# UXL Software Stack & RISC-V Exploration

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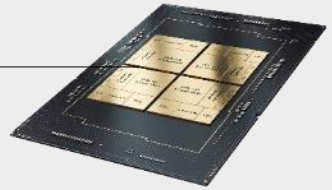
# Agenda

- Introduction of oneAPI and UXL
- UXL Software Stack & RISC-V Support
- Codeplay oneAPI Construction Kit

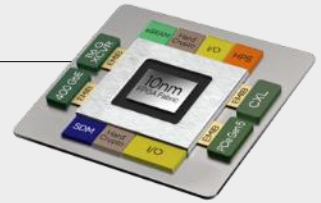
# Solving the Challenge of Diverse Hardware Acceleration

CPU



GPU

FPGA



Other Accelerators

48% of developers target heterogeneous systems that use more than one kind of processor or core[1]

Developer Challenges: Multiple Architectures, Vendors, and Programming Models

oneAPI

Open, Standards-based, Multiarchitecture Programming

Video: What is oneAPI? Overview & Benefits

*1. Evans Data Global Development Survey Report 23.1*

# oneAPI

## Specification and Open Source

Open industry initiative driving a vendor-neutral software ecosystem for multiarchitecture accelerated computing.

Now governed by the Linux Foundation.

UXL Unified Acceleration Foundation

### Freedom to Make Your Best Choice

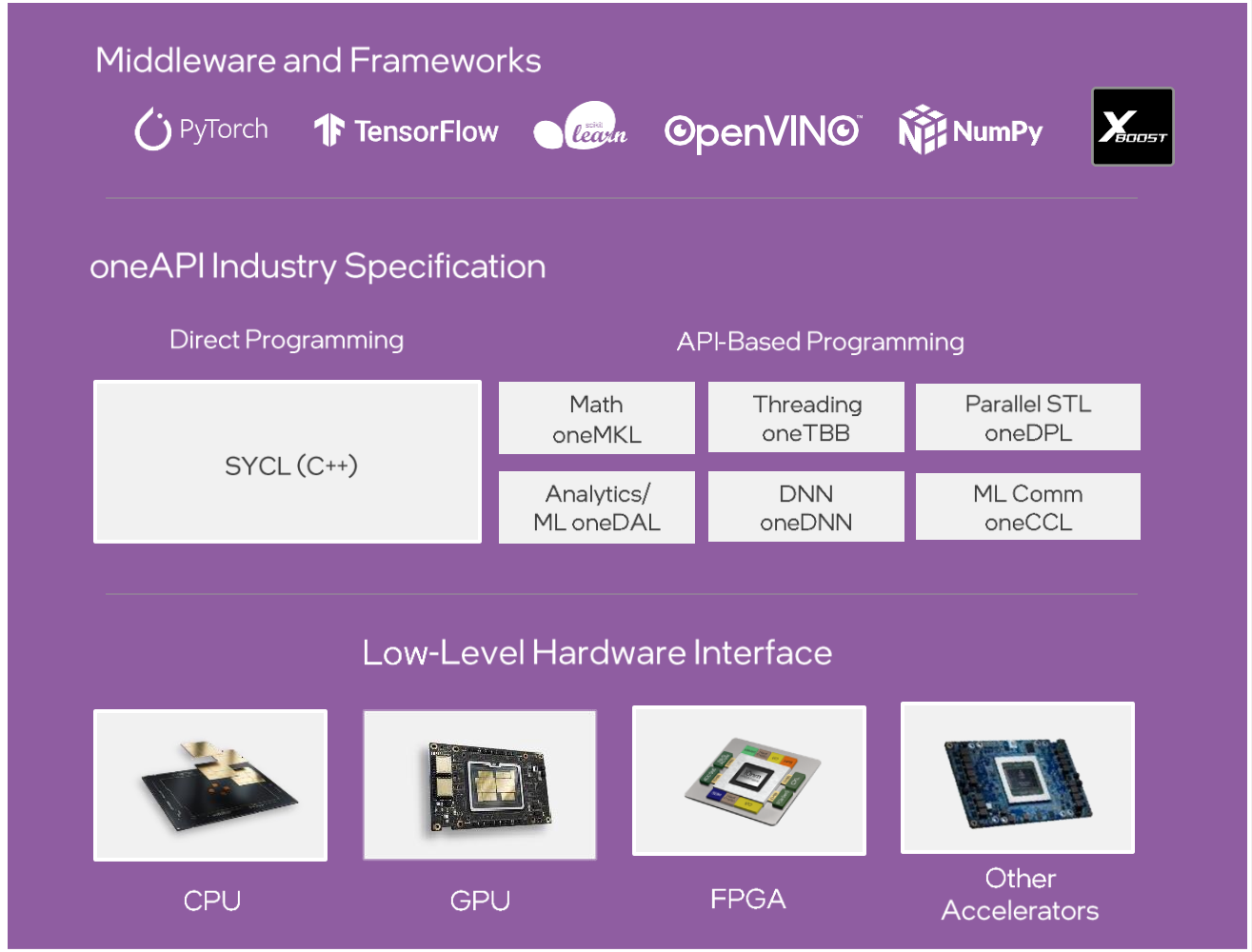
- An open alternative to single-vendor/proprietary lock-in enables easy architecture retargeting
- Open, standards-based programming (C++ with SYCL) so software investments continue to add value in future hardware generations

### Performance – Realize All the Hardware Value

- Expose and exploit all the cutting-edge features and maximize performance across CPUs, GPUs, FPGAs, and other accelerators.
- Powerful libraries for acceleration of domain-specific functions

### Productivity – Develop Performant Code Quickly

- One programming model for all – easy integration with existing code including migration of CUDA code to SYCL
- Based on familiar C++ – no need to learn a new language
- Interoperable with existing HPC standards including Fortran, C/C++, OpenMP, and MPI, as well as Python with a rich set of optimized Python libraries




Visit oneapi.io or https://uxlfoundation.org/ for more details

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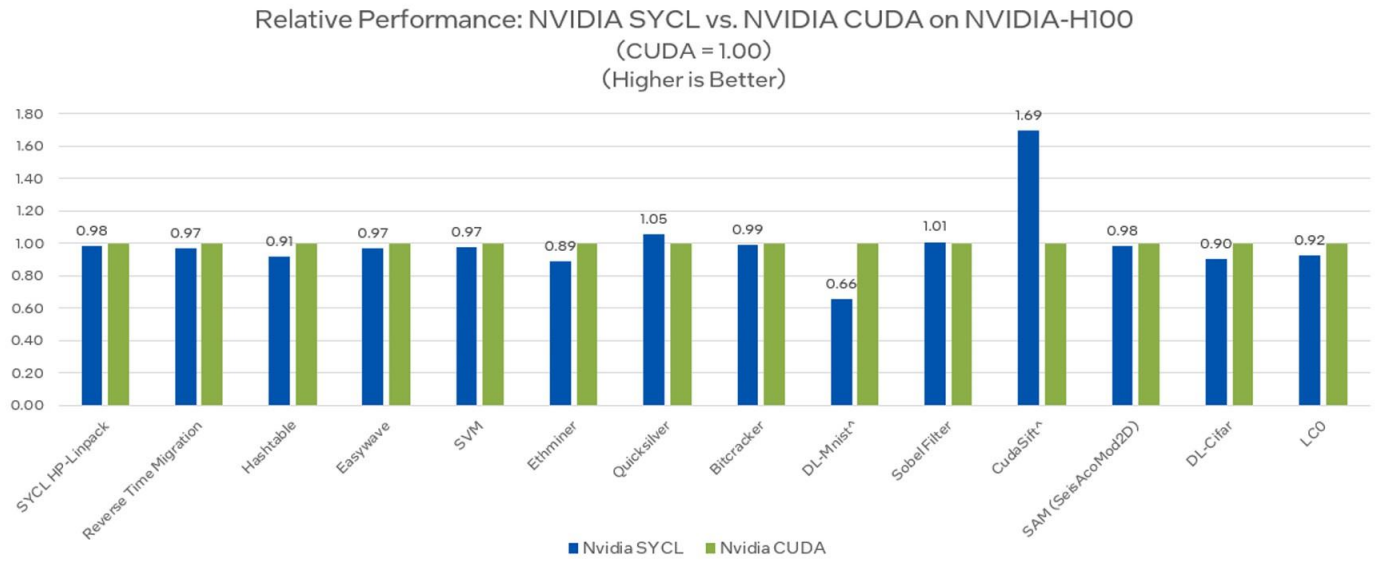
# Accelerating Choice with SYCL*

## Khronos Group Standard

- Open, standards-based
- Multiarchitecture performance
- Freedom from vendor lock-in
- Comparable performance to native CUDA on Nvidia GPUs
- Extension of widely used C++ language
- Speed code migration via Intel® DPC++ Compatibility Tool or open source SYCLomatic

## On NVIDIA GPU – SYCL Provides Comparable Performance to CUDA




**Testing Date:** Performance results are based on testing by Intel as of **August 1, 2023** and may not reflect all publicly available updates.

**Configuration Details and Workload Setup:** Intel® Xeon® Platinum 8360Y CPU @ 2.4GHz, 2 socket, Hyper Thread On, Turbo On, 256GB Hynix DDR4-3200, ucode 0xd000389, GPU: Nvidia H100 PCIe 80GB GPU memory. Software: Velocity Bench benchmark suite branch from 8/1/23. SYCL open source/CLANG 17.0.0, CUDA SDK 12.0 with NVIDIA-NVCC 12.0.76, cuMath 12.0, cuDNN 12.0, Ubuntu 22.04.1. SYCL open source/CLANG compiler switches: -fsycl-targets=nvptx64-nvidia-cuda -Xsycl-target-backend --cuda-gpu-arch=sm_90, NVIDIA NVCC compiler switches: -O3 –gencode arch=compute_90, code=sm_90. Represented workloads with Intel optimizations.

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See configuration disclosure for details. No product or component can be absolutely secure.

Performance varies by use, configuration, and other factors. Learn more at www.Intel.com/PerformanceIndex. Your costs and results may vary

| Architectures | Intel \| Nvidia \| AMD CPU & GPU \| RISC-V \| ARM Mali \| PowerVR \| Xilinx |
|---|---|

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# Commitment to Open, Scalable Acceleration

## Freeing the Developer Ecosystem from the Chains of Proprietary Software

UXL
Unified Acceleration Foundation

Linux Foundation governed open industry foundation driving a vendor-neutral software ecosystem for multiarchitecture accelerated computing

Founding Members: ARM, Fujitsu, Google Cloud, Imagination Tech, Intel, Qualcomm, Samsung, VMware

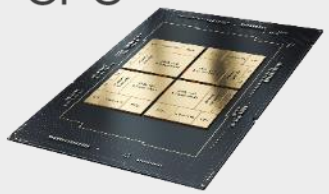
oneAPI Specification (oneAPI.io) is the starting point

oneAPI

Open, Standards-based, Multiarchitecture Programming

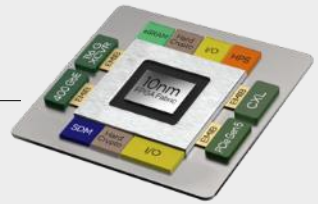
Performance | Productivity | Freedom from Vendor Lock-In

CPU



GPU

FPGA



Other Accelerators


Open initiative and community to build a multiarchitecture, multivendor accelerator software ecosystem.

Now governed by the Linux Foundation.

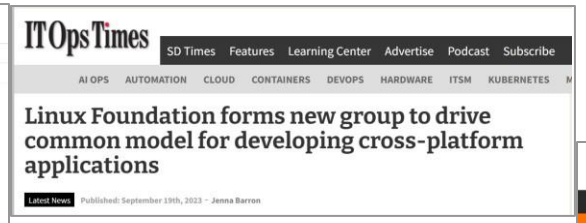

Initiative & Technology Advancements

| 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|
| Regular Cadence of Specification Updates | | | |
| oneAPI SYCL* implementation<br><br>Intel CPU, GPU, FPGA support<br><br>SYCL for Nvidia GPU<br><br>**PyTorch** accelerates models via oneDNN | **Fugaku** deploys oneDNN for Arm<br><br>**Univ. of Heidelberg** deploys SYCL for AMD CPUs & GPUs<br><br>**NERSC, Argonne** deploy SYCL for NVIDIA GPU<br><br>**Argonne, Oakridge Nat'l Labs deploy** SYCL for AMD GPU<br><br>Huawei CCE & Ascend uses oneAPI | **NVIDIA GPU, AMD CPU & GPU, Arm CPU**<br><br>**GROMACS** SYCL code on Intel CPUs/GPUs, NVIDIA & AMD GPUs<br><br>**oneAPI** community forum & open governance established<br><br>**Julia** interface to oneAPI<br><br>**TensorFlow** accelerates models via oneDNN<br><br>**SYCL performance** matches NVIDIA/AMD native system languages | **Codeplay oneAPI plug-ins** for NVIDIA & AMD<br><br>**Linux Foundation announces** Unified Acceleration Foundation, starting with oneAPI Spec<br><br>Founding Members: ARM, Fujitsu, Google Cloud, Imagination Tech, Intel, Qualcomm, Samsung, VMware |

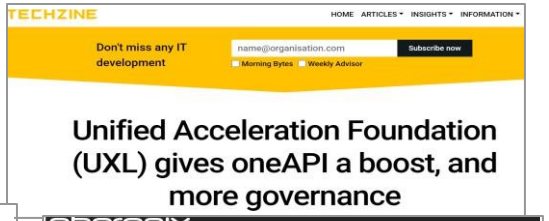
# Unified Acceleration (UXL) Foundation

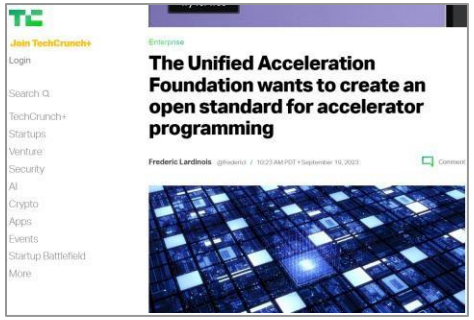
## Announced September 19, 2023

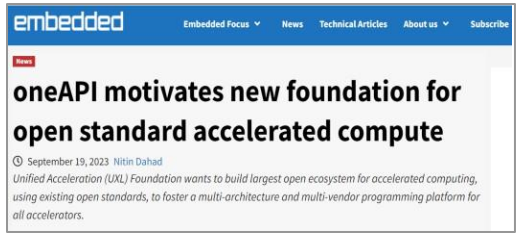
UXL
Unified Acceleration Foundation

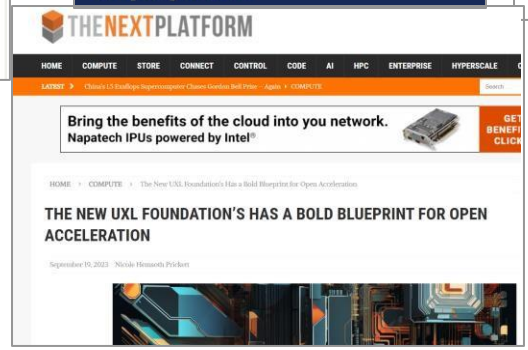



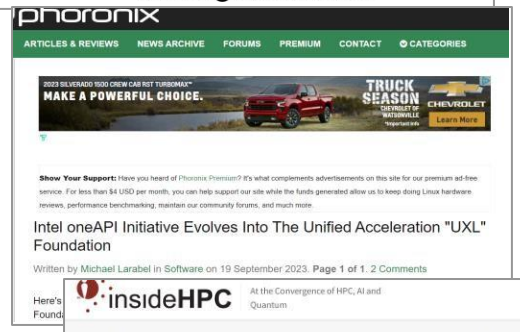


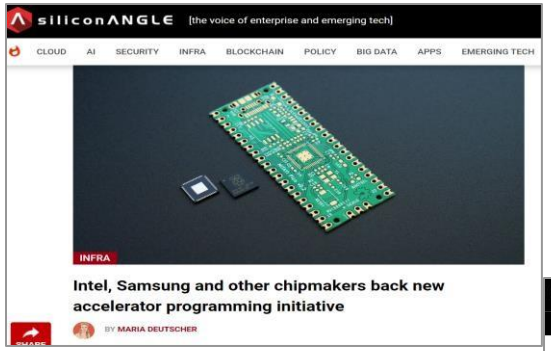


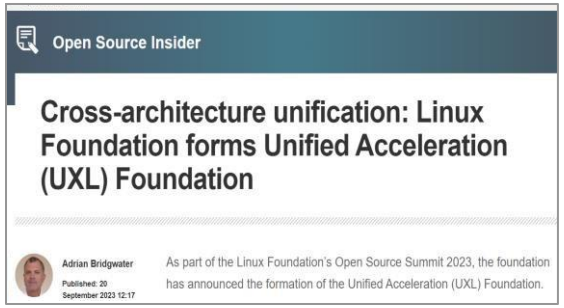



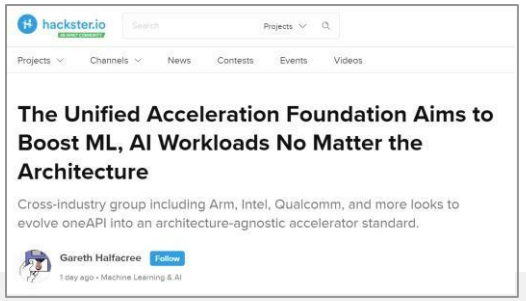











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# Unified Acceleration (UXL) Foundation

Building a multiarchitecture, multivendor accelerator software ecosystem

UXL
Unified Acceleration Foundation

- Governance: Linux Foundation's Joint Development Foundation
- Mission: Unify the heterogeneous compute ecosystem around open standards
- Starting point: oneAPI Specification (oneAPI.io)
- Goal: broad-based industry participation and contributions
- SIGs: AI, Hardware, Language, Math, Safety Critical
- Join Us: Participate in SIGs
  - www.UXLFoundation.org

## Steering Members

arm FUJITSU Google Cloud Imagination
intel Qualcomm SAMSUNG vmware

## UXL Foundation Structure

# Unified Acceleration (UXL) Foundation

[UXL Foundation Webinar]

# Unified Acceleration (UXL) Foundation

[UXL Foundation Webinar]

# UXL Extension to RISC-V

oneAPI

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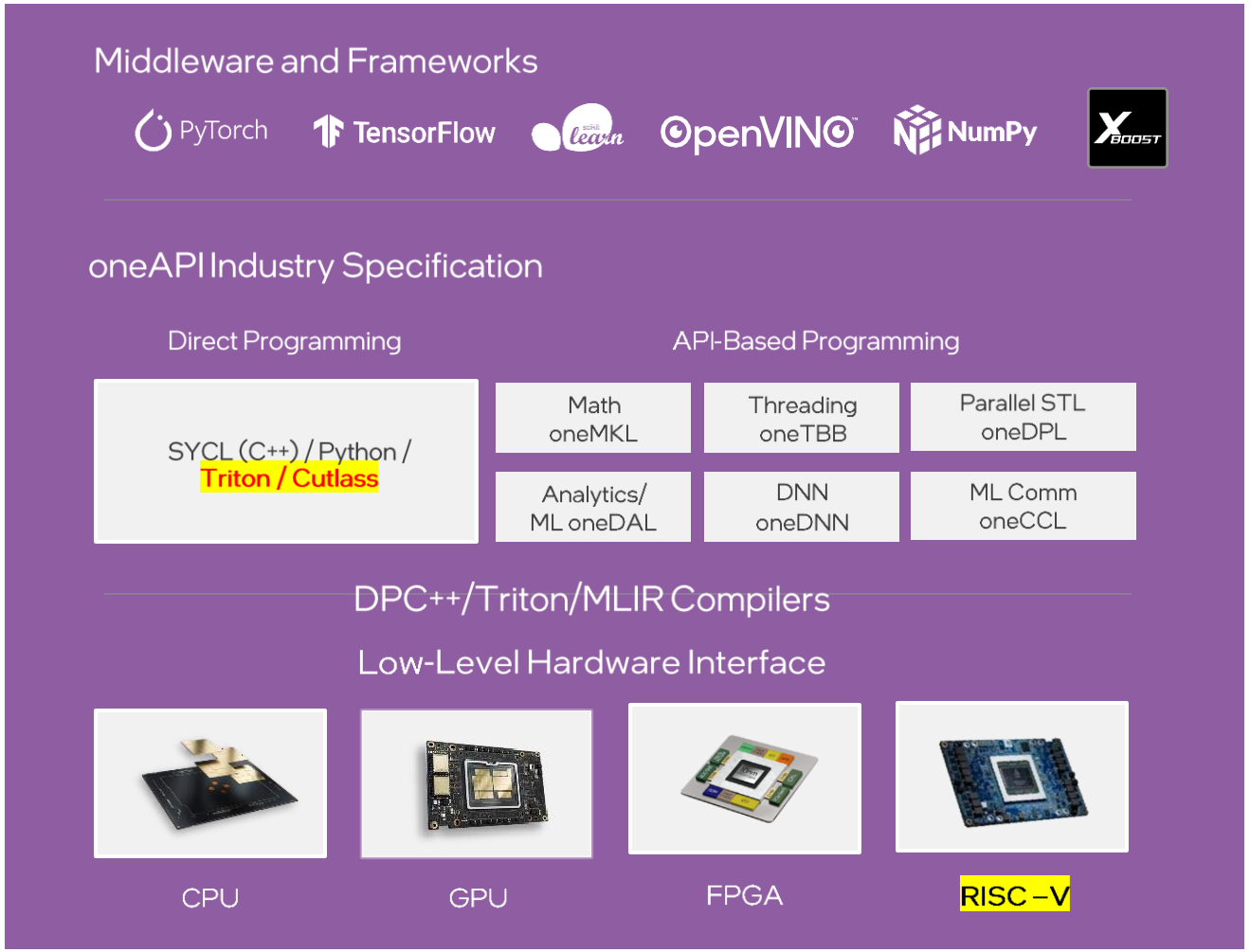
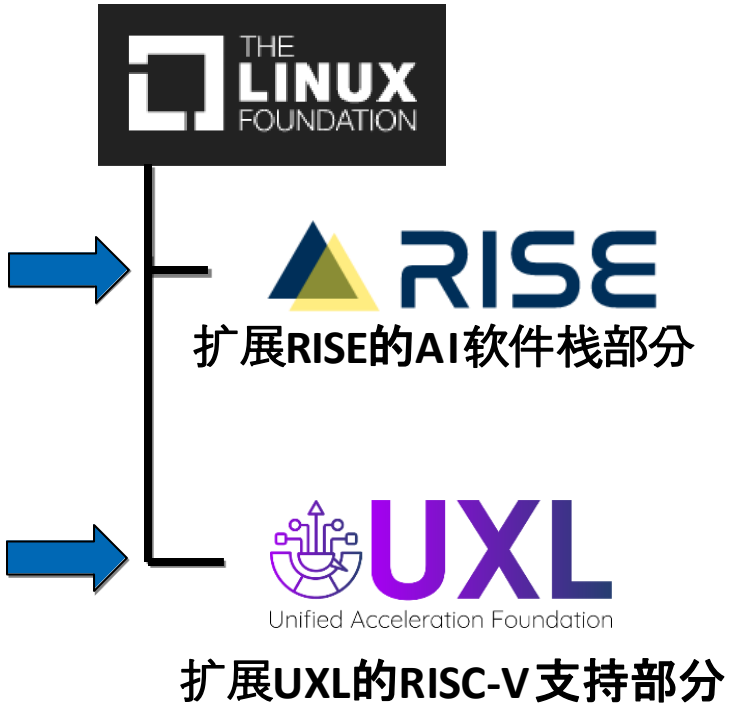
UXL Unified Acceleration Foundation




Visit oneapi.io or https://uxlfoundation.org/ for more details

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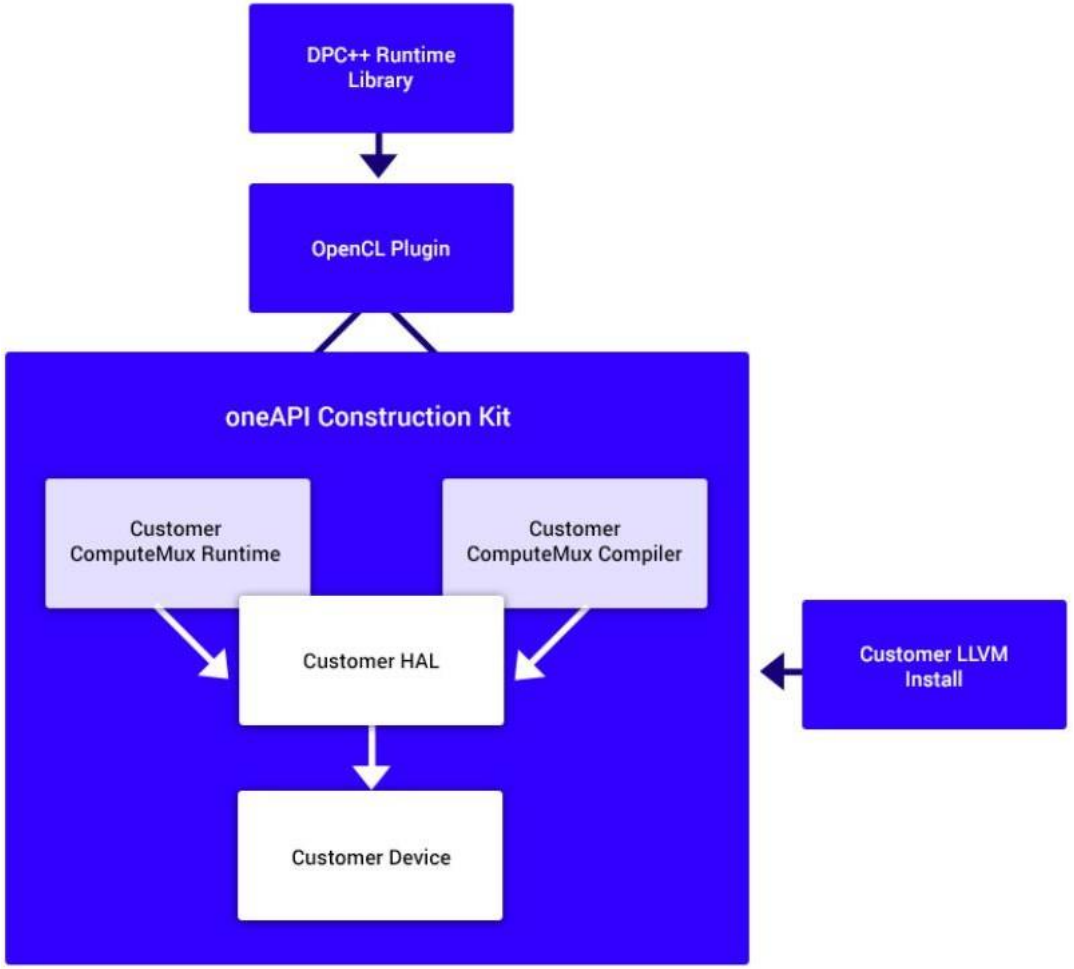
# Codeplay oneAPI Construction Kit




- Codeplay has an experimental project as oneAPI Construction Kit
- Bring oneAPI to new accelerator processor arch, e.g. RISC-V
- A customer target includes:
  - Runtime code
  - Compiler code
  - An optional HAL
- A blog to introduce: https://www.oneapi.io/blog/introducing-the-oneapi-construction-kit/
- Document: https://developer.codeplay.com/products/oneapi/construction-kit/guides/
- A real case: https://www.oneapi.io/blog/using-oneapi-construction-kit-to-enable-open-standards-programming-for-the-metis-aipu/

Welcome to join us to explore UXL and RISC-V journey!

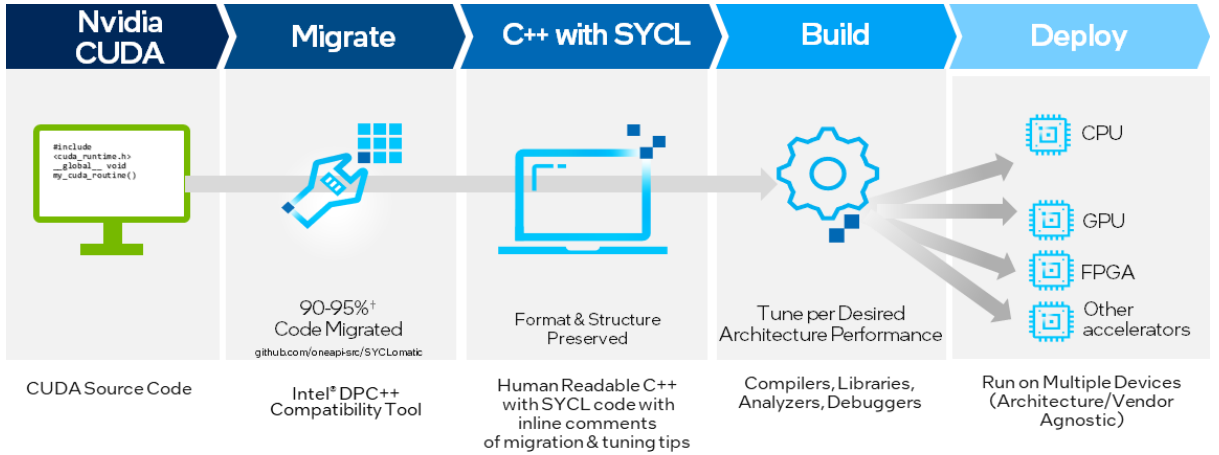
# Backup

# Migrate from CUDA* to C++ with SYCL*

Stop writing and maintaining different codebases for different architectures

CUDA to SYCL Migration Portal

- Choose your accelerated computing hardware and reuse code with performance portability
- Single C++ with SYCL codebase can run on accelerators with multiple architectures from multiple vendors
- Intel ®DPC++ Compatibility Tool & Open Source SYCLomatic automatically migrates ~90-95%* of a typical CUDA app to SYCL
- Generates helpful comments to guide you to finish migration and tune performance
- Visit the CUDA to SYCL Migration Portal for tutorials, best practices, code samples, apps catalog, and community support




## Migration Success Examples:

Argonne NATIONAL LABORATORY · THE UNIVERSITY OF TENNESSEE KNOXVILLE · Arcvideo · blender · inesc id lisboa · IST TÉCNICO LISBOA · FAST. FLEXIBLE. FREE. GROMACS · Stockholm University · KTH · BittWare a molex company · THE UNIVERSITY OF UTAH · OLD DOMINION UNIVERSITY · SAMSUNG MEDISON · ZUSE INSTITUTE BERLIN

[1]Intel estimates as of March 2023. Based on measurements on a set of 85 HPC benchmarks and samples, with examples like Rodinia, SHOC, PENNANT. Results may vary.
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# oneAPI Plug-ins for Nvidia* & AMD*

Codeplay Support for Nvidia & AMD GPUs to Intel® oneAPI Base Toolkit

## oneAPI for NVIDIA & AMD GPUs

- Free download of binary plugins to Intel® oneAPI DPC++/C++ Compiler:
- Nvidia GPU
- AMD beta GPU
- No need to build from source!
- Plug-ins updated quarterly in-sync with SYCL 2020 conformance & performance

## Priority Support

- Available through Intel, Codeplay & our channel
- Requires Intel Priority Support for Intel oneAPI DPC++/C++ Compiler
- Intel takes first call, Codeplay delivers backend support
- Codeplay provides access to older plug-in versions

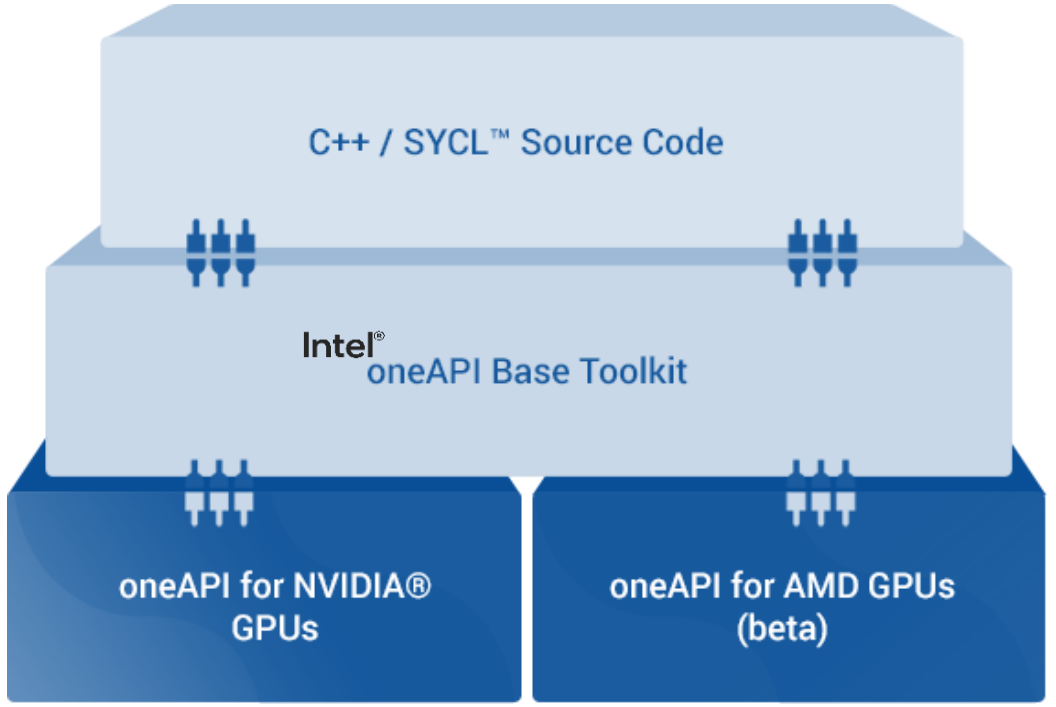


Image courtesy of Codeplay Software Ltd.

Nvidia GPU plug-in

AMD GPU plug-in

Codeplay blog

Codeplay press release

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# oneAPI Industry Momentum

## End Users

archanan · FOUNDRY MODO · BioDataAnalysis GmbH GeoEast · BENTLEY · CINESITE · LAIKA · Accrad Accelerated Radiology · GE · kt · AUTODESK ARNOLD · 中国石油集团东方地球物理勘探有限责任公司 BGP INC.,CHINA NATIONAL PETROLEUM CORPORATION · iOmniscient Autonomous · EURECOM · Brightskies · PHILIPS · WeBank · 大势智慧 DASPATIAL · SAMSUNG MEDISON · TANGENT ANIMATION · allegro.ai · ILLUMINATION MACGUFF · Verizon · MediaKind

## National Labs

Argonne NATIONAL LABORATORY · UT-BATTELLE Oak Ridge National Laboratory · CERN openlab · CINECA · Peraton Labs · Laboratório Nacional de Computação Científica · Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities · SANKHYA SUTRA LABS

## ISVs & OSVs

codeplay · CANONICAL · CERTIFACE · ANACONDA · Ansys · MAX PLANCK COMPUTING & DATA FACILITY · MPCDF · AI SINGAPORE · sas · Red Hat OpenShift Data Science · KATANA GRAPH · CGG · AIBLE · CHAOSGROUP · MAXON · Ospirent · FOUNDRY · mercenaries engineering Guerilla · Hisense Medical 海信医疗 · SENAI CIMATEC · FIEB · SAP · E4 COMPUTER ENGINEERING · YUAN · GIGASPACES innovate with confidence · MEGH COMPUTING · KFBIO · Tech Mahindra · AsiaInfo 亚信科技 · SUSE · vmware · UNITED IMAGING

## OEMs & SIs

BittWare a molex company · Hewlett Packard Enterprise · DELL Technologies · Atos · Lenovo · HCL · rENIAC · MEGWARE SUPERCOMPUTING · TECHNOLOGY

## Universities & Research Institutes

LOBACHEVSKY UNIVERSITY · TECHNION Israel Institute of Technology · UNIVERSITY OF CAMBRIDGE · ICT 中国科学院计算技术研究所 INSTITUTE OF COMPUTING TECHNOLOGY, CHINESE ACADEMY OF SCIENCES · Ben-Gurion University of the Negev · Berkeley UNIVERSITY OF CALIFORNIA · UCDAVIS UNIVERSITY OF CALIFORNIA · THE UNIVERSITY OF TENNESSEE KNOXVILLE · UNIVERSIDAD COMPLUTENSE MADRID · OLD DOMINION UNIVERSITY · 北京大学软件与微电子学院 School of Software & Microelectronics · THE UNIVERSITY OF UTAH · UNIVERSITY OF OREGON · TÉCNICO LISBOA · inesc id lisboa · ILLINOIS · ZIB · PURDUE UNIVERSITY Elmore Family School of Electrical and Computer Engineering · FACULTY OF MATHEMATICS AND PHYSICS Charles University · University College London · Durham University · University of Stuttgart Germany · IIT GOA · Indian Institutes of Technology Delhi / Kharagpur / Roorkee · SDSC SAN DIEGO SUPERCOMPUTER CENTER · CDAC · UKRI Science and Technology Facilities Council Scientific Computing · ATLAS EXPERIMENT · TACC · Indian Institute of Science Bangalore · IISER PUNE Indian Institute of Science Education & Research Pune · UNIVERSIDAD DE MÁLAGA · HEIDELBERG UNIVERSITY COMPUTING CENTRE · Northern Illinois University · University of BRISTOL · Stockholm University · KTH

## CSPs & Frameworks

Microsoft Azure · Alibaba Cloud · Google Cloud · TensorFlow · Taboola · Tencent 腾讯 · DataRobot · Baidu 百度 · 飞桨 PaddlePaddle · QCT · NAVER CLOVA · PyTorch

These organizations support the oneAPI initiative for a single, unified programming model for cross-architecture development.
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