

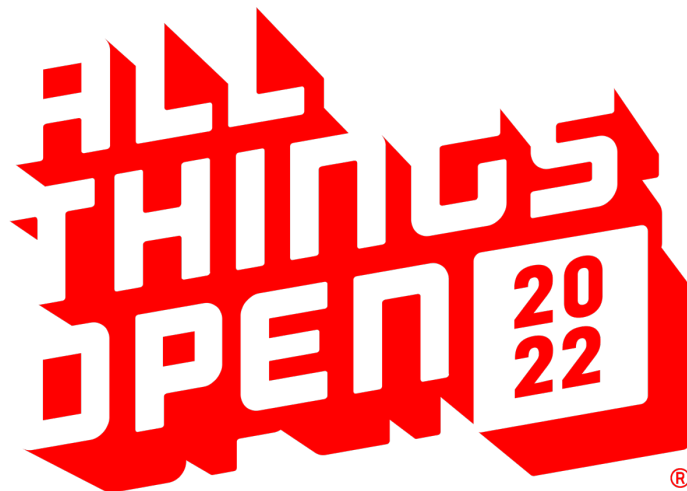
SUSTAINABILITY ALL THE WAY DOWN

SRI RAMKRISHNA

ONEAPI COMMUNITY MANAGER | INTEL

ERIK RIEDEL, PHD

CHIEF ENGINEERING OFFICER | FLAX COMPUTING



SUSTAINABILITY DEMANDS COMPREHENSIVE APPROACHES

Renewable energy
progress is great, and
necessary, but
INSUFFICIENT



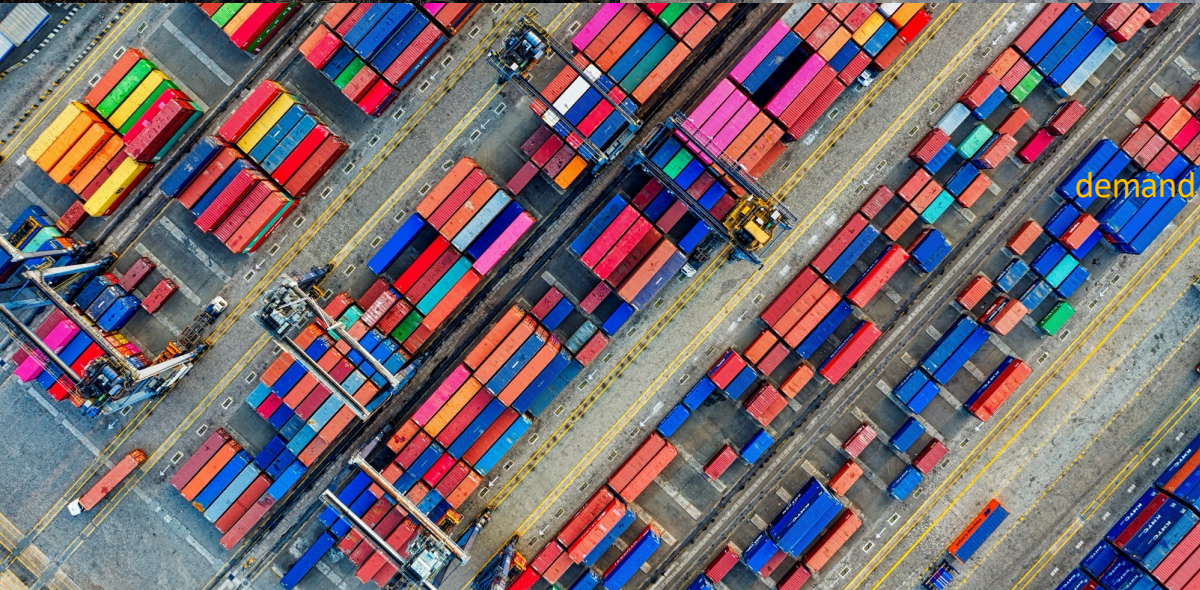


natural



resources

carbon



demand

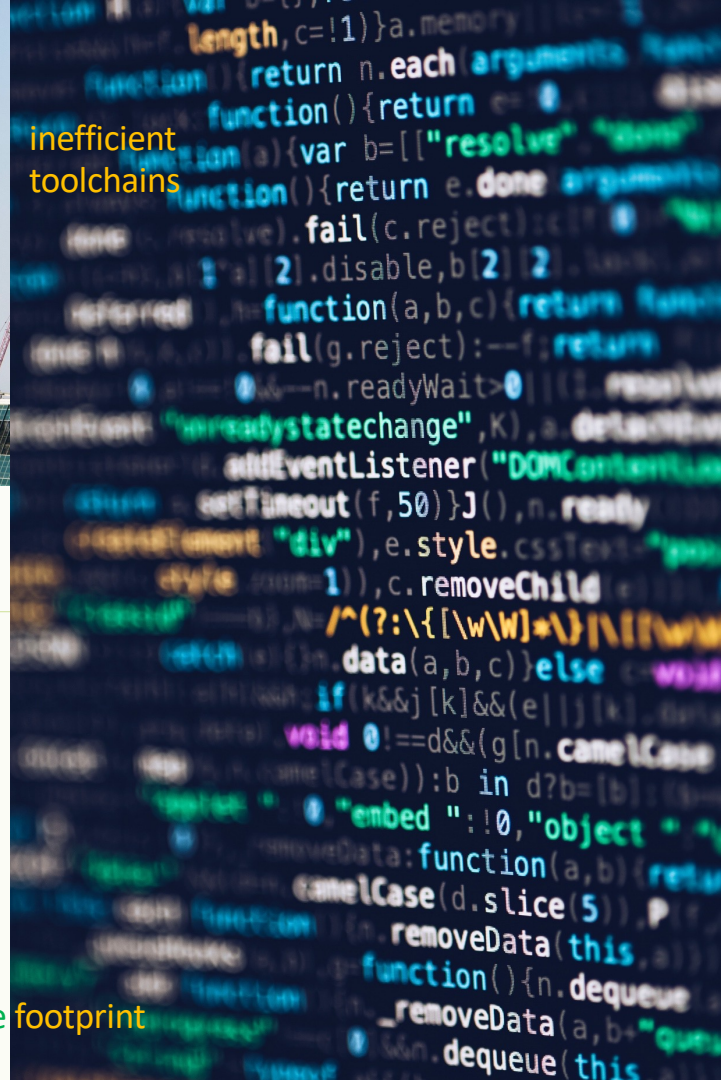


footprint

growth

clouds
drive
demand

inefficient
toolchains



[About](#) [Working Groups](#) [Projects](#) [Resources](#) [Articles](#)

We are building a trusted ecosystem of people,
standards, tooling and best practices for

GREEN SOFTWARE

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<https://greensoftware.foundation/>

software footprint

SUSTAINABILITY ALL THE WAY DOWN

Focusing on Software / Applications at the “top” of the stack

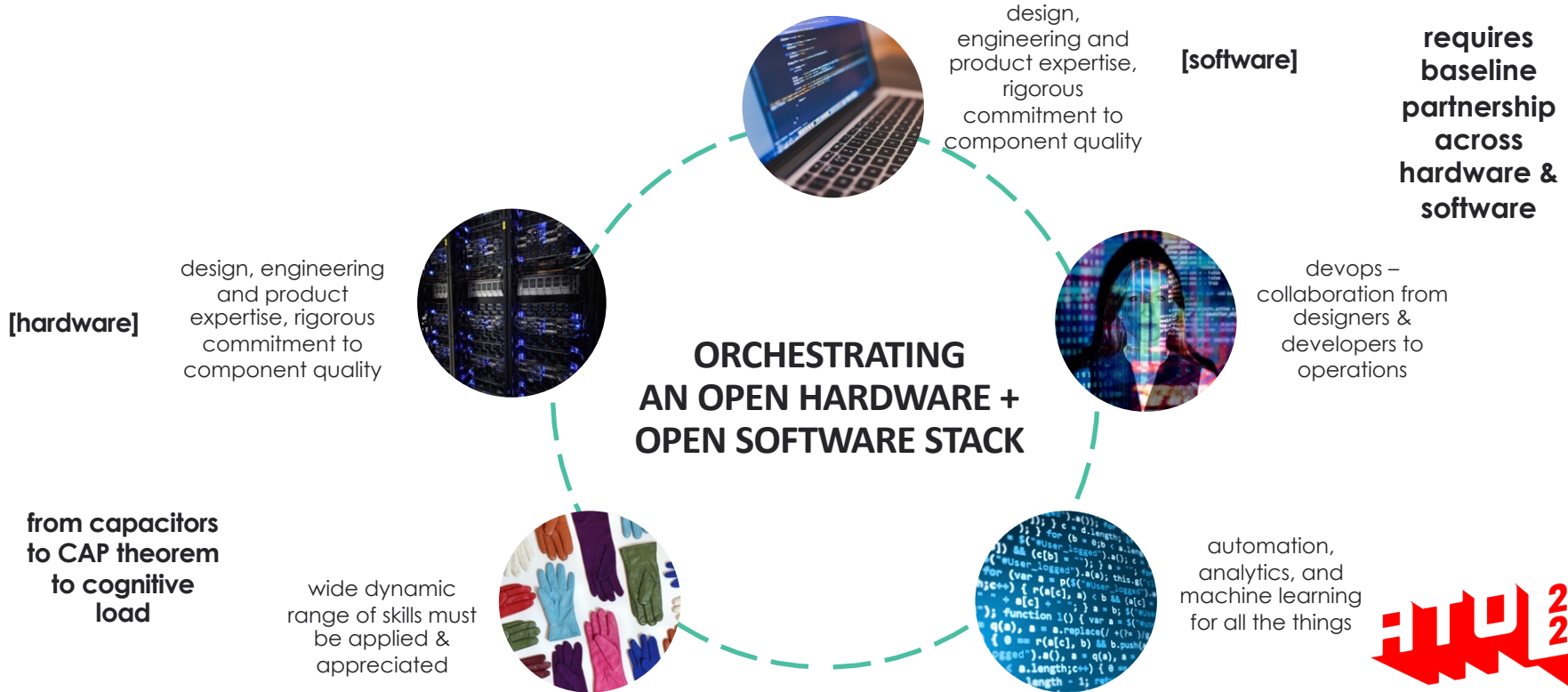
Hardware is at the “bottom” of the stack

The stack is **DEEP** and **WIDE**

Software and Hardware sustainability can work together to realize complete sustainability – across Scope 1, Scope 2, **Scope 3**

Let's talk about hardware and the sustainability work that's happening today

Open Is Necessary, But Not Sufficient Per Se



OPEN HARDWARE, OPEN SPECIFICATIONS

- instead of every company making their own unique specifications
- we work together on common elements to consider
- specifications that e.g. maximize cooling and reduce heat
- high density servers for maximum computation per floor tile
- form factors that can use any space in any location – under desks, in closets of various sizes, outdoors – to drive edge computing
- design for use of off-the-shelf components that are already efficient in mass production
- re-use, re-purpose, revamp the Hardware Supply Chain

OPEN HARDWARE – OPEN COMPUTE PROJECT (OCP)



ENGINEERED SYSTEMS READY TO DEPLOY

Engineered, tested, supported
as a single stack
Roll it in, turn it on

FLEXIBLE SCALE & CAPACITY

6 to 96 nodes per rack
>1,000 nodes per cluster
25/100G networking

PURPOSE-BUILT CONFIGURATIONS

Kubernetes
Converged/HCI
AI/ML

STANDARD RACK SIZE & POWER

No data center redesign
Leverage existing power



What Are As Built Drawings?

<https://constructionblog.autodesk.com/as-built-drawings/>

OPERATIONS

By Grace Ellis

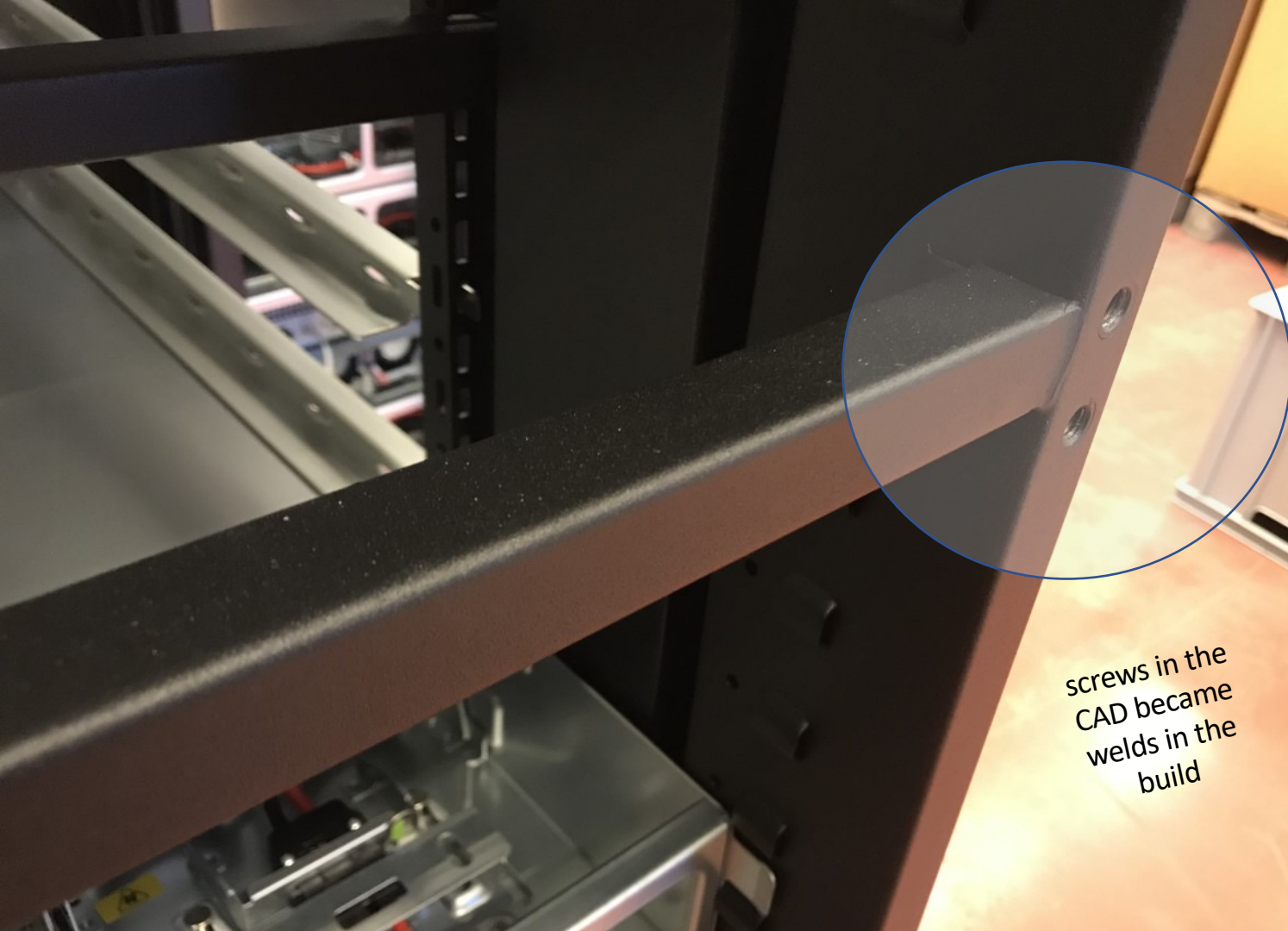
September 1, 2021

13 min read

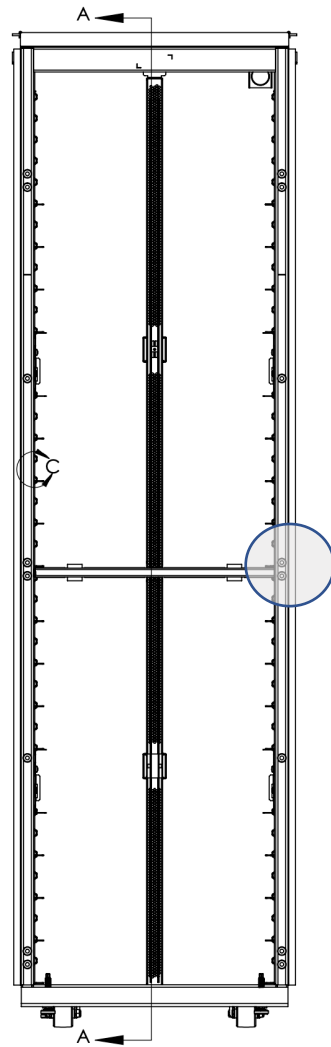


challenge in
hardware over
software – need
“as-built”
documentation

the “ground truth”
isn’t necessarily the
most recent git
commit



screws in the
CAD became
welds in the
build





OPEN HARDWARE – READY TODAY

ACTUALLY, READY FOR THE PAST TEN YEARS



These are not pie in the sky ideas – they are already actively implemented under the aegis of the Open Compute Project and the Linux Foundation



Platinum

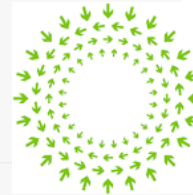
Alibaba (since 2017) 	AMD (since 2012) 	AMI (since 2018) 	Ampere Computing (since 2019) 	Meta (since 2011) 	Microsoft (since 2014) 	MITAC (since 2017) 	Nokia (since 2015) 
Arista Networks (since 2019) 	ARM (since 2018) 	ASUS (since 2019) 	AT&T (since 2015) 	NVIDIA (since 2017) 	Quanta Cloud Technology (since 2012) 	Rackspace (since 2011) 	Ragile Networks (since 2020) 
Baidu (since 2019) 	ByteDance Technology (since 2021) 	Cisco (since 2014) 	Delta Electronics (since 2016) 	Rittal (since 2017) 	Samsung Electronics (since 2019) 	Schneider (since 2014) 	Shell (since 2020) 
Edgecore Networks (since 2016) 	Google (since 2015) 	HPE (since 2015) 	Huawei (since 2021) 	Sims Lifecycle Services (since 2020) 	Submer (since 2018) 	Target (since 2021) 	Tencent (since 2018) 
Hyve Solutions (since 2012) 	IBM (since 2013) 	Inspur (since 2016) 	Intel (since 2021) 	UL Inc. (since 2021) 	Vertiv (since 2019) 	Wwynn (since 2014) 	

Gold

Seagate (since 2017) 	ZT Systems (since 2019) 
---	---

Silver

Celestica (since 2019) 	Innolight Technology (since 2021) 	Inventec (since 2014) 	Sony Interactive Entertainment (since 2020) 
--	--	---	---



OPEN
Compute Project®

members



Data Center Facility

Sub-Projects:

Modular Data Center
Critical Facility Operations - Incubation
Advanced Cooling Facility - Incubation



Hardware Management

Sub-Projects:

OpenRMC
Hardware Management Module - Incubation
Hardware Fault Management - Incubation



Networking

Sub-Projects:

ONIE
Open Network Linux
SAI
SONIC

Project

- Server (65)
- Networking (48)
- Rack & Power (36)
- Telco (21)
- Data Center Facility (15)
- Storage (13)
- Security (Incubation) (2)

[Show more](#)



Open System Firmware



Rack & Power

Sub-Projects:

ACS Immersion
ACS Cold Plate
ACS Door Heat Exchange



Security

Contributor

- Facebook (52)
- Microsoft (35)
- Edgecore Networks (18)
- Intel (7)
- AT&T (6)
- Delta Electronics (6)
- Inspur (6)

[Show more](#)

Family

- Network Switch (38)
- OpenRack v2 (24)
- OCS (18)
- OTHER (15)
- Olympus (14)
- Data Center (10)
- Storage (8)
- Telco (8)
- Power (7)
- OpenRack (6)
- SOC Boards (6)
- Server (6)
- 19" Server (5)
- Software (5)
- Accessory (4)
- Optical NW (4)
- ACS (3)
- CG-Openrack-19 (3)
- PCI Card (3)
- Access Point (2)
- Barreleye (2)
- Mezz Card (2)
- OCP Mezzanine (2)
- Security (2)
- uCPE (2)
- Debug Card (1)
- Honey Badger (1)
- Information (1)
- Open Vault Storage (1)



Server

Sub-Projects:

High Performance Computing - Incubation
Mezz (NIC)
Open Accelerator Infrastructure
Open Domain-Specific Architecture



Storage



Telco

Sub-Projects:

openEDGE



OPEN
Compute Project®

projects



CONTRIBUTED PROJECT

DISCOVERY EDGE ENCLOSURE

<https://github.com/opencomputeproject/Discovery>

github.com/opencomputeproject/Discovery

Product Solutions Open Source Pricing

Search Sign in Sign up

opencomputeproject / Discovery Public

Code Issues 1 Pull requests Actions Projects Security Insights

master 1 branch 0 tags Go to file Code About

vejmarie Merge pull request #8 from vejmarie/intro 88f154a on Apr 18, 2019 26 commits

docs	Add initial files to the repo as well as directory structure	4 years ago
electrical	Merge branch 'master' of https://github.com/van-liefde-t/Discovery	4 years ago
licenses	Add initial contributors list	4 years ago
mechanical	Update README.md	4 years ago
pictures	Add intro pictures of Discovery chassis concept	4 years ago
README.md	Fix the picture raw path	4 years ago

README.md

Discovery

Work in progress for hardware rack discovery

About
Work in progress for hardware rack discovery

- Readme
- 4 stars
- 5 watching
- 6 forks

Releases
No releases published

Packages
No packages published

Contributors

- vejmarie
- van-liefde-t
- JJChanut54 JJ Chanut
- rajeevsharma1 Rajeev Sharma

Database

Streaming & Messaging

Application Definition & Image Build

Continuous Integration & Delivery

App Definition and Development

KV CNCF Graduated	Vitess CNCF Graduated	CartoDB Couchbase CREATE.IO	Ignite Couchbase CREATE.IO	Apache Atlas BIGHAM	cloudevents CNCF Incubating	NATS CNCF Incubating	ibm ibm	HELM CNCF Graduated	Backstage CNCF Incubating	Buildpacks.io CNCF Incubating	KubeVirt CNCF Incubating	Operator Framework CNCF Incubating	argo CNCF Incubating	flux CNCF Incubating	keptn CNCF Incubating	agola AKUITY	Appveyor	Bombao
amundata C.U.L.	Databand Dgraph druid FusionDB Iguazio nifi neo4j qoms redis BerlinkDB Scale DB SEALTS SEATA SingleStore	IBM DB2 IBM DB2 IBM DB2	IBM DB2 IBM DB2 IBM DB2	IBM DB2 IBM DB2 IBM DB2	beam cd events EMO Flink Fluvio kafka KubeMQ Pulsar Siddhi StreamSets	Spark Spark Spark	ibm ibm ibm	bitnami CARVEL CHEF HABITAT KubePlus codezero Devfile.io DevSpace Eclipse Che Gefyra Gripad Gradle Itopia Kariko KONVEYOR kots kubernetes Nocahost rafft sealer	bitnami CARVEL CHEF HABITAT KubePlus codezero Devfile.io DevSpace Eclipse Che Gefyra Gripad Gradle Itopia Kariko KONVEYOR kots kubernetes Nocahost rafft sealer	bitnami CARVEL CHEF HABITAT KubePlus codezero Devfile.io DevSpace Eclipse Che Gefyra Gripad Gradle Itopia Kariko KONVEYOR kots kubernetes Nocahost rafft sealer	bitnami CARVEL CHEF HABITAT KubePlus codezero Devfile.io DevSpace Eclipse Che Gefyra Gripad Gradle Itopia Kariko KONVEYOR kots kubernetes Nocahost rafft sealer	bitnami CARVEL CHEF HABITAT KubePlus codezero Devfile.io DevSpace Eclipse Che Gefyra Gripad Gradle Itopia Kariko KONVEYOR kots kubernetes Nocahost rafft sealer	BRIGADE Buildkite bunnet Byzantine codefresh D2 IQ devtron Docker flagger GitLab go harness hydra Jenkins k6 Kekploy Open Feature OpenCICD OpenKruise openone Piper Razee Sentry TeamCity TESTKUBE Travis CI werf	BRIGADE Buildkite bunnet Byzantine codefresh D2 IQ devtron Docker flagger GitLab go harness hydra Jenkins k6 Kekploy Open Feature OpenCICD OpenKruise openone Piper Razee Sentry TeamCity TESTKUBE Travis CI werf	BRIGADE Buildkite bunnet Byzantine codefresh D2 IQ devtron Docker flagger GitLab go harness hydra Jenkins k6 Kekploy Open Feature OpenCICD OpenKruise openone Piper Razee Sentry TeamCity TESTKUBE Travis CI werf	BRIGADE Buildkite bunnet Byzantine codefresh D2 IQ devtron Docker flagger GitLab go harness hydra Jenkins k6 Kekploy Open Feature OpenCICD OpenKruise openone Piper Razee Sentry TeamCity TESTKUBE Travis CI werf	BRIGADE Buildkite bunnet Byzantine codefresh D2 IQ devtron Docker flagger GitLab go harness hydra Jenkins k6 Kekploy Open Feature OpenCICD OpenKruise openone Piper Razee Sentry TeamCity TESTKUBE Travis CI werf	

Orchestration & Management

kubernetes CNCF Graduated	Crossplane CNCF Incubating	VOLCANO CNCF Incubating	istio	CoreDNS CNCF Graduated	etcd CNCF Graduated	gRPC CNCF Incubating	Apache Thrift CloudAVGo DUBBO SDFRPC SRPC	envoy CNCF Graduated	CONTOUR CNCF Incubating	AVI NETWORKS Caddy citrix	EMISSARY INGRESS CNCF Incubating	RESCALE akana APIGEE Easgress Kong MuleSoft Sentinel Tyk WSO2	LINKERD CNCF Graduated	Istio CNCF Incubating	Aracll Mesh Istio
crossplane crossplane	Capsule Clientstack Chorestack FLUID K8S K8S K8S	Volcano Volcano Volcano	istio istio istio	CoreDNS CoreDNS CoreDNS	etcd etcd etcd	gRPC gRPC gRPC	Apache Thrift CloudAVGo DUBBO SDFRPC SRPC	envoy envoy envoy	CONTOUR CONTOUR CONTOUR	AVI NETWORKS Caddy citrix	EMISSARY INGRESS EMISSARY INGRESS EMISSARY INGRESS	RESCALE akana APIGEE Easgress Kong MuleSoft Sentinel Tyk WSO2	LINKERD LINKERD LINKERD	Istio Istio Istio	Aracll Mesh Istio

Runtime

ROOK CNCF Graduated	CubeFS CNCF Incubating	LONGHORN CNCF Incubating	CSI Curve DATABOLT DATARA DOLLEMC GEMINI GLUSTER HITACHI Nutanix OpenIO Purvis QINSTAR Qumulo Quobyte ROBIN SANGFOR SANGFOR SANGFOR Toshiba Veeva Veeva ZENKO	Cloud Native Storage Carina ceph cloudstor GLUSTER HITACHI Nutanix OpenIO Purvis QINSTAR Qumulo Quobyte ROBIN SANGFOR SANGFOR SANGFOR Toshiba Veeva Veeva ZENKO	ContainerD cri-o rkt	Fincore gVirt INCLAVITY kata Lima lxd	cilium CNCF Incubating	CNI CNCF Incubating	ANIPIC AQUITY CNI-Genie CUMULUS.P
ROOK ROOK	CubeFS CubeFS	LONGHORN LONGHORN	CSI Curve DATABOLT DATARA DOLLEMC GEMINI GLUSTER HITACHI Nutanix OpenIO Purvis QINSTAR Qumulo Quobyte ROBIN SANGFOR SANGFOR SANGFOR Toshiba Veeva Veeva ZENKO	Cloud Native Storage Carina ceph cloudstor GLUSTER HITACHI Nutanix OpenIO Purvis QINSTAR Qumulo Quobyte ROBIN SANGFOR SANGFOR SANGFOR Toshiba Veeva Veeva ZENKO	ContainerD cri-o rkt	Fincore gVirt INCLAVITY kata Lima lxd	cilium cilium	CNI CNI	ANIPIC AQUITY CNI-Genie CUMULUS.P

CLOUD NATIVE LANDSCAPE

This landscape is intended as a map through the previously uncharted terrain of cloud native technologies. There are many routes to deploying a cloud native application, with CNCF Projects representing a particularly well-travelled path.

l.cncf.io

Automation & Configuration

Container Registry

Security & Compliance

Key Management

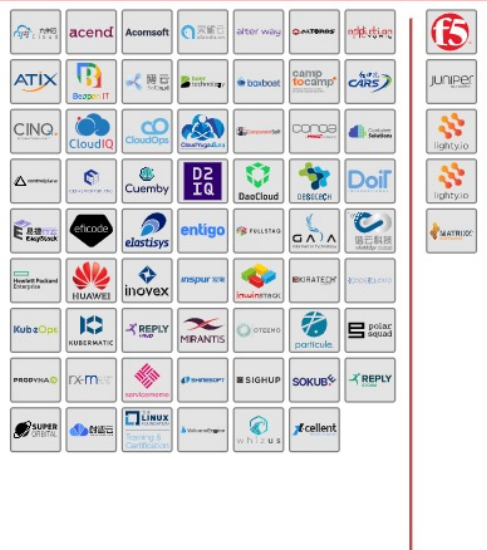
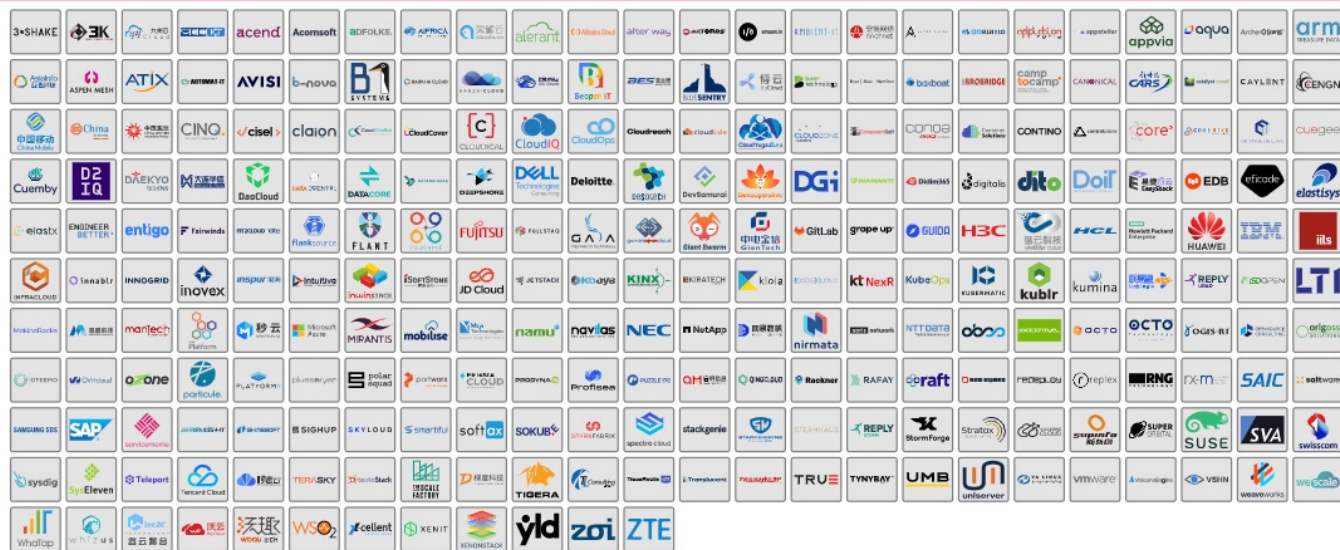


Provisioning

Kubernetes Certified Service Provider

Kubernetes Training Partner

Certified CNFs



Special

REAL WORLD EXAMPLES

Blockheating uses the waste product of water cooled servers to greenhouses to produce tomatoes

<https://www.datacenterdynamics.com/en/news/itrenew-and-blockheating-combine-edge-data-centers-greenhouses/>

Open Compute open specifications on heating, cooling, and rack design

https://www.opencompute.org/wiki/Open_Rack/SpecsAndDesigns

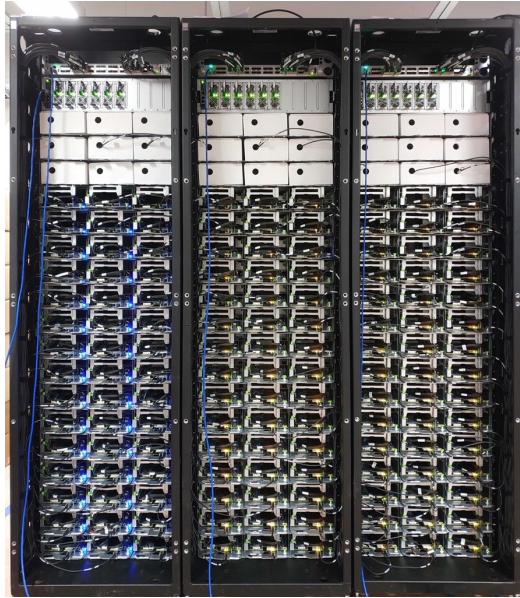
<https://www.opencompute.org/projects/advanced-cooling-facilities-incubation>

Open Compute Cross Project Sustainability Initiative

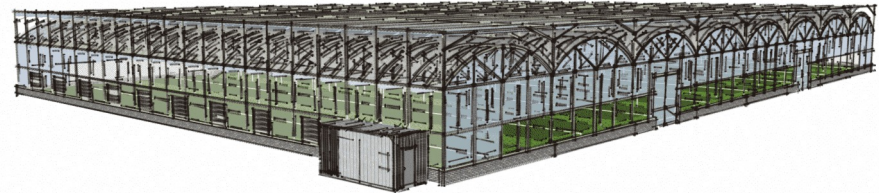
<https://www.opencompute.org/projects/sustainability-initiative>

CASE STUDY – AMSTERDAM

...FOR GREENHOUSES



blockheating
Recycling datacenter energy



CASE STUDY – AMSTERDAM

Green data centers require innovative partners



“WE’RE SAVING **20 - 30% ON AIR-CONDITIONING COSTS** BY GOING WITH OUR DECENTRALIZED APPROACH. **CONSTRUCTION TIMES ARE ALSO SIGNIFICANTLY REDUCED.** THOSE BENEFITS ALLOW US TO BE **SUSTAINABLE AND ECONOMICALLY COMPETITIVE AT THE SAME TIME.**”



“WE CHOSE ITRENEW FOR THEIR **SUSTAINABILITY CREDENTIALS, SUPERIOR TECHNOLOGY, ‘OPEN COMPUTE’ FLEXIBILITY,** AND THE SKILL OF THEIR ENGINEERING TEAM TO DELIVER ON OUR REQUIREMENTS AT SCALE—ALL OF WHICH HAVE **ENABLED US TO ACCELERATE OUR DEVELOPMENT.**”

JEROEN BURKS, CEO
BLOCKHEATING



CIRCULAR ECONOMY – HARDWARE

WHAT IF...



46

million servers



31

million tonnes CO₂e



6.7

million cars' annual emissions

KUBERNETES AT HOME

- 4-node hyperscale cluster
- >100 cores; up to 2 TB memory
- 25G/100G networking; NVMe storage



KUBERNETES AT HOME (2)

```
pxadmin@fast-sfp4: ~  
sri in   
> ssh lugh  
Last login: Tue Nov 1 07:37:03 PDT 2022 from 100.85.154.2 on pts/2  
Have a lot of fun...  
sri on lugh in ~  
> ssh pxadmin@fast-sfp4  
Welcome to Ubuntu 20.04.4 LTS (GNU/Linux 5.4.0-113-generic x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/advantage  
New release '22.04.1 LTS' available.  
Run 'do-release-upgrade' to upgrade to it.  
  
Last login: Tue Nov 1 07:38:14 2022  
pxadmin@fast-sfp4:~$
```

```
pxadmin@fast-sfp4: ~  
sri on lugh in /export/nodes/fast  
> pingall bmcs.txt | grep -v sfp5  
fast-sfp1      succeeded  
fast-sfp2      succeeded  
fast-sfp3      --not pingable--  
fast-sfp4      succeeded  
sri on lugh in /export/nodes/fast took 5s  
> ipmitool -H fast-sfp1-bmc -U USERID -P PASSWORD fru | grep Board  
Board Mfg Date      : Wed 24 Aug 2016 11:11:00 PM PDT PDT  
Board Mfg           : Quanta  
Board Product       : Leopard ORV2-DDR4  
Board Serial        : QTF5K063501583  
Board Part Number   : 31F06MB0050  
Board Extra         : 02-000174  
sri on lugh in /export/nodes/fast  
> ipmitool -H fast-sfp2-bmc -U USERID -P PASSWORD fru | grep Board  
Board Mfg Date      : Tue 16 Aug 2016 11:26:00 PM PDT PDT  
Board Mfg           : Quanta  
Board Product       : Leopard ORV2-DDR4  
Board Serial        : QTF5K063302096  
Board Part Number   : 31F06MB0050  
Board Extra         : 02-000174  
sri on lugh in /export/nodes/fast  
> ipmitool -H fast-sfp4-bmc -U USERID -P PASSWORD fru | grep Board  
Board Mfg Date      : Thu 26 May 2016 06:55:00 AM PDT PDT  
Board Mfg           : Quanta  
Board Product       : Leopard ORV2-DDR4  
Board Serial        : QTF5K062202036  
Board Part Number   : 31F06MB0050  
Board Extra         : 02-000174  
sri on lugh in /export/nodes/fast  
>
```

```
sri@fedora:~ -- ssh lugh  
pxadmin@fast-sfp4:~$ lsccsi  
[4:0:0:0] disk ATA KINGSTON SUV500M 56RI /dev/sda  
[5:0:0:0] disk ATA ST4000NC001-1FS1 CN03 /dev/sdb  
pxadmin@fast-sfp4:~$ sudo dmidecode | grep -i Xeon  
Family: Xeon  
Version: Intel(R) Xeon(R) CPU E5-2678 v3 @ 2.50GHz  
Family: Xeon  
Version: Intel(R) Xeon(R) CPU E5-2678 v3 @ 2.50GHz  
pxadmin@fast-sfp4:~$ sudo smartctl -i /dev/sdb  
smartctl 7.1 2019-12-30 r5022 [x86_64-linux-5.4.0-113-generic] (local build)  
Copyright (C) 2002-19, Bruce Allen, Christian Franke, www.smartmontools.org  
  
=== START OF INFORMATION SECTION ===  
Device Model: ST4000NC001-1FS168  
Serial Number: Z304FVY1  
LU WWN Device Id: 5 000c50 07baea106  
Firmware Version: CN03  
User Capacity: 4,000,787,030,016 bytes [4.00 TB]  
Sector Sizes: 512 bytes logical, 4096 bytes physical  
Rotation Rate: 5900 rpm  
Form Factor: 3.5 inches  
Device is: Not in smartctl database [for details use: -P showall]  
ATA Version is: ACS-2, ACS-3 T13/2161-D revision 3b  
SATA Version is: SATA 3.1, 6.0 Gb/s (current: 6.0 Gb/s)  
Local Time is: Tue Nov 1 07:48:48 2022 PDT  
SMART support is: Available - device has SMART capability.  
SMART support is: Enabled  
  
pxadmin@fast-sfp4:~$
```

```
sri on lugh in /export/nodes/fast
> pingall bmcs.txt | grep -v sfp5
fast-sfp1      succeeded
fast-sfp2      succeeded
fast-sfp3      --not pingable--
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Board Part Number   : 31F06MB00S0
Board Extra         : 02-000174
sri on lugh in /export/nodes/fast
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Board Mfg Date      : Tue 16 Aug 2016 11:26:00 PM PDT PDT
Board Mfg           : Quanta
Board Product       : Leopard ORv2-DDR4
Board Serial        : QTF5KQ63302096
Board Part Number   : 31F06MB00S0
Board Extra         : 02-000174
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Board Mfg Date      : Thu 26 May 2016 06:55:00 AM PDT PDT
Board Mfg           : Quanta
Board Product       : Leopard ORv2-DDR4
Board Serial        : QTF5KQ62202036
Board Part Number   : 31F06MB00S0
Board Extra         : 02-000174
sri on lugh in /export/nodes/fast
> □
```



SESAME BY ITRENEW

INTRODUCING
SESAME FAST-START

Top 7 Cool Features



<https://youtu.be/kHLM8h0RV-k>



CIRCULAR ECONOMY – SOFTWARE

- near metal open source toolchains like coreboot, linuxboot, u-root keep machines in the market longer with community support
- open hardware can be re-designed, re-purposed for new uses like modular datacenter, edge computing at near-neutral carbon cost and lower TCO than new hardware
- open hardware doesn't just mean servers, but also switches
- augments software projects like LF's OpenSwitch [\[https://www.openswitch.net/\]](https://www.openswitch.net/)
- any software project that supports using off the shelf parts to build open infrastructure can leverage the supply chain provided by the circular economy

SUMMARY

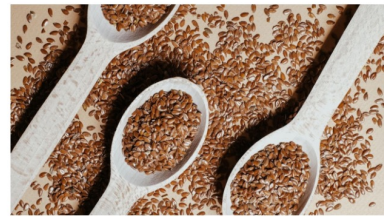
YES – improve the software toolchain and open source projects so that hardware is used at high utilization and high efficiency via efforts such as the Green Software Foundation

YES – leverage the supply chain and circular economy to benefit from open hardware and reduced carbon of recertified equipment

YES – adapt your infrastructure with open hardware and open source software – e.g. SONiC, openswitch, kubernetes, OpenBMC

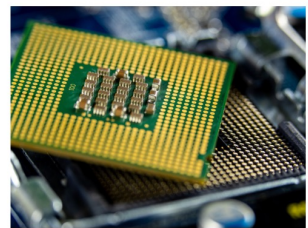
YES – find ways to re-use the output of your on-premise cloud or datacenter

Flax Computing



thank you for visiting us here

read about our key approaches to [Decarbonization](#) and improved [Efficiency](#) in your data centers worldwide, using the data-driven [FlaxPoints](#) methodology
contact us via info@flaxcomputing.com or using our [Contact](#) form



Decarbonization & Efficiency

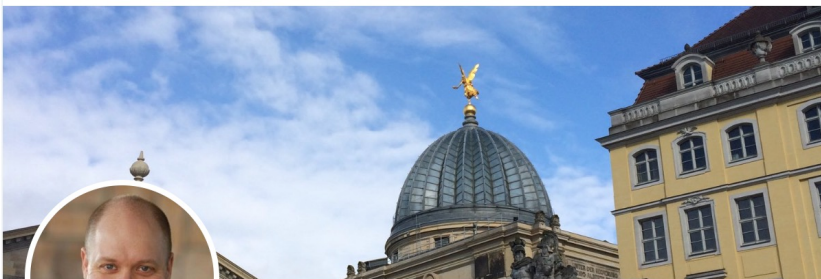
• www.flaxcomputing.com



SUSTAINABILITY ALL THE WAY DOWN

Sustainability all the way down – means we don't just consider software but explore everything below it as well

If you have a sustainability program at your company – leverage open communities to navigate the cross-silo collaboration required to support open sustainable infrastructure as well as open code



Follow

Dr. Erik Riedel at #AllThingsOpen

@er1p

i build sustainable clouds; father of four; PhD; engineering leader, do-er, & mentor; practitioner of innovation & inclusion; he/him; my heart is in the work

Science & Technology Boston, MA [linkedin.com/in/er1p](https://www.linkedin.com/in/er1p)
 Joined January 2008

5,001 Following 3,009 Followers

Erik Riedel, PhD, Chief Engineering Officer, Flax Computing
Twitter: @er1p, @RiedelAtWork email: erik @ flaxcomputing.com

Sriram (Sri) Ramkrishna, OneAPI Community Manager, Intel
Twitter: @sramkrishna, email: sriram.ramkrishna @ intel.com



Follow

absurdum expectum - embrace it

@sramkrishna

Follow for politics, velociraptors, and FOSS. Looking for my next adventure. FOSS communities, liasoning and influence is my jam! Hit me up in my DMs!

Oregon, USA Joined September 2007

1,931 Following 1,802 Followers



**ALL
THINGS
OPEN 20
22**

®

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THINGS
OPEN 20
22**

ACKNOWLEDGEMENTS

Photo acknowledgement and thanks:

<https://unsplash.com/photos/K5KmnZHv1Pg>

<https://unsplash.com/photos/rmzQwpKt4XM>

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BACKUP SLIDES



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