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 an 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, as developers and suppliers can build their solution once and deploy that same solution for multiple automakers.



**An open source project at the Linux Foundation, AGL unites the automotive and tech industries around shared software for all in-vehicle applications, from infotainment to autonomous driving.**

The AGL community continuously evaluates open source technologies for automotive use cases to ensure that best-in-class software is integrated into the platform. In 2022, AGL began transitioning to newer technologies, including VirtIO for cloud-native AGL applications and

Toyota's embedded automotive version of Flutter (initially developed by Google) with cutting-edge 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 the following two milestone platform releases in 2022: UCB 13 “Magic Marlin” and UCB 14 “Nifty Needlefish.” AGL UCB 14 is based on Yocto Long Term Support (LTS) 4.0, and AGL UCB 13 is based on LTS 3.1. These releases included several updates to graphics, audio, speech recognition, application and security frameworks, web apps, and Chromium.

## Software Defined Vehicle

As the lines between embedded automotive software and IT/cloud continues to blur, AGL is paving the way for the Software Defined Vehicle. AGL is the only neutral organization planning to address all in-vehicle software, including infotainment, instrument cluster, telematics, heads-up display, advanced driver assistance systems, and autonomous driving.

The following three AGL expert groups (EGs) will address the growing complexity of automotive software and the “cloudification” of the vehicle:

### ► Container and service mesh

**Expert Group:** Led by AWS, this EG is developing an in-vehicle container solution for AGL and creating a service mesh and orchestration framework that’s deployable as part of AGL. The goal is to standardize the deployment of software in the vehicle and simplify deployments of upgrades and continuous updates.

### ► Virtualization Expert Group:

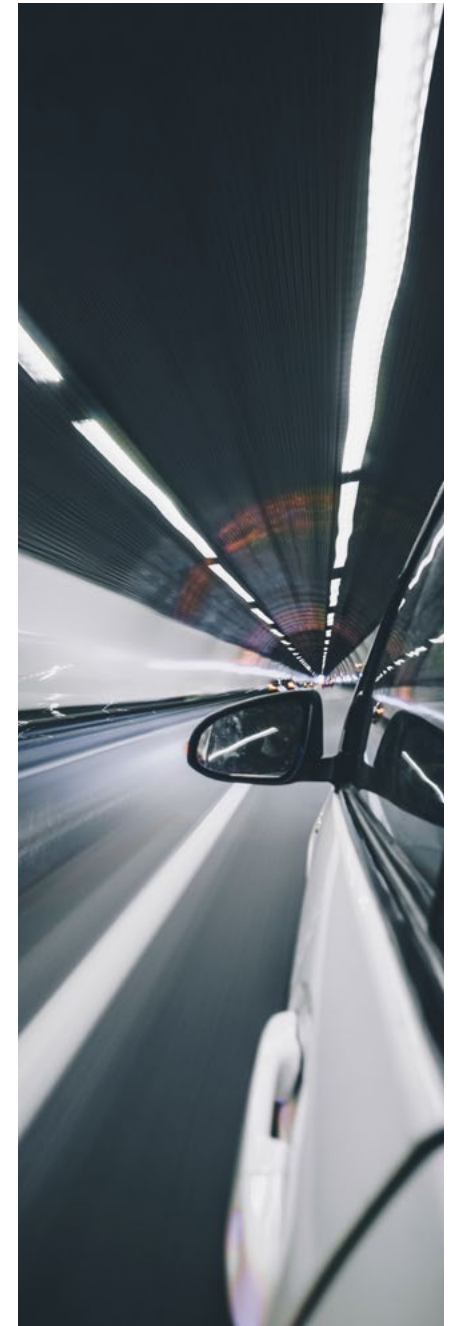
The consolidated cockpit is a vision for the future under development at AGL today. Led by Panasonic, the Virtualization EG focuses on cockpit software consolidation with VirtIO technology, enabling systems such as infotainment, instrument cluster, and heads-up displays to run on a single processor. This also enables use cases such as running Android for infotainment and AGL for instrument clusters side by side on a single virtualized CPU.

### ► Vehicle to cloud Expert Group:

As high-speed connectivity becomes ubiquitous, this EG evaluates how to move more functionality to the cloud and extend automotive use cases.

An open source project at the Linux Foundation, AGL unites the automotive and tech industries around shared software for all in-vehicle applications, from infotainment to autonomous driving.

“As the lines between embedded automotive software and IT/cloud continues to blur, AGL is paving the way for the Software Defined Vehicle.”



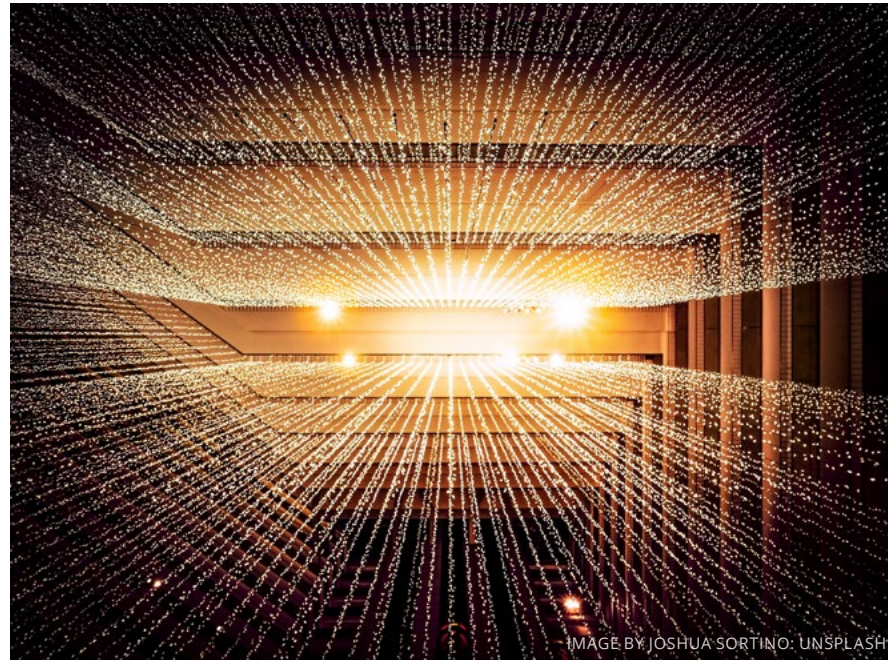


### The Trust over IP Foundation

(ToIP) Foundation aims to provide a robust, common-standard, and complete architecture for Internet-scale digital trust.

In 2022, we are expanding our foundation by introducing a new working group for Data Modeling and Representation. The scope of the Data Modeling & Representation Working Group (DMRWG) is to define the specifications, best practices, and standards related to data modeling, plus logical and concrete representations regarding how to store, process, and transmit data across all aspects of the ToIP stack and whether these standards are hosted at the Linux Foundation or externally.

Other activities will include creating template requests for proposals and additional guidance for utility and service providers regarding implementations in that capacity. The working group will



split into one or more task forces and focus groups on escalating the development of specific components.

The 2022 ToIP Foundation highlights include the following:

- ▶ We hosted the first ToIP Summit in Dublin during OSS Europe and had over 200 registrants.

- ▶ We evolved design principles and deliverables to include Principles of SSI, Design Principles for the ToIP Stack, Authentic Chained Data Container Specifications, and the ToIP Technology Architecture Specification.

- ▶ We began a presentation series within the Ecosystem Foundry working group that features presenters discussing governance in SSI ecosystems with Trust Registries, ecosystem governance under development, verifiable credentials and exploring talent in the marketplace.
- ▶ We launched a new website and web series to feature community members and their work in the field related to ToIP.



The Confidential Computing Consortium (CCC) brings together hardware vendors, cloud providers, and software developers to accelerate the adoption of trusted execution environment technologies and standards.

The CCC had a great year, adding new members and bringing more awareness to confidential computing. The CCC had a presence at Black Hat and Defcon in Las Vegas, NV, with over 30,000 attendees; at the event, we educated attendees about the consortium and confidential computing.

The CCC created a new governance, risk, and compliance SIG to focus on connecting development communities

with regulators to create regulations for confidential computing. In addition, they are finalizing a confidential computing terminology whitepaper and launching a fresh new website.

Veraison is the newest project added to the consortium, building components that can be used for an Attestation Verification Service.

Join the [Confidential Computing Consortium](#) and find out how confidential computing is relevant to you.



Linux is a reliable and stable development platform that advances innovation for a wide range of industries. As Linux continues to be a key component in safety-related applications, [Enabling Linux in Safety Applications \(ELISA\)](#) will make it easier for companies to build, test, and analyze these safety-critical systems.

Since its launch in 2019, ELISA has established several working groups to further the cross-industry project's crucial work toward advancing open source safety-critical systems. The activities and goals of these groups became evident this year when six new members joined the project to

focus on the [Automotive Working Group](#) and a new Aerospace Working Group.

Adding Automotive Intelligence and Control of China, Bosch, LOTUS Cars, and ZTE strengthened the global ecosystem for automotive use cases. This includes one collaboration with [Automotive Grade Linux](#) focused on the "safe displaying of warning signs on instrument cockpits," also called the "[Tell-tales Use Case](#)."

Boeing joined the project to launch a new Aerospace WG and enforce a standard in an industry already using Linux in selected applications. Boeing will lead the group and collaborate with other working groups, such as safety architecture

and the recently launched Systems WG.

[The Systems WG](#) will create a reproducible reference system based on real-world architectures and implement it fully based on open source technologies. The goal is to enable safety use cases with open source software or use mixed-criticality system elements as a base for their product lines.

The project's momentum continued this year as ELISA hosted five virtual and in-person workshops and webinars that brought together more than 400 industry thought leaders and open source community members.





The [Yocto project](#) builds, customizes, and combines Linux and other operating systems as needed to meet the ever-changing needs of a connected world in a maintainable and scalable way. It appears in cars, TVs, routers, telecoms, aerospace, satellites, server management, and more.

Having anticipated the need for supply chain audit and security, the project has world-leading Software Bill of Material capabilities building on standards, such as SPDX and the project's own powerful build reproducibility technology. This is all integrated into the project's tooling, supporting a wide variety of public and private ecosystems, including Automotive Grade Linux (AGL), OpenBMC, Comcast's Reference Design Kit, and Huawei's OpenHarmony.

Supporting this diverse user base, the project has extended its first long-term stable (LTS) release, which now covers four years. It has successfully engaged with the broader community through physical and dedicated virtual (summit) events, allowing access to and collaboration with a new audience.



From eight members on its first birthday in April 2021, the [seL4 Foundation](#) has grown to 20 full members (including six premium) and five associate members in the space of a year. This represents a dramatic boost to the open source ecosystem around the world's most-assured operating system kernel, seL4. The effectiveness of the kernel's security was demonstrated at Defcon 2021, where seL4's formally verified security enforcement defeated the assembled hacker elite trying to attack the quadcopter developed in DARPA's HACMS program.

Through membership fees and further financial contributions from government and industry members, the seL4 Foundation is funding work on extending seL4's unique mathematical correctness proofs from 32-bit Arm, 64-bit Intel, and RISC-V architectures to the 64-bit Arm architecture, as well as exploratory work toward proving correctness on multicore processors. Moreover, community contributions to the code base have increased sharply.







If you use a distance tracker, smartwatch, hearing aid, or new Google Chromebook next year, you may have interacted with the [Zephyr Real-time Operating System \(RTOS\)](#). Zephyr has gained [momentum over the last few years](#). It is now deployed in various embedded products, focused on wearables, medical electronics, and industrial control equipment, as shown on [the website](#).

Zephyr RTOS unites companies, developers, and end users worldwide to ensure balanced collaboration and feedback to evolve and meet the needs of its community. This innovative relationship among stakeholders advances the Zephyr Project's support of new hardware, developer tools, sensors, and drivers while maximizing the functionality of devices that run applications developed using the Zephyr operating system. For

example, T-Mobile is leveraging Zephyr to power its new [Developer Kit](#), which was launched in April and gives innovators fast and easy access to build on T-Mobile's network.

This year, Zephyr welcomed [Baumer](#), [Qualcomm Innovation Center, Inc.](#), and [T-Mobile](#) as Platinum members and [Infineon Technologies](#), [Percepio](#), and [Silicon Labs](#) as Silver members.

In 2022, Zephyr's technical community achieved several milestones, including the following:

- ▶ It has celebrated more than 1,400 contributors and 75,000 commits to building advanced support for multiple architectures, including Arm® Cortex®-M, Intel x86, ARC, NIOS II, Tensilica Xtensa, and RISC-V, and more than 400 boards, which has doubled since last year.

- ▶ It has hosted its second [Zephyr Developer Summit](#) in person at the Computer History Museum in Mountain View, California, and virtually for attendees around the globe. The event consisted of more than 380 registrants, four tracks, two mini-conferences, two tutorials, 54 sessions, and 58 speakers who presented engaging technical content, best practices, use cases, and more. Videos are available on the [Zephyr Project Youtube Channel](#).

- ▶ In the year since Zephyr made the switch from Slack to [Discord](#), the community grew to more than 3,700 members in the new discussion forum, with an estimated 8,000+ messages being sent each month.
- ▶ Zephyr highlighted member solutions and opportunities this year through a new [career resource](#) highlighting technical

jobs, including a [vendor offering support showcase](#) that can be filtered by tools, applications, and training, and continued refinement of the [product creators' vulnerability registry](#).

- ▶ The Zephyr Project was listed in the [#22 top projects in a Velocity report by prs](#) and [seventh out of the Linux Foundation's top projects](#).



From consistency across architectures and distributed datacenters to tighter security, better resource utilization, and reduced administration, the benefits of mainframe modernization can address today's IT challenges. [Open Mainframe Project](#) is helping modern mainframes transform today's businesses through its many open source projects and educational programs.

Several technical communities test their open source code on hardware, with over 20 projects and working groups under the Open Mainframe Project umbrella. In September, Open Mainframe announced the availability of a z15 mainframe system dedicated to training next-generation talent and developing new open software technologies to strengthen the mainframe and cloud integration further. Donated by Broadcom

Mainframe Software Division, the mainframe will be available for all Open Mainframe Projects and the open source community in 2023. This provides a critical new resource to foster greater collaboration and the development of new toolsets across the mainframe community.

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

- [Zowe](#) is an open source software framework for the mainframe that strengthens integration with modern enterprise applications and offers vendors and customers product stability, security, interoperability, easy installation, and upgraded features. The Zowe community worked hard

to launch its Long-Term Support (LTS) V2 release this year, resulting in the 2022 DevOps Dozen competition awarding Zowe the [Best DevOps for Mainframe Award](#).

- Aiming to build a vendor-neutral ecosystem around Zowe, Open Mainframe Project's Zowe Conformance Program launched in 2020. The program helps project members, including ASG Technologies, BMC, Broadcom, IBM, Micro Focus, Phoenix Software International, and Rocket Software, incorporate Zowe with new and existing products that enable the integration of mainframe applications and data across the enterprise. To date, 75 products have implemented extensions based on the Zowe framework and earned these members conformance badges.

- [The COBOL Working Group conducted a survey last year](#) that confirmed an estimated 250 billion lines of COBOL code running the world economy, suggesting there is a dire need for programmers, among other details. This year, [the COBOL WG partnered with Linux Foundation Research and Linux Foundation Training and Certification](#) on a new research study to explore a detailed understanding of how organizations' usage of COBOL has evolved and what strategies and attitudes are driving change in the future. The program will begin in January 2023, and the results will be published at Open Mainframe Summit 2023.

On September 21–23, Philadelphia, PA, became an open source and mainframe hub as more than 300 students, engineers, and developers attended the



first-ever in-person and virtual [Open Mainframe Summit](#). The event included a streaming option so that global participants could network with their colleagues, ask questions, and learn more about all aspects of security, mainframes, and beyond, including cloud native services, automation, software supply chain management, and more this year.

The Open Mainframe project will continue evolving its mission as the primary foundation for community engagement and scale it across the ecosystem of vendors and academic partners and the next generation of mainframe talent.

The [Civil Infrastructure Platform](#) (CIP) is focused on hardening Linux to enable its use in civil infrastructure (e.g., energy, transportation, healthcare) and industry. CIP is addressing security, long-term kernel maintenance and core components, automated testing, and remote updates to enable adoption and broader use. CIP now supports Debian 11-based reference images and is working on IEC 62443 security standard compliance and reproducibility. In 2022, CIP expanded work on super long-term supported (SLTS) kernel maintenance. Linux kernel 5.10 is now supported, along with 4.4 and 4.19. CIP commits to maintaining



all SLTS versions for 10 years after the original release.

In late June, the [Dronecode Foundation](#), the vendor-neutral foundation for open source drone projects, held its annual PX4 Developer Summit in Austin, Texas, for the first time in person since 2019, gathering developers from 37 countries. June also saw the stable release of PX4 Autopilot v1.13.0, which featured new hardware and sensor support, critical battery functions, and the truly amazing Dynamic Control Allocation for complete 360-degree flight control. This year, the advanced air mobility startup Kittyhawk joined the Dronecode Foundation as a silver member. They will contribute to developing distributed and modular sensor systems that are utilized by electric vertical take-off and landing.

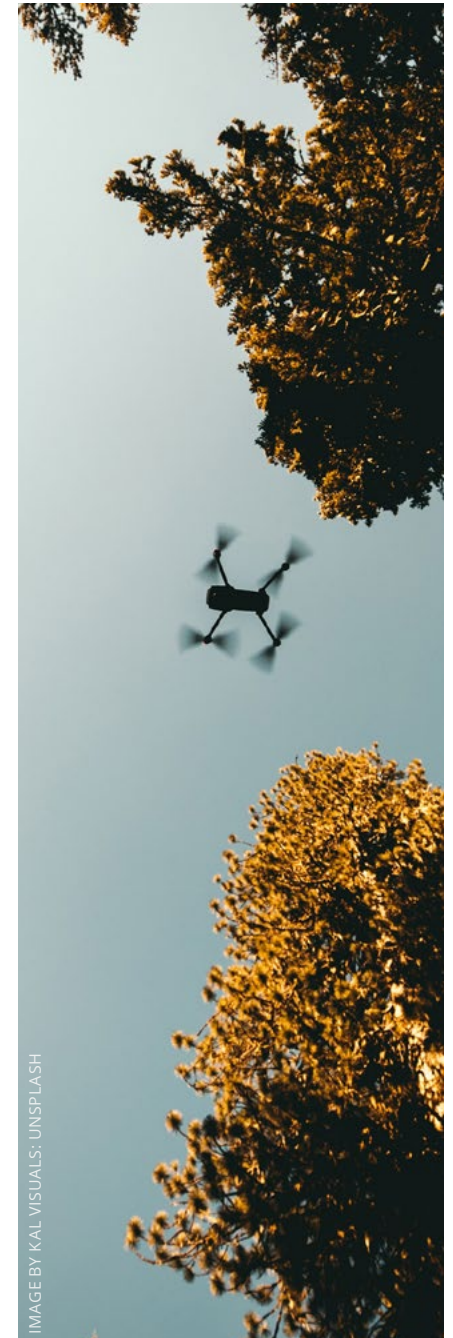
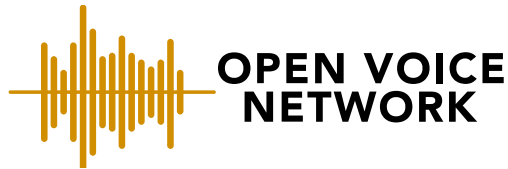


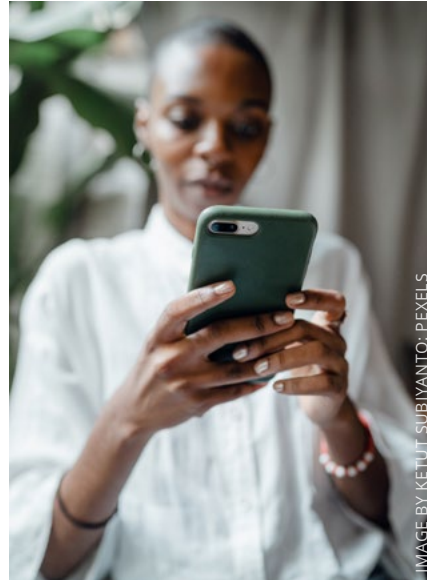
IMAGE BY KAL VISUALS: UNSPLASH



The [Open Voice Network](https://www.openvoicenet.org/) (OVON) is a Linux Foundation open source association dedicated to developing and advancing open standards for the emerging world of voice assistance.

Currently, its work is driven by more than 200 monthly active volunteers across 13 nations.

Voice is on track to be a primary digital interface in the years ahead. We foresee the development of a worldwide voice web, an ecosystem measured in billions of voice-enabled digital destinations, ranging from the applications now on general-purpose platforms to voice-enabled websites to a metaverse that will increasingly be explored and lived in through user utterances. Voice assistance is, at its heart, an application of AI and ML; its leading specialties are automatic speech recognition and natural language processing, understanding, and generation.



At present, the OVON focuses on the following areas of research and development:

► **Interoperability of conversational assistants:** This enables assistants of different platform parentage to fulfill user intents by passing textual, acoustic, and contextual data from one to another. Moreover, within an approach to interoperability, destination and location services will

allow conversational assistants to find desired destinations and, in turn, allow others to find their addresses and content.

► **Personal data protection unique to voice:** Enables users to manage the control, access, and use of voice-based data.

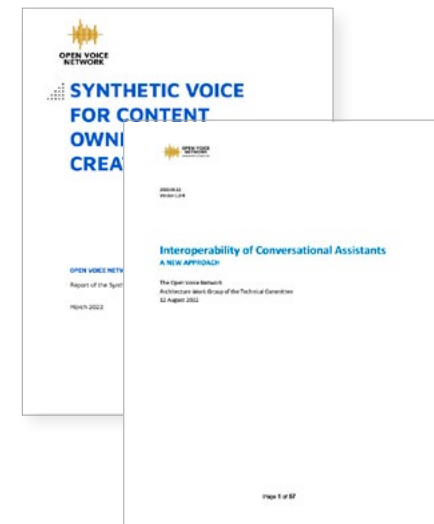
► **Data security unique to voice:** This is a critical issue in a world of digital synthesis, personal authentication, and interoperability.

► **The ethical use of voice technologies:** Companies offering voice services in their products now must ethically ensure the processing of user data.

► **Voice-centric authentication:** This is not only for individuals but also for destinations in a worldwide voice web.

Through 2022, the Work Groups of the Open Voice Network have published directional

statements and whitepapers on these and other topics. Access these documents at [https://www.openvoicenet.org/white\\_papers](https://www.openvoicenet.org/white_papers).



In the first quarter of 2023, the Open Voice Network expects to publish draft specifications of the interoperability messaging protocols that will allow the sharing of dialogs.



## Innovation in open standards

While best known for its Open Source Software projects, the Linux Foundation has always understood that promoting Open Standards is crucial to extending the power of open source implementations. Today, the Linux Foundation boasts over 200 projects engaged in standards and specification development.



## Standards and specification development



In 2019, the Linux Foundation added the [Joint Development Foundation](#) (JDF) to its family of project communities to build upon its current specification work. The JDF brought a unique but straightforward process to allow new projects to form quickly and collaborate under a standardized set of governance principles that ensure the resulting specification can be implemented with open source licenses. In addition, the JDF is a Publicly Available Standard submitter to JTC1/ISO/IEC, which gives our Standards projects the ability to submit our specifications to become ISO specifications.

“In the past year, we have seen new momentum from our members wanting to start Specification projects at the LF. The idea that a project can start quickly

with a fully formed corporate identity, governance structure, and process template strongly appeals to our community,” said Jory Burson, VP of Standards for the Linux Foundation. “Traditionally, there are months of work to form a legal entity for simple collaboration and a lot of administrative overhead to keep it running. Our members appreciate the ability to move quickly from an idea to a functioning project in weeks rather than months. The Linux Foundation has invested in Staff, Tools, and Process streamlining to improve project formation and execution continuously.”

A sampling of the active LF Standards projects follows.

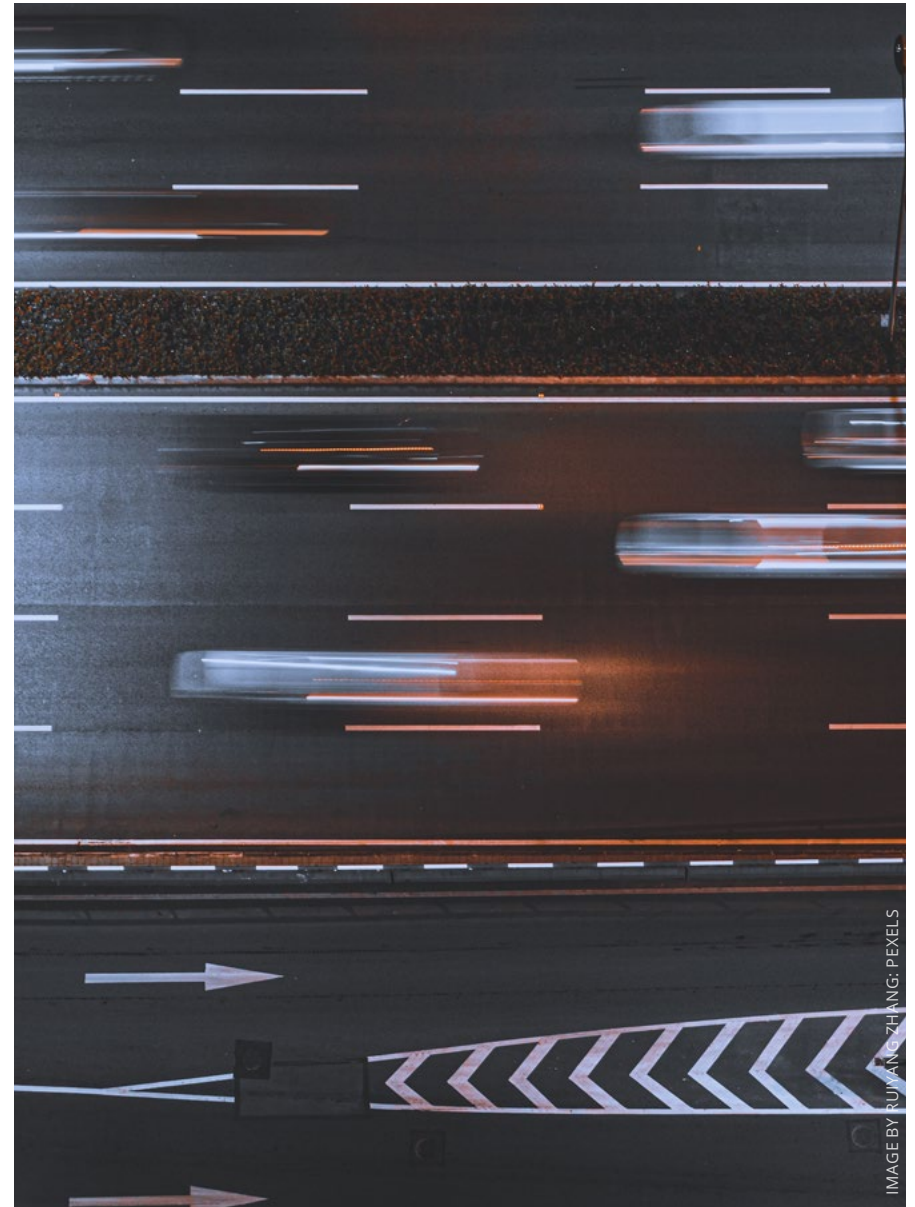


IMAGE BY RUJIAN ZHANG: PEXELS



### The Carbon Data Specification Consortium

(CDSC), organized under the JDF Community Specification, is developing standards to enable access to energy data, including a data dictionary for raw data and a standard for data requirements. These standards will simplify access and use of data for measuring, quantifying, and tracking carbon emissions from energy producers and consumers. The standards are intended to boost confidence in energy data sources, improve the ease of data utilization, promote scalability, enable data aggregation for centralized platforms, and support and inform decarbonization pathways and decision-making for the energy grid.

## LF ENERGY SUPER ADVANCED METER

The Super Advanced Meter specification, organized under the JDF Community Specification, aims to create a worldwide meter and data gateway specification that focuses on basic metering functionality, country-specific functionality, third-party functionality, and integration capability for system operation applications. These

standards and requirements are intended to boost the development of the meter as a reliable virtual node in the energy grid, enabling the energy transition and supporting new business models. The meter design can measure electricity and may be further capable of interfacing with gas, water, and heat meters while communicating dynamic

pricing and greenhouse gas emission data on-premises. A particular focus is put on the gateway, which is the smart part; it provides the functionality to connect to the respective meters and enable communication toward LAN and WAN and translation between them via current and future standards.



IMAGE BY CHRIS JANDA: PEXELS



# OPEN 19™

The Linux Foundation and its community created open specifications for a brick cage that fits into standard 19" datacenter racks, a variety of server brick format factors, unique “plug-and-play” power and network connectors, and a high-efficiency power shelf.

The [Open19](#) framework enables datacenter hardware design that powers edge, 5G, and custom cloud deployments worldwide via hardware and software.

The standard has been adopted by leading technology suppliers, datacenter operators, and enterprise and service provider customers. In 2020, the Open19 Foundation joined the Linux Foundation, bringing its community of hardware and datacenter innovators to the world’s largest open source ecosystem.

The year 2022 brought a refresh to the Open19 standard, with enhancements to the technical capabilities while maintaining the features of blind mate connectivity for every aspect of the installation: simplicity, ease of use, and scalability. Additionally, the standards group launched four Sub-working Groups for power, cooling, mechanical, and networking.

In 2022, the Open19 v2 specification reached the “Release Candidate” stage of their specification, which includes updated data connector specifications, a new power shelf that is 48V native “to the brick,” and a pluggable liquid cooling connector that we expect will massively accelerate the adoption of this powerful technology. The teams are now moving into prototyping and hope to have early working samples of much of the specification in late 2022 or early 2023.



**Open19 8RU Brick Cage**



**Open19 2U-Open19-SKU MILAN2**



## [The Quantum Intermediate Representation \(QIR\) Alliance](#)

is a joint effort organized under the JDF Community Specification to develop a forward-looking quantum intermediate representation to enable full interoperability within the quantum ecosystem and reduce the development effort from all parties. The QIR project collaborates closely with the quantum community to design and implement the necessary compiler technology to accelerate advances in quantum programming language design and execution systems. The project aims to develop a holistic solution that takes full advantage of unique and distinct capabilities in the landscape of heterogeneous quantum processors.





(C2PA) addresses the prevalence of misleading online information by developing technical standards for certifying the source and history (or provenance) of media content. C2PA is a JDF project formed through an alliance between Adobe, Arm, Intel, Microsoft, and Truepic. C2PA unifies the efforts of the Adobe-led Content Authenticity Initiative. We provide important support and

In early 2022, the C2PA released version 1.0 of its technical specification for digital provenance. This specification is the first of its kind. It empowers content creators and editors worldwide to create tamper-evident media, enabling them to disclose who created or changed digital content selectively. In September 2022, the C2PA updated the

The C2PA's work results from industry-wide collaborations focused on digital media transparency that will accelerate progress toward global adoption of content provenance.

```
.select(),toElement()||va...$.getActiveIndex();$=this.$items.length>0?this.slicing...
$.element.one("slide",function(){r.to(t);n-=7*this.pause().cycle();this.slide(t=="next"?prev,e(this.$items[t]),p
(t){return t}(this.paused==10),this.$element.find(".next","prev").length&&e.support.transition.end&&(this.$element.tri
support.transition.end,this.cycle(0)),clearInterval(this.interval),this.interval=null,this.next=function(){if(thi
return;return this.slide("next");},prev:function(){if(this.sliding)return;return this.slide("prev");},slide:function(t,n
r=this.$element.find(".item.active"),i=n||r[0],s=this.interval,o=t=="next"?7:"left":"right",u=t=="next"?7:"first":"last"
this.sliding=10,$&this.pause(),i=i.length?this.$element.find(".item")[u][0]:f.e.Event("slide",{relatedTarget:i[0]},di
if(i.hasClass("active"))return;this.$indicators.length&&(this.$indicators.find(".active").removeClass("active"),this.$
("slide",function)(var t=e.a.$indicators.children()[a.getActiveIndex()];t.addClass("active"));};if(e.support.trans
$.element.hasClass("slide"){this.$element.trigger(f).if(f.isDefaultPrevented())return;i.addClass(t,[0].offsetWidth
,i.addClass(o),this.$element.one(e.support.transition.end,function(){i.removeClass(ft,o).join(" ").addClass("active")
}.removeClass("active",o).join(" ")),a.sliding=1,setTimeout(function(){a.$element.trigger("slide"),0})}else{this.set
(f);if(f.isDefaultPrevented())return;r.removeClass("active"),i.addClass("active"),this.sliding=1,this.$element.trigge
return $&this.cycle(t),this);var n=e.fn.carousel.e.fn.carousel=function(n){return this.each(function){(var r=e(this
"carousel"),s=e.extend({e:fn.carousel.defaults,typeof n=="object"&&n,o:typeof n=="string"?n:s.slide:i[r.data("car
t"(this,s)),typeof i=="number"?i.to(n):o[i[0]].s.interval&&i.pause().cycle());e.fn.carousel.defaults.interval=563,
pause("hover"),e.fn.carousel.Constructor.prototype.fn.carousel.noConflict=function(){return e.fn.carousel=n},e.docment
page:n)detritill,Uniqid,Uniqid,Iden-alericall,6setat,shon,e-eaf,ettn(Uniqid-n,unth3,e-eaf,ettn(Uniqid-n,unth3,e-eaf,ettn
```

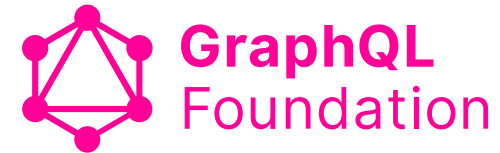
## Uptane

The [Uptane](#) project is an example of how an industry consortium can benefit from the JDF process at no cost.

Uptane is incorporated under the JDF governance structure but operates as a completely volunteer-led effort. Uptane is an open and secure software update framework design that protects software delivered over the air to automobile electronic control units. The framework protects against malicious actors who can compromise servers and networks to sign and deliver updates. Hence, it is designed to be resilient even to the best efforts of nation-state attackers. Uptane is integrated into Automotive Grade Linux, an open source system currently used by many large OEMs, and has also been adopted by several U.S. and international manufacturers. There are multiple free open source and closed source implementations available.



The [OpenAPI Specification](#) (OAS) defines a standard, language-agnostic interface description for HTTP APIs, which allows humans and computers to discover and understand the capabilities of a service without requiring access to source code, additional documentation, or inspection of network traffic. The latest version of OAS, version 3.1, added full support for JSON Schema and the addition of webhooks. The webhooks feature allows incoming HTTP requests to respond to external events or stimuli. The [OpenAPI Initiative](#) is listening to user feedback to determine the direction of the next planned release, 4.0, to meet the needs of businesses and organizations better. We are also investigating ways to broaden our community reach and provide member companies with more avenues to connect.



[GraphQL](#) is a query language for APIs and a runtime for fulfilling those queries with your existing data. GraphQL provides a complete and understandable description of the data in your API, gives clients the power to ask for exactly what they need and nothing more, makes it easier to evolve APIs over time, and enables powerful developer tools.

- ▶ GraphQL hosted its first-ever community conference in June of this year and registered eight new memberships following the conference in Austin.
- ▶ The foundation relaunched its [meetup.com](#) events globally with the support and sponsorship of member companies and community leaders.
- ▶ The foundation is working to drive engagement by featuring member organizations within the community and amplifying the work they're doing across the community.



## consortium

[The R Consortium](#) is a group organized under an open source governance and foundation model to support the worldwide community of R software users, maintainers, and developers. Its [members](#) include leading institutions and companies dedicated to R's use, development, and growth.

The R language is an open source environment for statistical computing and graphics. The R community has grown significantly, with more than 2 million users worldwide. Many organizations have adopted the R language as a data science platform, including the biotech, finance, research, and high-technology industries. The R language is often integrated into third-party analysis, visualization, and reporting applications and runs on various computing platforms.

The following are some highlights from the 2022 R Consortium:

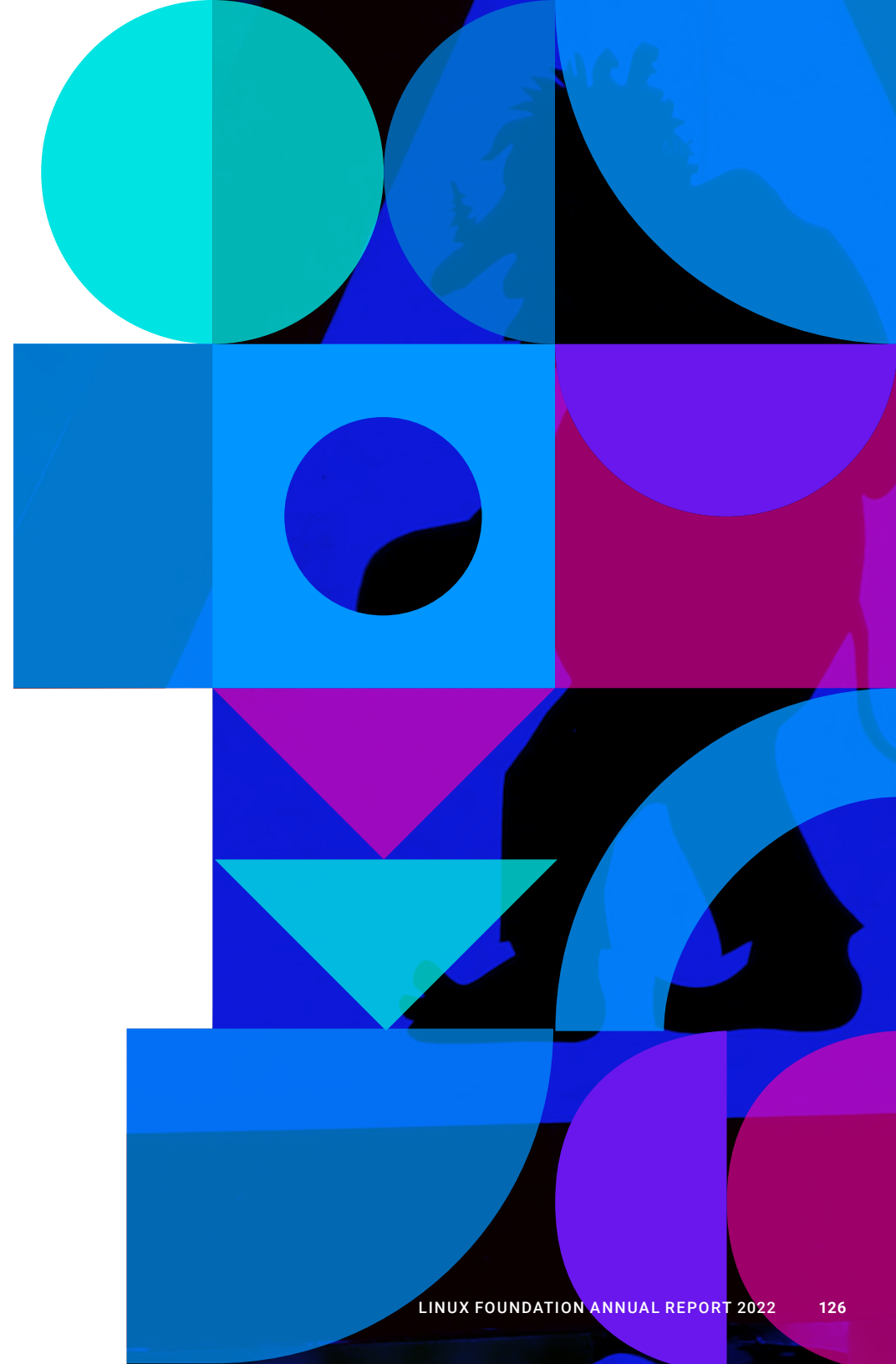
- ▶ Changed bylaws to expand additional ISC Board seats to our Silver members with this bylaw amendment (Silver-level members will now elect as members of the ISC as Silver-level directors are serving on the Board).
- ▶ Held elections to vote on three additional seats to the ISC Board of Directors.
- ▶ Launched a new grant management system to manage our grant program.
- ▶ Established two sessions for technical infrastructure grants and open enrollment for our social infrastructure grants.
- ▶ Introduced the idea of initiating a certification program in conjunction with the LF Training team and aim to vote on this formally in Q4.
- ▶ Successfully hosted another conference—R Medicine Conference—with record attendance and received sponsorship to offset overall costs.
- ▶ R Diversity and Inclusion team has virtually launched a Francophone SatRdays series to help connect the R Community in French.
- ▶ R Certification is finalizing questions and identifying a viable host option for the platform. They are optimistic that the beta will launch before the end of the year.
- ▶ The R Validation Hub submitted a paper to the ASA BIOP journal.
- ▶ Social media presence has increased with grant recipient interviews and promotion for grant-sponsored events.



IMAGE BY CLAY BANKS: UNSPLASH

# Unified Patents Open Source Zone

Defending against patent trolls, protecting Linux  
and open source.







Three years ago, the Linux Foundation partnered with Open Invention Network, IBM, and Microsoft to [announce an ambitious plan](#) to fund an [Open Source Zone within Unified Patents](#) to deter non-practicing entities with invalid patents (“patent trolls”) from asserting against OSS packages such as Linux. These trolls often threaten or sue open source implementors as a way to extract settlements given the high cost and uncertainty of litigation, even though their patents are almost always invalidated if challenged. Since its initial funding, Meta, Mercedes-Benz, and others have provided additional support, allowing Unified’s activities and deterrence to increase. In addition, any small company can join Unified for free and help support this activity as well. To get involved, visit [www.unifiedpatents.com/join](http://www.unifiedpatents.com/join).

Unified uses this support to detect, disrupt, and deter patent trolls from patents covered by the Zone. Fighting patent trolls takes years, but, since launch, Unified has already done a lot to change the game.

So far, it has challenged 50 patents with an almost perfect success rate.

- ▶ 34 were invalidated.
- ▶ Seven have been initially determined to be flawed.
- ▶ Three more are awaiting review.

In addition to the directly challenging patents, Unified runs PATROLL, the world’s only crowd-sourced prior art contest. Anyone can submit prior art against trolls demonstrating their patents are invalid. Even better, winning submitters win thousands of dollars in prize money—over 40 contests have resulted in over 200 submissions and tens of thousands of dollars awarded. For more information and to participate, go to [www.patroll.art](http://www.patroll.art).

Some of the 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, Automotive Grade Linux, Ceph, ClamAV, DigiKam, Linux kernel “ip” command, Linux kernel NFS module, iptables, KVM, Magento, Nagios, OAuth, OpenACH, OpenSwan, frredesktop.org’s OpenWFD, QEMU, Quagga, Redis, Rygel, sedutil, Signal, Varnish Cache, and WebM.

## Innovating with artificial intelligence, machine learning, data, blockchain, and financial services

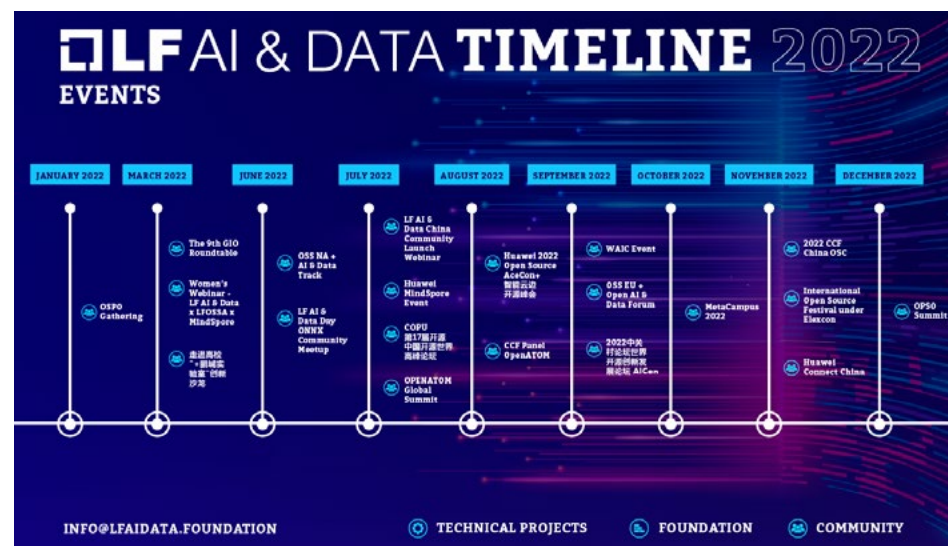
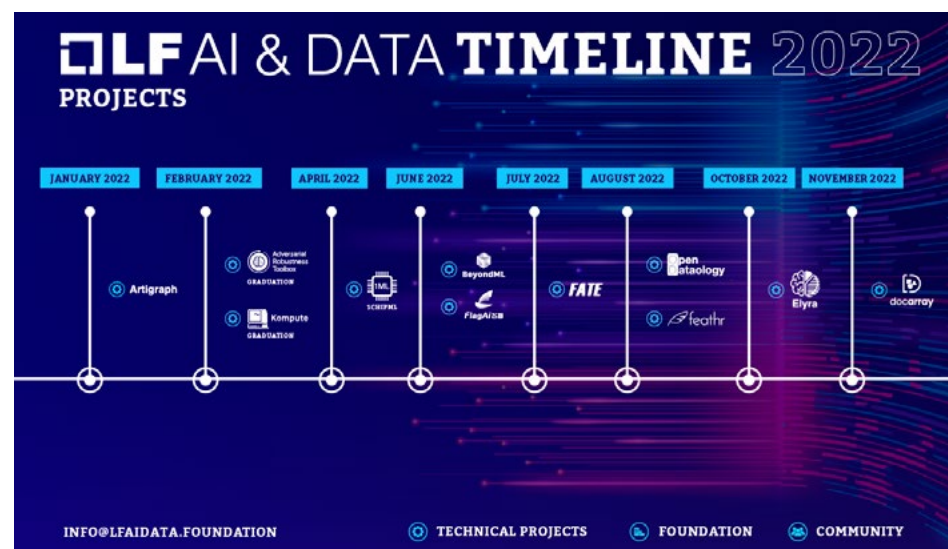
The Linux Foundation continues to foster leadership and innovation using leading-edge open technologies and best practices for financial services and insurance verticals, as well as developing best-of-breed artificial intelligence, big data, blockchain, and distributed ledger tools for the entire technology industry.



## Creating communities with the LF AI & Data Foundation

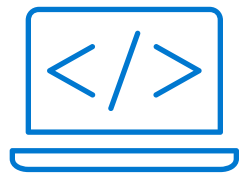
[The LF AI & Data Foundation](#) is growing and supporting an open community along with an expanding ecosystem. This umbrella foundation includes open source AI, data, and analytics projects. We focus on accelerating project development and innovation by enabling collaboration and creating new opportunities for all community members.

The Foundation provides a neutral, trusted hub for developers to code, manage, and scale open source AI and data technology projects. Our community is growing quickly. On average, we're adding one new project per month. At the time of writing this report, LF AI & Data has [48 members](#) and hosts [41 technical projects](#). The projects cover open source and open standards everyone in the world relies on for AI and data analytics systems. In addition to hosting technical projects, LF AI & Data hosts several committees focused on fostering collaboration among its members on specific topics such as BI & AI, Trusted and Responsible AI, MLOps, and DataOps.

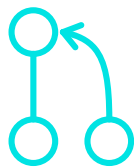


## LF AI & Data by the numbers

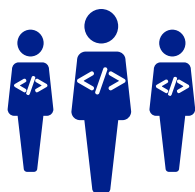
We encourage open source projects to [join](#) the growing roster of LF AI & Data hosted projects and take advantage of our resources and emerging community.



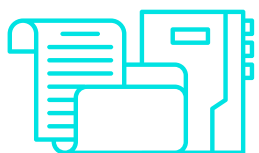
**10.5M Lines of Code**  
managed across all  
hosted projects



**68,000+**  
**Pull Requests**  
contributed during  
the past three years



**17,200+ developers**  
contributing code to  
our hosted projects



**41 Projects**  
hosted in LF AI & Data



**550+ organizations**  
participated in code  
commits during the  
past three years



## DELTA LAKE

Delta Lake is the world's most widely used lakehouse format. In 2022, Delta Lake [monthly downloads skyrocketed](#) skyrocket from 685K to over 7M. Due to this activity and the growth in unique contributions, the Delta Lake project logged an [astounding 633% increase in contributor strength over the last three years](#).

[Delta Lake](#) provides an open source storage framework that offers key features, including time travel, ACID transactions, scalable

metadata, and more. With compute engines including Flink, Hive, Kafka, Presto, Spark, Trino, and APIs for Scala, Java, Rust, Ruby, and Python, Delta Lake enables the building of lakehouse architectures on any platform or environment. Delta Lake has over 190 contributors across 70 organizations, including Microsoft, Amazon, Disney, Apple, eBay, Adobe, and SambaTV. The project is growing quickly, adding new contributors and members weekly.

### Delta Lake 2.0: We are open sourcing all of Delta

Unlock the power of Delta Lake

Coming Soon!

ACID Transactions	Scalable Metadata	Time Travel	Schema Evolution	OPTIMIZE	OPTIMIZE ZORDER	Change data feed	Generated column support w/ partitioning	Clones
Unified Batch/Streaming	Schema Enforcement	Audit History	DML Operations	Table Restore	S3 Multi-cluster writes	Data Skipping via Column Stats	Identity Columns	Iceberg to Delta converter
Compaction	MERGE Enhancements	Stream Enhancements	Simplified Logstore	Generated Columns	Multi-part checkpoint writes	Column Mapping	Subqueries in deletes and updates	Fast metadata only deletes

DATA+AI SUMMIT 2022



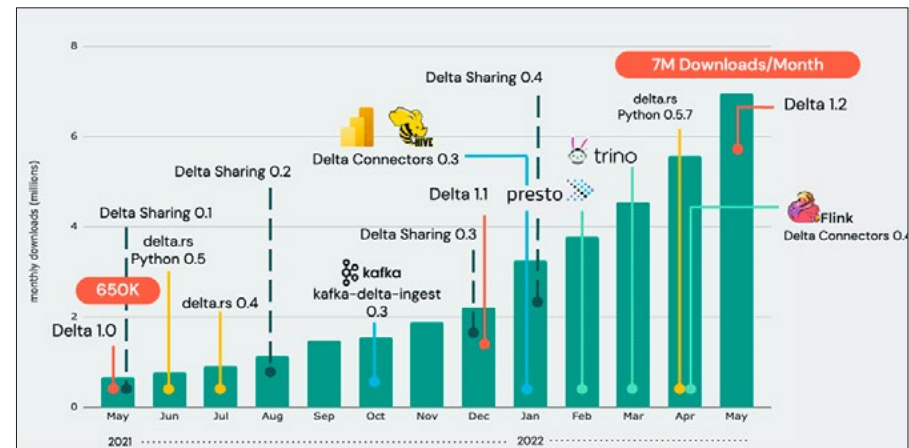
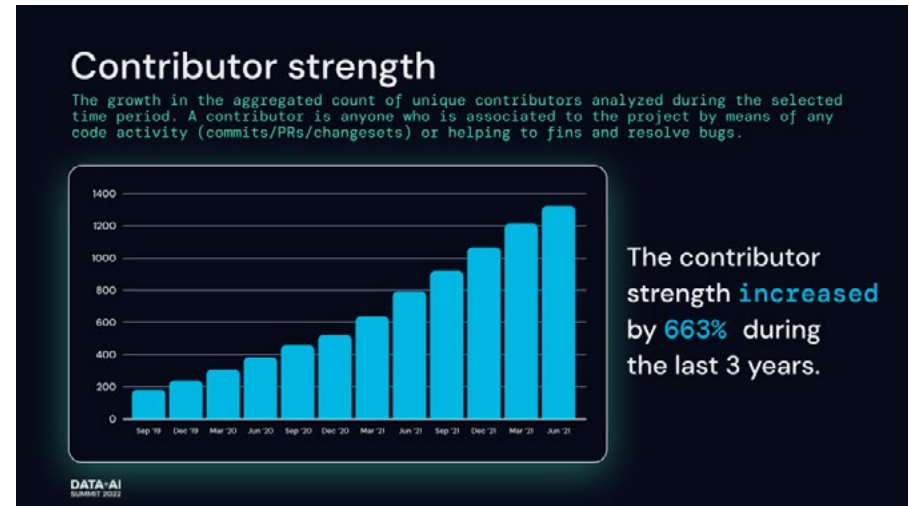
In June 2022, Delta Lake announced Delta Lake 2.0. This milestone version enabled the community to benefit from all Delta Lake innovations, with all Delta Lake APIs being open sourced. The wider Delta community collaborated to add features to this version like [OPTIMIZE ZORDER](#), data skipping using column stats, [S3 multi-cluster writes](#), [Change Data Feed](#), and more. These new features dramatically improve performance and manageability compared with previous versions. Completing the work to open source all of Delta Lake while tens of thousands of organizations were running in production was no small feat. Kudos to the Delta Lake community and its many contributors for making this possible.

The Delta Lake project also has a vibrant ecosystem of direct open source connectors. This year, Delta Lake added connectors for [Presto](#), [Flink](#), and [Trino](#). The project is continuously adding

more connectors. Engineers from various industries and companies have contributed connectors to the Delta Lake ecosystem. Delta Lake's commitment to supporting connectors makes it easy to build ETL pipelines with various technologies. Building connectors for the most popular compute engines and technologies increases the appeal and utility of Delta Lake. This, in turn, will drive community growth and accelerate adoption.

Florian Valeye is a Data Engineering Manager at Back Market and a contributor to Delta-rs, a native Rust library for Delta Lake:

*"Contributing to open source is key to learning how to solve problems within worldwide, benevolent communities of people."*  
– Florian Valeye



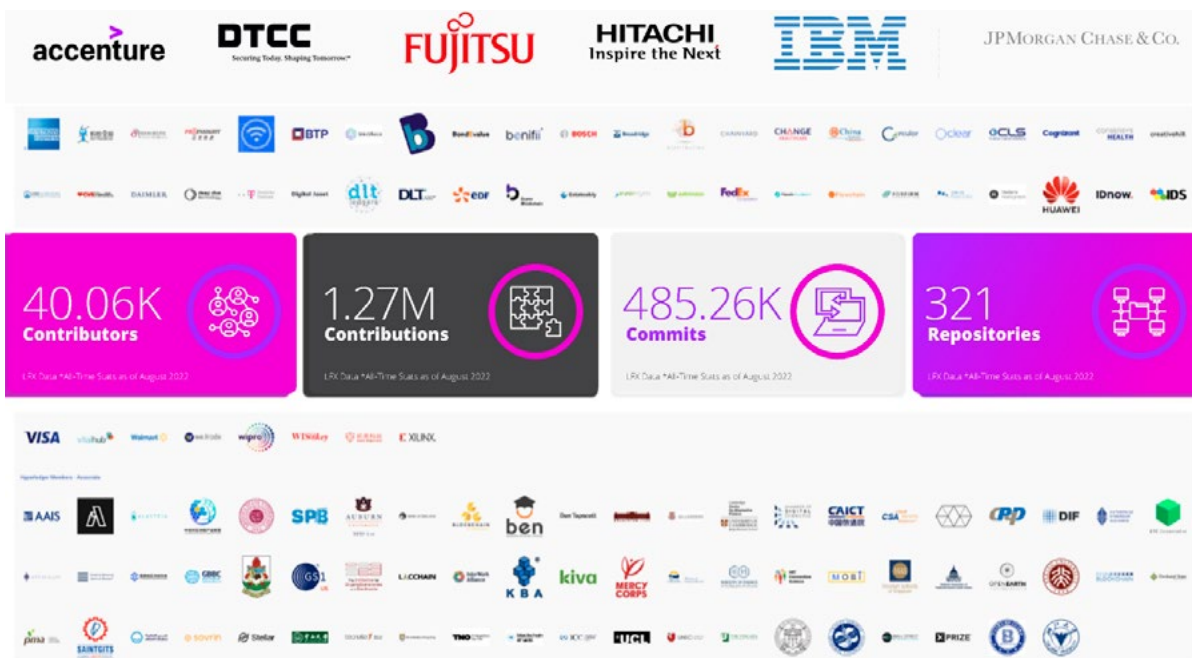


While 2022 has been a year of ups and downs worldwide, [Hyperledger Foundation](#) marched steadily forward, scaling its ecosystem and team to support a growing global community and a maturing blockchain market. The volatility of the crypto market sharpened the line between the perceived value

of speculative, headline-grabbing cryptocurrencies and the actual value of enterprise-grade blockchain technologies and the applications they power.

Over the last seven years, the Hyperledger community has been developing and refining the core technologies for

a once-in-a-generation upgrade to the foundational layer for finance, banking, healthcare, supply chains, manufacturing, technology, and beyond. Hyperledger technologies are [powering new payment solutions, including central bank digital currencies \(CBDCs\)](#), tackling climate change, and [enabling new, more](#)



### secure ways of proving identities and credentials for individuals, companies, and even devices.

Hyperledger's success is built on its strong and diverse community. Over the last five years, there have been more than 40K contributors and over 1.2M contributions to Hyperledger projects. There are more than 80K worldwide community members and hundreds of member companies and government institutions supporting the work of the Hyperledger Foundation. That includes regional chapters in Brazil, Latin America, Africa, Japan, and India as a host of Special Interest Groups covering Climate Action and Accounting, Telecom, Media and Entertainment, and more.

In the last 12 months, Hyperledger has added three new projects, Hyperledger FireFly, Hyperledger Bevel, and, most recently, Hyperledger Solang. They all started as Hyperledger Labs, a space for innovation and testing of ideas that are helping advance this market and the Hyperledger ecosystem. As importantly,

four Hyperledger projects were sunsetted, demonstrating that the community is actively managing projects through their lifecycle.

The evolving Hyperledger ecosystem signals a few key things where this market is headed. The diversity of Hyperledger distributed ledger platforms, all of which are graduated, production-grade projects with growing user bases, reflect the coming multi-chain world with a continuum of permissioned, public, public permissioned, and other hybrid networks. The intertwining of public and permissioned is most apparent with Hyperledger Besu, which is one of the top three most popular Ethereum execution clients according to Ethernode.

However, Hyperledger is more than just a DLT community. Much of the recent innovation is occurring on the tools and library front. New projects tackling cross-chain interoperability, smart contract portability and even multi-chain deployments of apps are all laying the groundwork for the next

wave of complex networks.

Likewise, Hyperledger projects are increasingly serving as the core for a new generation of digital trust tools that leverage decentralized technologies such as distributed ledgers and verifiable credentials.

While there are committed communities driving the development of every Hyperledger project, there is an important and growing level of collaboration across the ecosystem. This cross-project collaboration is critical to delivering mature, enterprise-grade technologies and to building out the complex, decentralized infrastructure that will serve as the trusted foundation for trade, healthcare, banking, commerce, and more. This collective effort is what we call "building better together."



[openIDL](#), an open source, distributed ledger platform, infuses efficiency, transparency and security into regulatory reporting: With openIDL, insurers fulfill requirements while retaining the privacy of their data. Regulators have the transparency and insights they need when they need them.

A primary business case for openIDL is the compelling opportunity to greatly reduce the cost and complexity of timely regulatory reporting to state regulators on the part of insurance carriers. Furthermore, since openIDL is a non-profit, open source, and anti-trust industry collaboration, low-level aggregated and anonymized data provided by carriers in different regions and lines of business can be consolidated and made available to both carriers and regulators. This creates a "win/win" for both sides that is unique in the industry.

It has been an exciting year for openIDL. We have added staff,

engaged with new infrastructure partners, and made great strides in getting member consensus on business requirements and technical architecture. We are establishing an operational test net platform needed to support the onboarding of members, development testing, and the eventual support of the production network.

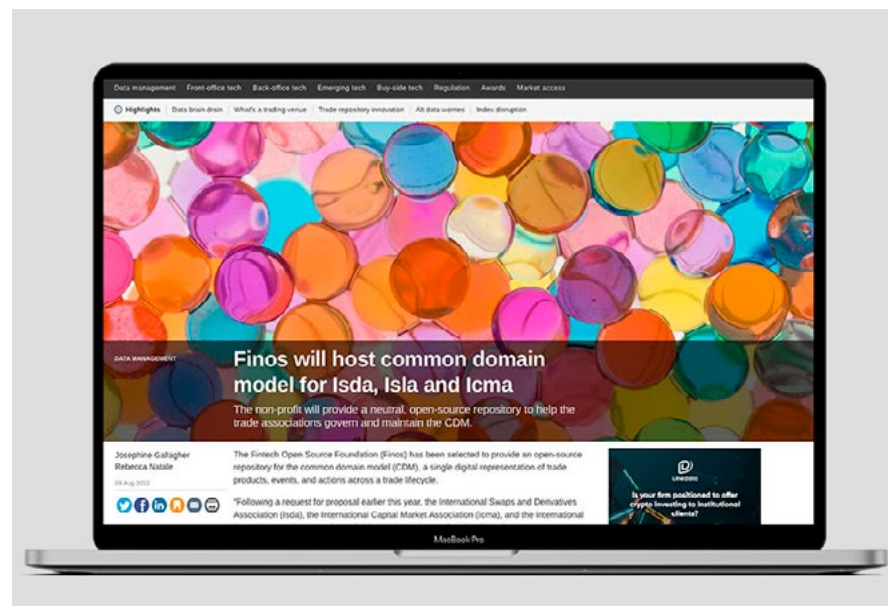
openIDL leverages and involves the significant contributions of other Linux Foundation projects. Notably, openIDL is an opportunity for which Hyperledger Fabric is ideally suited to provide an excellent platform solution and the cross-utilization of motivated resources from within the Linux Foundation and participating open source community members.

openIDL is one of the few Linux Foundation projects in which the Linux Foundation will operate and manage a consortium based on Hyperledger Fabric and other open source contributions. As such, it establishes the foundation of a decentralized network approach to realizing significant benefits to public/private efficiencies in other industries.



**FINOS** (Fintech Open Source Foundation) is focused on powering the next wave of financial technology innovation based on open (source, standards, and data) collaborative efforts among all financial services industry and technology constituents. After years of building awareness and best practices that enabled financial institutions to be first-class citizens in the open source community through the [FINOS open source readiness program](#), thanks to our community's support and energy, the industry is on the cusp of a major evolution as regulated entities are embracing open innovation at an unprecedented pace.

With historical cultural barriers coming down and [regulators increasing focus on Open Source sustainability](#), 2022 has seen the industry accelerating its investments in open source like never before: From dozens of



[financial institutions rolling out OSPOs](#) just in the last 12 months, to the largest financial institutions actively contributing to upstream and OSS sustainability efforts like [OpenSSF](#), to [investors recognizing the disruptive potential](#) of an open fintech commercial ecosystem. Some of the year-on-year early from FINOS second “State of Open Source in Financial Services” report (to be released

to the public on December 8 at the sixth [Open Source in Finance Forum](#) in NYC) are simply staggering:

- Globally, GitHub commits from financial services institutions were up **113% YoY**.
- **48%** of surveyed firms now openly encourage consumption, almost doubling in 2021.



- **28%** of respondents reported an increase in the time their organizations allocated for OS contributions.
- Notable decrease in contribution not being permitted, down to just **6%** from **20%** in 2021.

Consequently, FINOS, now a household name across the industry, is experiencing significant growth in contributions and membership and has onboarded several high-impact, industry-wide projects with a distinct acceleration in regulatory-focused projects under the [Open RegTech](#) initiative.

In 2022, we welcomed 15 new members (a 30% increase), with the notable additions of the buy-side's Wellington Management to the Governing Board, and Google, Societe Generale, and American Express to our Gold Members.

Contribution growth and project download statistics testify to our vibrant and growing community. Not only did our contributor strength continue to grow steadily at a 30% YoY but, most importantly, downloads,

the ultimate metric of value, are growing even faster, with YoY downloads up 330% on Maven Central for [Legend](#) and 278% for [FDC3](#) and 65% for [Perspective](#) on NPM. Other important testaments of the maturity of this community were having a +**217%** YoY attendance for our flagship event, [Open Source in Finance Forum](#), and creating a [Technical Steering Committee](#) with a majority of financial institutions.

Community-driven open standards are a key enabler for industry interoperability and innovation in a highly locked-in industry. Thus, standards development within financial services at all stack levels remained a major focus in 2022. Three key projects perfectly exemplify how FINOS is driving interoperability across the ecosystem:

- Application level: [FDC3](#), our very mature interoperability standard, released its [version 2.0](#) and is now becoming ubiquitous across [investment banks and buy sides](#). With a fully [open source Electron-based reference imple-](#)



Hilary Carter launching the *FINOS 2022 State of Open Source in Financial Services* survey in London at Open Source in Finance Forum.

[mentation](#) and poised to launch [its conformance program](#) in December, FDC3 is well on the way to becoming the “FIX for the Desktop” and driving seamless workflows across the financial services industry.

- Data level: On the heels of the [Legend](#) contribution by Goldman Sachs, in July 2022, three major trade associations ([ISDA](#), [ICMA](#), and [ISLA](#)) together [selected FINOS to host the Common Domain Model](#) (CDM) and utilize our community network to continue to extend the model

and promote its adoption in the industry. This is a massive recognition of FINOS's role in the industry, as the CDM establishes a single, common digital representation of trade events and actions across the lifecycle of financial products. This project will be live under FINOS in January 2023.

- Compliance and rules level: The [Open RegTech](#) initiative, started in late 2020 to create mutualized open source implementation of financial regulations and “shift left” regulators’ involvement in

open collaboration, fostered the open sourcing of projects like an [LCR implementation](#) (Liquidity Coverage Ratio) by Morgan Stanley and the acceleration of [Compliant Financial Infrastructure](#) as an industry-wide effort to build financial cloud compliant infrastructure as code.

As the Financial Services community is learning about the multiplicative power of open source, we see greater intersection and interoperability across our project landscape, with projects such as CDM, FDC3, and Legend leveraging each other's capabilities to bring vital solutions to the ecosystem.

In conclusion, we see a significant opportunity for early/late-stage technology and open source companies entering the ecosystem at this time, with a first-mover advantage to shape the next generation of financial applications through open collaboration with financial institutions.

## Maintainer highlights

Maintainers are the heartbeat of our community, and we are very thankful to those who lead the way as examples of open source best practices within the Financial Services industry.



**FDC3: Kris West**—Kris West is the Principal Engineer at Coda and is the lead maintainer for [FDC3](#). This year, Kris dedicated his time to stewarding the completion of the FDC3 2.0. Releasing this major version required balanced and considerate leadership and strong technical expertise, always displayed when Kris led work streams and discussions with the community. During our Open Source in Finance Forum conference in London, Kris introduced the 2.0 version to the community and presented its newest features. For his active engagement in FDC3, Kris was awarded the Most Active Individual award.



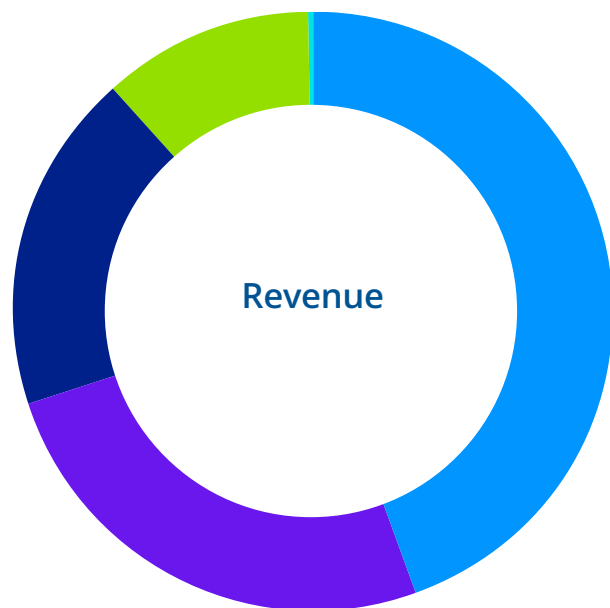
**Legend: Ffion Acland** co-leads the Global Data Models and Governance team at Goldman Sachs. She co-leads the Financial Object Special Interests Group at FINOS, which sponsors the collaborative development of standard financial data models and will engage with the community on CDM-focused efforts. Ffion's leadership has been instrumental in driving collaborative data modeling efforts within FINOS. When Goldman Sachs open sourced Legend, Ffion led the [FINOS Legend Studio Pilot](#) modeling work around FX Options and Commodities and demonstrated successful community collaboration using the Legend Studio shared hosted instance. Ffion generously adds to the DEI efforts in her local community; most recently, she participated in the FINOS Tech Gateway, showcasing Tech and Finance opportunities to underrepresented communities in London.



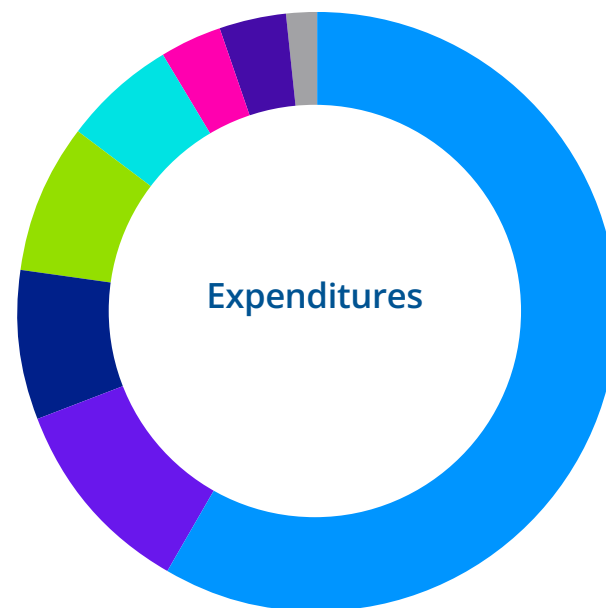
**Morphir: Stephen Goldbaum** is a Distinguished Engineer at Morgan Stanley and lead maintainer of the [Morphir](#) project, which has gained much larger adoption and contribution under his leadership. Stephen led the contribution of the first truly open source regulatory implementation of the [LCR](#) (Liquidity Coverage Ratio) regulation and [tech sprints](#) to foster a developer-driven collaborative approach to regulatory compliance. Stephen is a leading voice in the newly formed [FINOS technical steering committee](#) and is a frequent speaker at the [Open Source in Finance Forum](#).

# Financial transparency





- Membership & Donations **44.5%**
- Project Support **25.7%**
- Event Sponsorships & Registrations **18.4%**
- Training & Certification **11.3%**
- Other **0.1%**



- Project Support **59.2%**
- Community Infrastructure **9.8%**
- Corporate Operations **7.4%**
- Community Training **7.3%**
- Community Events **3.1%**
- Community Tooling **5.4%**
- Linux Kernel Support **3.2%**
- International Operations **1.5%**

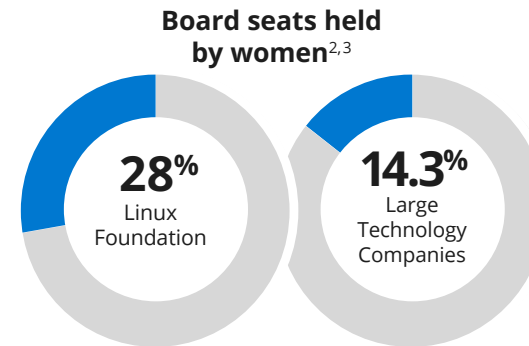
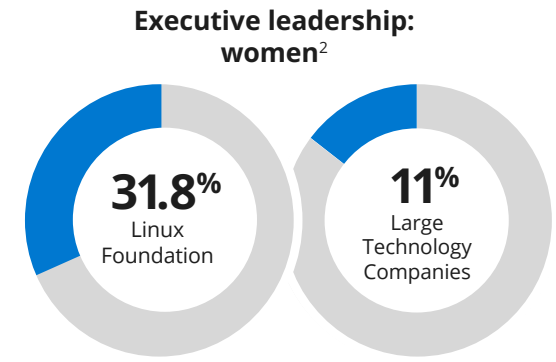
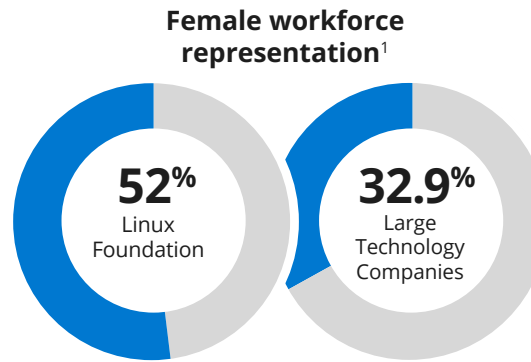
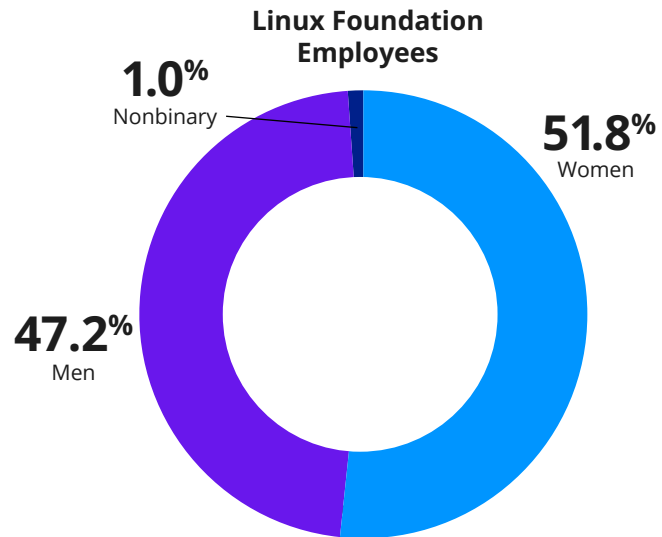
The Linux Foundation's revenue is derived from four main sources, Memberships and Donations, Project Support, Training and Certifications, and Event Registration and Sponsorship. In 2022 we are forecasting revenues of \$243.57M.

In 2022 the Linux Foundation is forecasting to spend over \$254.96M supporting our mission.

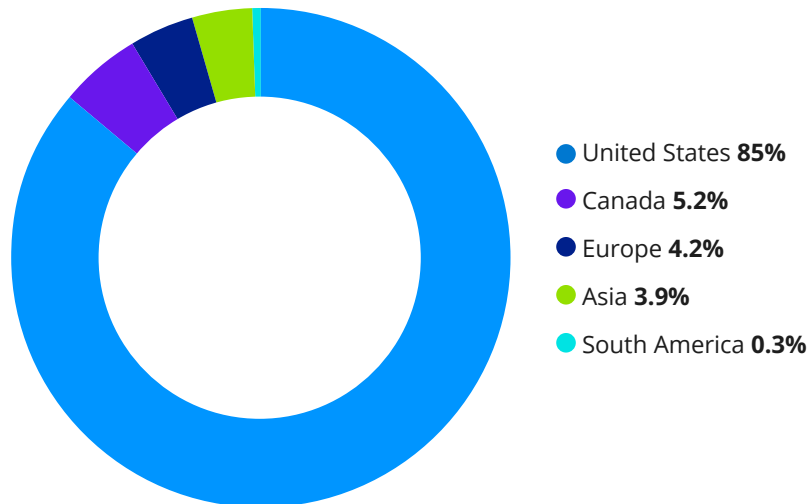
The LF and our directed fund projects operate on calendar year zero-based budgets, and any net surpluses are reserved for use by those projects in subsequent years. Annual aggregated expenses across the LF and our Projects may exceed annual revenue during a period, but the deficit is made up with reserve 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



## Linux Foundation around the world



<sup>1</sup> Susanne Hupfer and Jaime Austin, *Women in technology statistics*, Deloitte, 1 December 2021, <https://www2.deloitte.com/us/en/insights/industry/technology/technology-media-and-telecom-predictions/2022/statistics-show-women-in-technology-are-facing-new-headwinds.html>. Accessed 5 December 2022.

<sup>2,3</sup> Nikolina Cveticanin, *Women in Tech Statistics: Girls Get Tech*, DataProt, 14 March 2022, <https://dataprot.net/statistics/women-in-tech-statistics/>. Accessed 5 December 2022.



## 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](http://www.linuxfoundation.org).

## Connect with us



[twitter.com/linuxfoundation](https://twitter.com/linuxfoundation)



[facebook.com/TheLinuxFoundation](https://facebook.com/TheLinuxFoundation)



[linkedin.com/company/the-linux-foundation](https://linkedin.com/company/the-linux-foundation)



[youtube.com/user/TheLinuxFoundation](https://youtube.com/user/TheLinuxFoundation)



[github.com/LF-Engineering](https://github.com/LF-Engineering)

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

[info@linuxfoundation.org](mailto:info@linuxfoundation.org)

[www.linuxfoundation.org](http://www.linuxfoundation.org)