Overview of ROCm and Compilers

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together we advance_

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Agenda

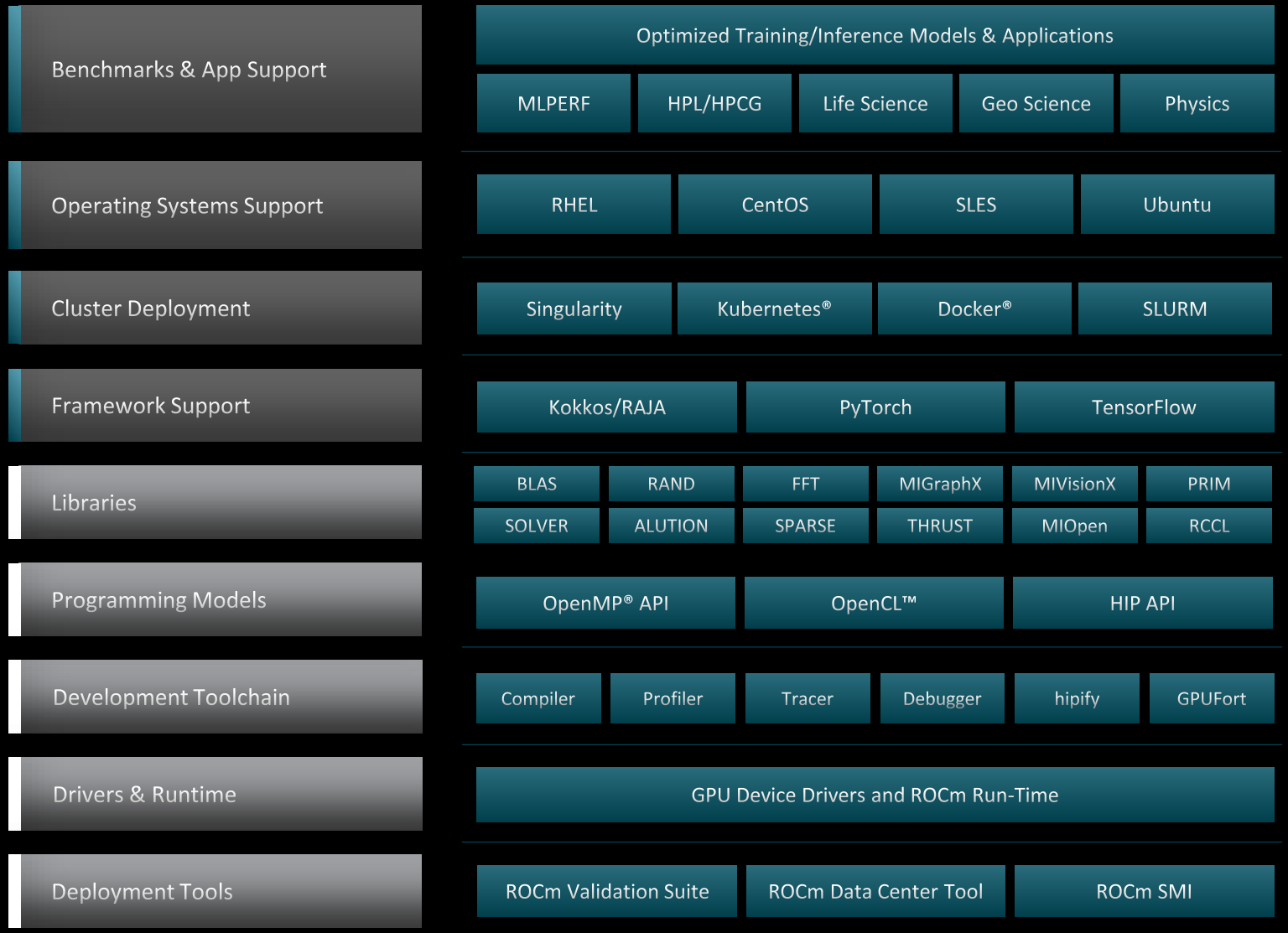
1. ROCm Software Ecosystem
2. Compilers for AMD GPUs

2. ROCm Software Ecosystem

Open Software Platform For GPU Compute

AMD ROCm

- Unlocked GPU Power To Accelerate Computational Tasks
- Optimized for HPC and Deep Learning Workloads at Scale
- Open Source Enabling Innovation, Differentiation, and Collaboration



AMD ROCm 5.0

DEMOCRATIZING EXASCALE FOR ALL

EXPANDING SUPPORT & ACCESS

- Support for Radeon Pro W6800 Workstation GPUs
- Remote access through the AMD Accelerator Cloud

OPTIMIZING PERFORMANCE

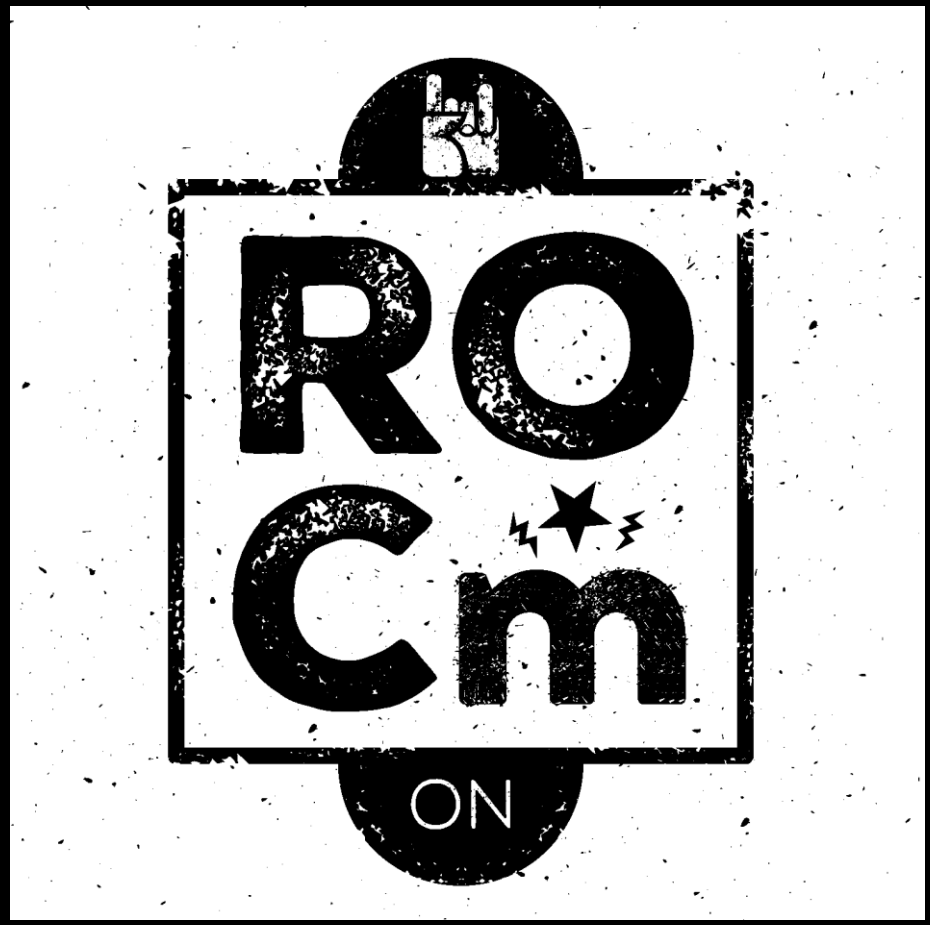
- MI200 Optimizations: FP64 Matrix ops, Improved Cache
- Improved launch latency and kernel performance

ENABLING DEVELOPER SUCCESS

- HPC Apps & ML Frameworks on AMD InfinityHub
- Streamlined and improved tools increasing productivity

ROCm Software Ecosystem

- **H**eterogeneous-compute **I**nterface for **P**ortability (HIP) is part of a larger software distribution called ROCm
- Install instructions and documentation:
  - https://rocm.docs.amd.com/en/latest/deploy/linux/quick_start.html
  - https://gpuopen.com/learn/amd-lab-notes/amd-lab-notes-rocm-installation-readme/
- The ROCm package provides libraries and programming tools for developing HPC and ML applications on AMD GPUs
- All the ROCm environment and the libraries are provided from the supercomputer, usually, there is no need to install something yourselves
- Heterogeneous System Architecture (HSA) runtime is an API that exposes the necessary interfaces to access and interact with the hardware driven by AMDGPU driver



ROCm GPU Libraries

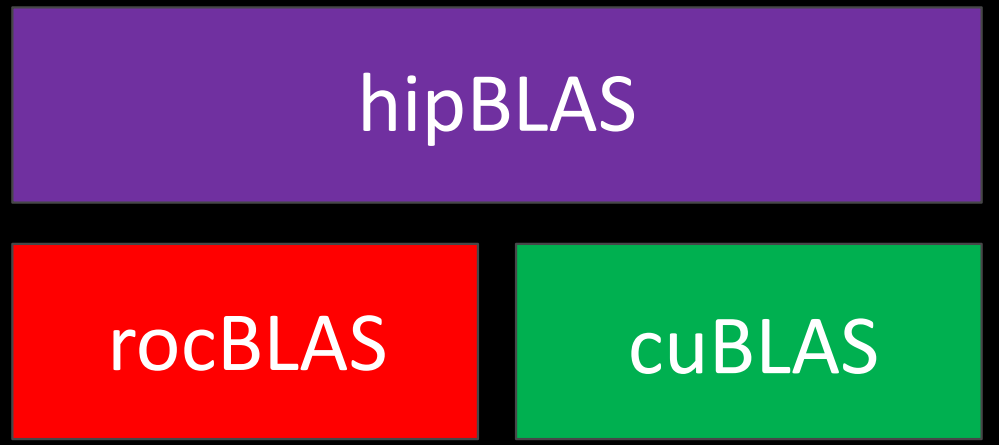
ROCm provides several GPU math libraries

- Typically, two versions:
  - roc* -> AMD GPU library, usually written in HIP
  - hip* -> Thin interface between roc* and Nvidia cu* library

When developing an application meant to target both CUDA and AMD devices, use the hip* libraries (portability)

When developing an application meant to target only AMD devices, may prefer the roc* library API (performance).

- Some roc* libraries perform **better** by using addition APIs not available in the cu* equivalents



AMD Math Library Equivalents: “Decoder Ring”

CUBLAS	**ROCBLAS**	Basic Linear Algebra Subroutines
CUFFT	**ROCFFT**	Fast Fourier Transforms
CURAND	**ROCRAND**	Random Number Generation
THRUST	**ROCTHRUST**	C++ Parallel Algorithms
CUB	**ROCPRIM**	Optimized Parallel Primitives

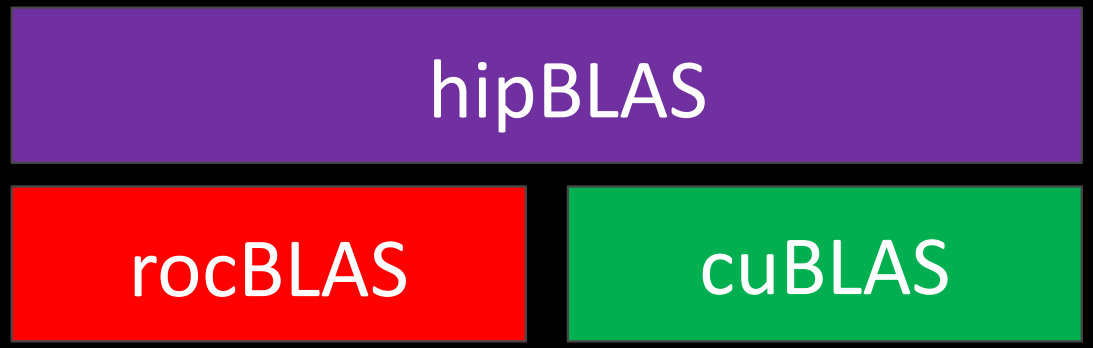
AMD Math Library Equivalents: “Decoder Ring”

CUSPARSE	**ROCSPARSE**	Sparse BLAS, SpMV, etc.
CUSOLVER	**ROCSOLVER**	Linear Solvers
AMGX	**ROCALUTION**	Solvers and preconditioners for sparse linear systems

GITHUB.COM/ROCM-DEVELOPER-TOOLS/HIP → HIP_PORTING_GUIDE.MD FOR A COMPLETE LIST

AMD GPU Libraries: BLAS

- rocBLAS – `sudo apt install rocblas`
  - Source code: https://github.com/ROCmSoftwarePlatform/rocBLAS
  - Documentation: https://rocblas.readthedocs.io/en/latest/
  - Basic linear algebra functionality
    - axpy, gemv, trsm, etc
  - Use hipBLAS if you need portability between AMD and NVIDIA devices
- hipBLAS - `sudo apt install hipblas`
  - Documentation: https://github.com/ROCmSoftwarePlatform/hipBLAS/wiki/Exported-functions
  - Use this if you need portability between AMD and NVIDIA
  - It is just a thin wrapper:
    - It can dispatch calls to rocBLAS for AMD devices
    - It can dispatch calls to cuBLAS for NVIDIA devices



AMD GPU Libraries: rocBLAS example

- rocBLAS
  - Documentation: https://rocblas.readthedocs.io/en/latest/
  - Level 1, 2, and 3 functionality
    - axpy, gemv, trsm, etc
  - Note: rocBLAS syntax matches BLAS closer than hipBLAS or cuBLAS
    - Use hipBLAS only if you need portability between AMD and NVIDIA devices
  - Link with: `-lrocblas`

```
#include <rocblas.h>

int main(int argc, char ** argv) {
  rocblas_int N = 500000;

  // Allocate device memory
  double * dx, * dy;
  hipMalloc(&dx, sizeof(double) * N);
  hipMalloc(&dy, sizeof(double) * N);

  // Allocate host memory (and fill up the arrays) here
  std::vector<double> hx(N), hy(N);

  // Copy host arrays to device
  hipMemcpy(dx, hx.data(), sizeof(double) * N, hipMemcpyHostToDevice);
  hipMemcpy(dy, hy.data(), sizeof(double) * N, hipMemcpyHostToDevice);

  const double alpha = 1.0;
  rocblas_handle handle;
  rocblas_create_handle(&handle);
  rocblas_status status;
  status = rocblas_daxpy(handle, N, &alpha, dx, 1, dy, 1);
  rocblas_destroy_handle(handle);

  // Copy result back to host
  hipMemcpy(hy.data(), dy, sizeof(double) * N, hipMemcpyDeviceToHost);
  hipFree(dx);
  hipFree(dy);
  return 0;
}
```

Some Links to Key Libraries

- BLAS
  - rocBLAS (https://github.com/ROCmSoftwarePlatform/rocBLAS)
  - hipBLAS (https://github.com/ROCmSoftwarePlatform/hipBLAS)
- FFTs
  - rocFFT (https://github.com/ROCmSoftwarePlatform/rocFFT)
  - hipFFT (https://github.com/ROCmSoftwarePlatform/hipFFT)
- Random number generation
  - rocRAND (https://github.com/ROCmSoftwarePlatform/rocRAND)
- Sparse linear algebra
  - rocSPARSE (https://github.com/ROCmSoftwarePlatform/rocSPARSE)
  - hipSPARSE (https://github.com/ROCmSoftwarePlatform/hipSPARSE)
- Iterative solvers
  - rocALUTION (https://github.com/ROCmSoftwarePlatform/rocALUTION)
- Parallel primitives
  - rocPRIM (https://github.com/ROCmSoftwarePlatform/rocPRIM)
  - hipCUB (https://github.com/ROCmSoftwarePlatform/hipCUB)

AMD Machine Learning Library Support

Machine Learning Frameworks:

- Tensorflow: https://github.com/ROCmSoftwarePlatform/tensorflow-upstream
- Pytorch: https://github.com/ROCmSoftwarePlatform/pytorch
- Caffe: https://github.com/ROCmSoftwarePlatform/hipCaffe

Machine Learning Libraries:

- MIOpen (similar to cuDNN): https://github.com/ROCmSoftwarePlatform/MIOpen
- Tensile (GEMM Autotuner): https://github.com/ROCmSoftwarePlatform/Tensile
- RCCL (ROCm analogue of NCCL): https://github.com/ROCmSoftwarePlatform/rccl
- Horovod (Distributed ML): https://github.com/ROCmSoftwarePlatform/horovod

Benchmarks:

- DeepBench: https://github.com/ROCmSoftwarePlatform/DeepBench
- MLPerf: https://mlperf.org

Usage of hipcc

Usage is straightforward. Accepts all/any flags that clang accepts, e.g.,

```
hipcc --offload-arch=gfx90a dotprod.cpp -o dotprod
```

Set HIPCC_VERBOSE=7 to see a bunch of useful information

- Compile and link lines
- Various paths

```
$ HIPCC_VERBOSE=7 hipcc --offload-arch=gfx90a dotprod.cpp -o dotprod
HIP_PATH=/opt/rocm-5.2.0
HIP_PLATFORM=amd
HIP_COMPILER=clang
HIP_RUNTIME=rocclr
ROCM_PATH=/opt/rocm-5.2.0
...
hipcc-args: --offload-arch=gfx90a dotprod.cpp -o dotprod
hipcc-cmd: /opt/rocm-5.2.0/llvm/bin/clang++ -stdc=c++11 -hc  -D__HIPCC__ -isystem /opt/rocm-
5.2.0/llvm/lib/clang/14.0.0/include
-isystem /opt/rocm-5.2.0/has/include -isystem /opt/rocm-5.2.0/include –offload-arch=gfx90a –O3 ...
```

- You can use also *`hipcc -v`* … to print some information
- With the command *`hipconfig`* you can see many information about environment variables declaration

OpenMP Offload GPU Support

- ROCm and AOMP
  - ROCm supports both HIP and OpenMP
  - AOMP: the AMD OpenMP research compiler, it is used to prototype the new OpenMP features for ROCm
- HPE Compilers
  - Provides offloading support to AMD GPUs, through OpenMP, HIP, and OpenACC (only for Fortran)
- GNU compilers:
  - Provide OpenMP and OpenACC offloading support for AMD GPUs
  - GCC 11: Supports AMD GCN gfx908
  - GCC 13: Supports AMD GCN gfx90a

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