Huawei ARM HPC Software Update

The 2nd R-CCS International Symposium

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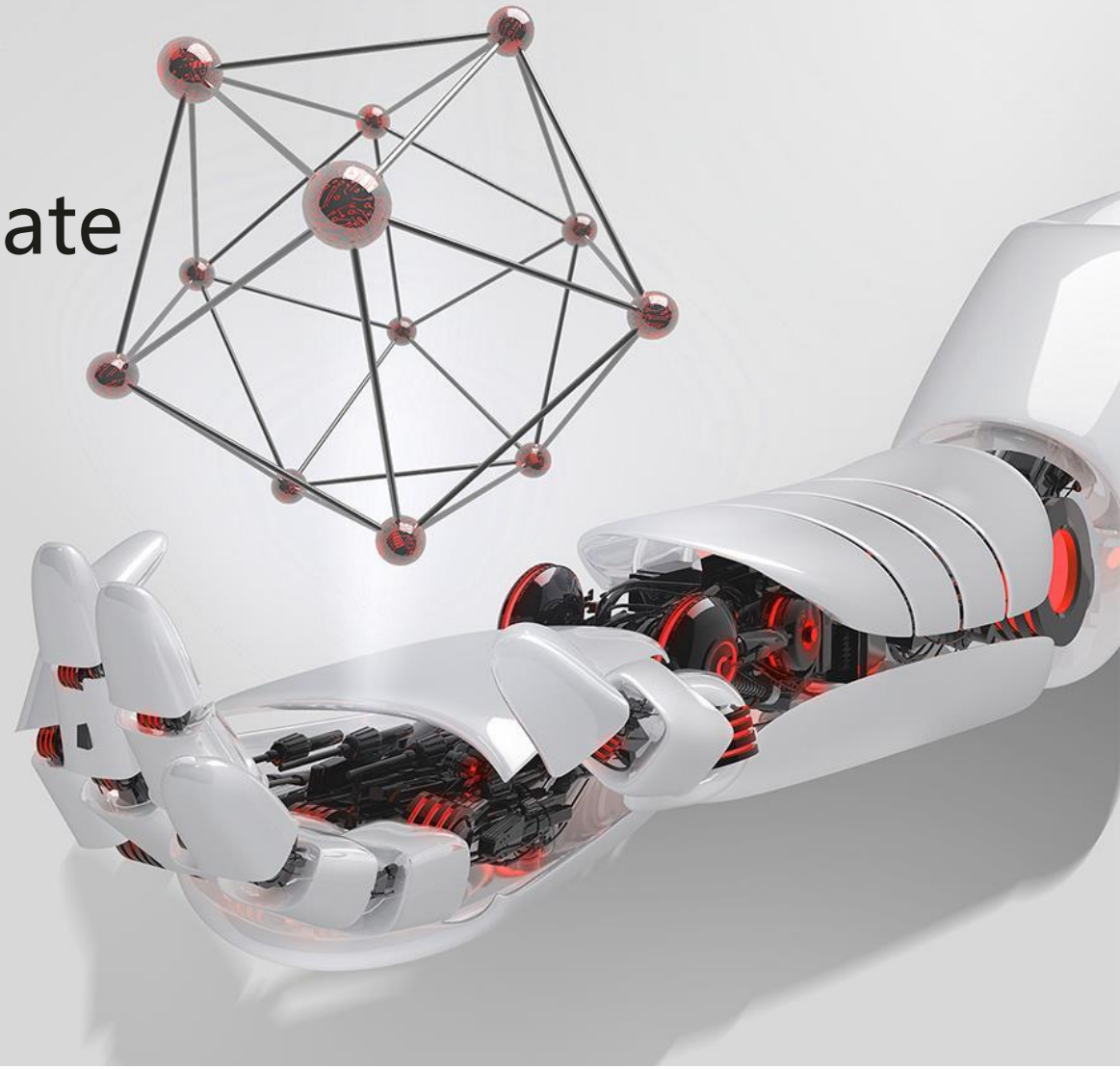

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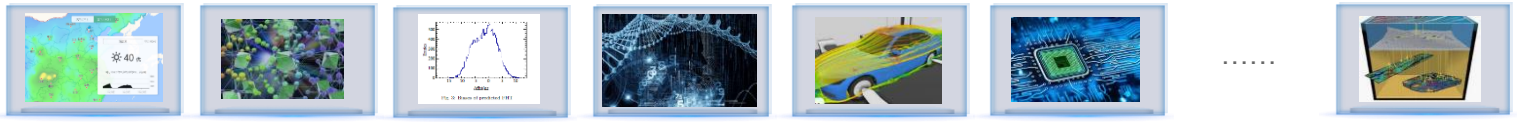
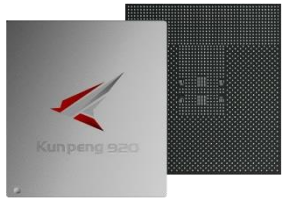
Huawei Kunpeng HPC Solution Stack



Meteorology | Computational Chemistry | Physics | Life Science | CAE | EDA | …… | Reservoir Simulation

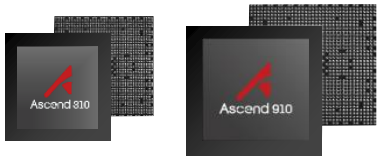
Workload Manager | Application Portal/Workflow | Cluster Management | Monitoring & Dashboard

Huawei Cloud Compiler | Huawei MPI | Math Libraries | Runtime | Tracer, Profiler, Debugger, Porting Advisor



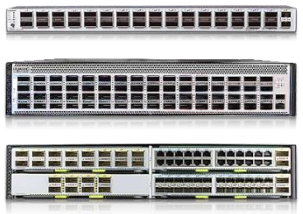
Kunpeng 920

Kunpeng Mainboard



Ascend 310 & 910

FusionStorage Distributed Storage



Ethernet Switches

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The Roadmap of Kunpeng

Hi1612

32 cores@16FF
2.1 GHz
4*64bit DDR3/4
PCIe 3.0 /SAS3.0/10GE

Kunpeng 916

32 cores@16FF+
2.4 GHz
4P
4*64bit DDR3/4
PCIe 3.0 /SAS3.0/10GE

Kunpeng 920

Up to 64 cores@7nm
Up to 3.0 GHz
4P
8 DDR4 Channels
CCIX
RoCE v2
PCIe 4.0 /100GE

Kunpeng 930

Kunpeng 950

Hi1610

16 cores@16FF
2.1 GHz
2*64bit DDR3/4
PCIe 3.0 /SAS3.0/10GE

Available 920 models in 2019 Jun:

- Kunpeng 920-6430: 64C@3.0GHz, 200W
- Kunpeng 920-6426: 64C@2.6GHz, 180W
- Kunpeng 920-4826: 48C@2.6GHz, 150W
- Kunpeng 920-3226: 32C@2.6GHz, 120W

Production
Development
Planning

2014 **2016** **2018** **2020** **2022**

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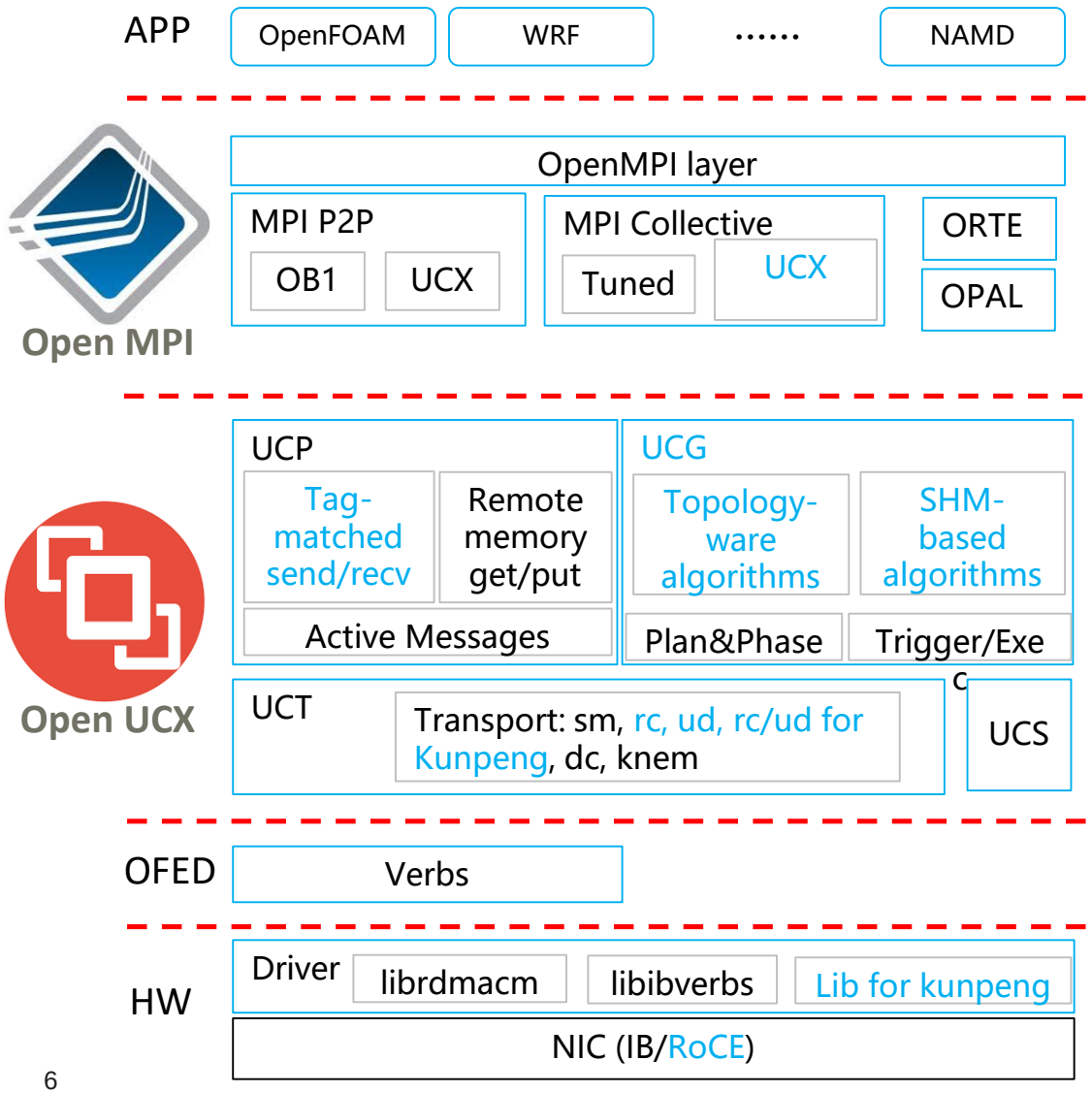
Huawei MPI



Open MPI & Open UCX

- Open MPI is modular, and easily extendable MPI implementation
- Open UCX is communication framework created by industry, laboratories and academia.
- OpenMPI's p2p module is using Open UCX

Huawei MPI

- An optimized implementation based on Open MPI
- Proposed UCG(Groups) – collective operations API to UCX
- Implement optimized collective operations algorithms based on Open UCX
- Support ARM and x86
- Optimized topology-aware, SHM algorithms for Kunpeng CPU
- Communication offloading for p2p and coll
- Computing offload in switch

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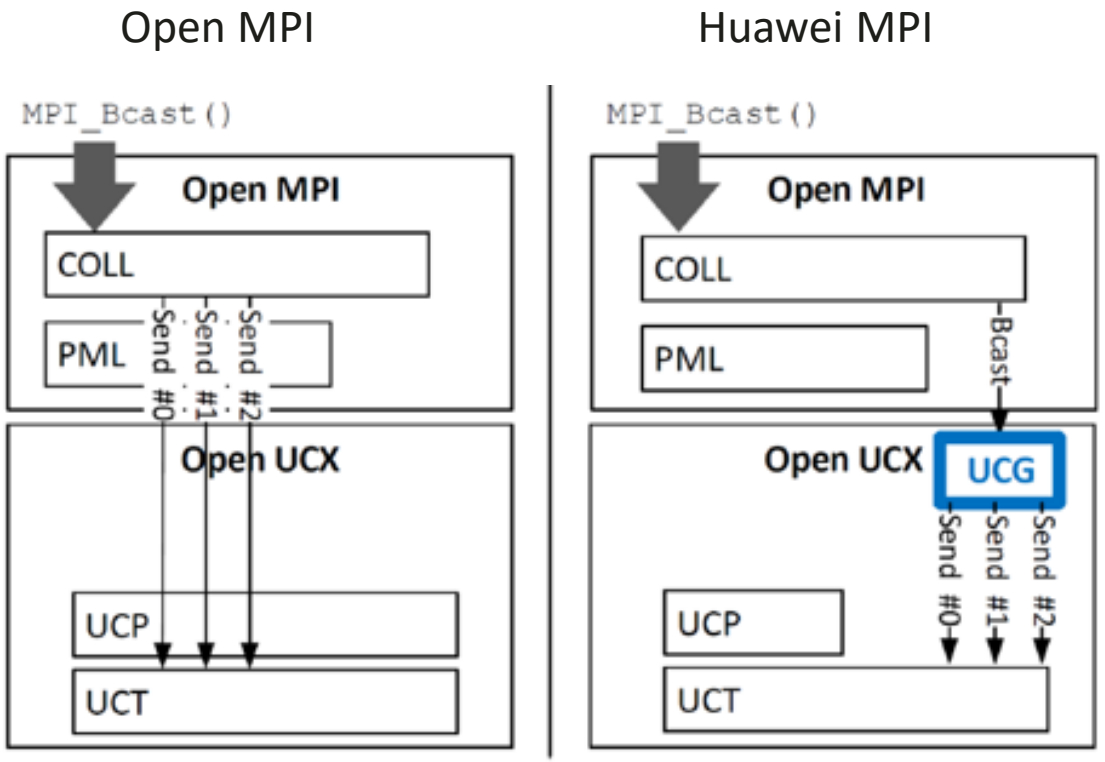
Consolidating UCX P2P Communication

- Open UCX, as most P2P libraries, contains considerable logic on how best to send data.
- During collective operations, messages of the same size are often sent consecutively. This makes most of the P2P logic redundant.
- Proposed UCG(Groups), move the collective operations logic down to UCX layer
- Consolidating the per-message logic, making it per-collective, to save latency
- Decoupling planning and execution, the collective algorithms can be extended easily by 3rd party.



"RDMA-Based Library for Collective Operations in MPI", Alex Margolin and Amnon Barak, ExaMPI'19

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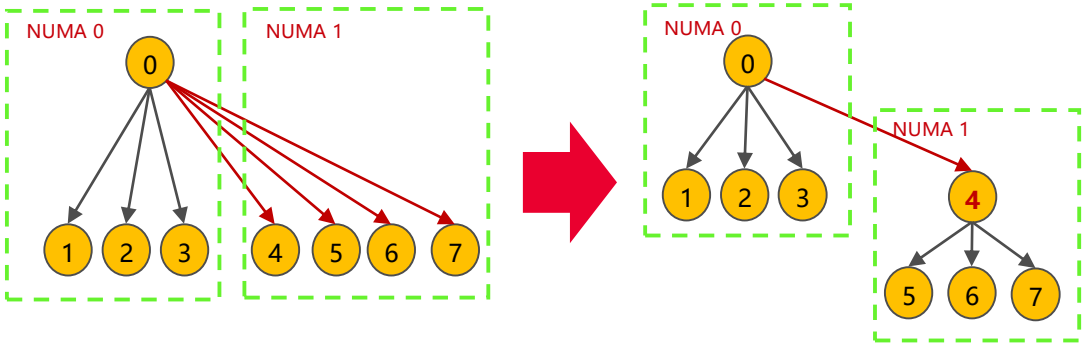
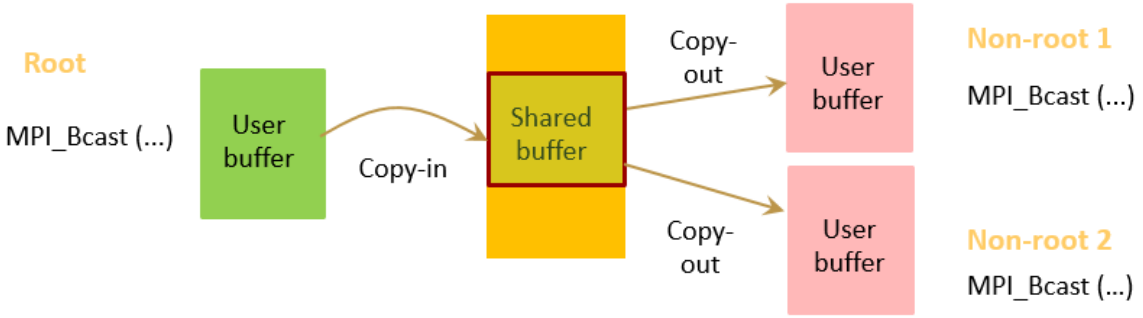
Collective Algorithms

- Optimized MPI_bcast, MPI_allreduce, MPI_barrier
- NUMA aware and SHM-based intra-node collectives
- Collective operation algorithms
  - Bcast: Binomial, Knomial
  - Allreduce: Recursive doubling, Binomial, Knomial, Ring
  - Barrier: Recursive doubling, Binomial, Knomial
- All the algorithms are implemented under UCG, binomial Bcast, Recursive doubling Allreduce and Barrier are open source.



NUMA-awared MPI_bcast



SHM-based MPI_bcast

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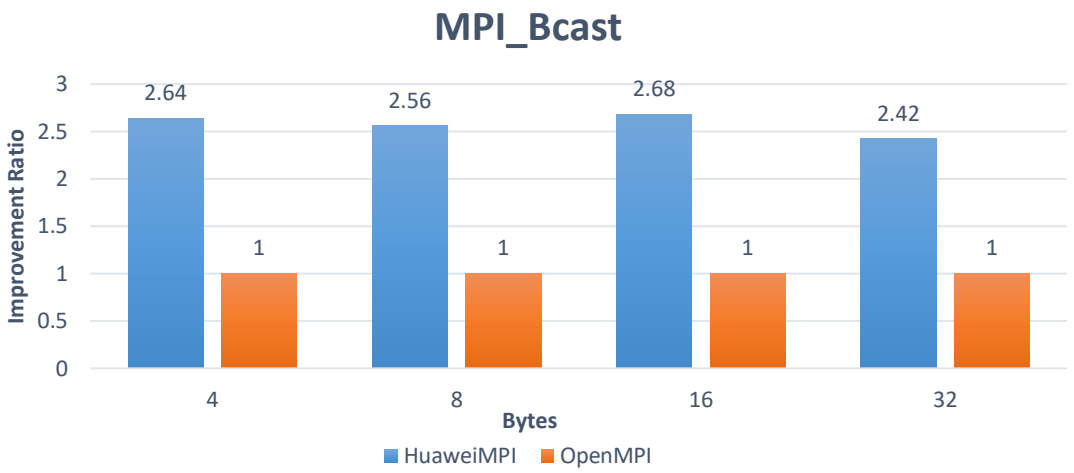
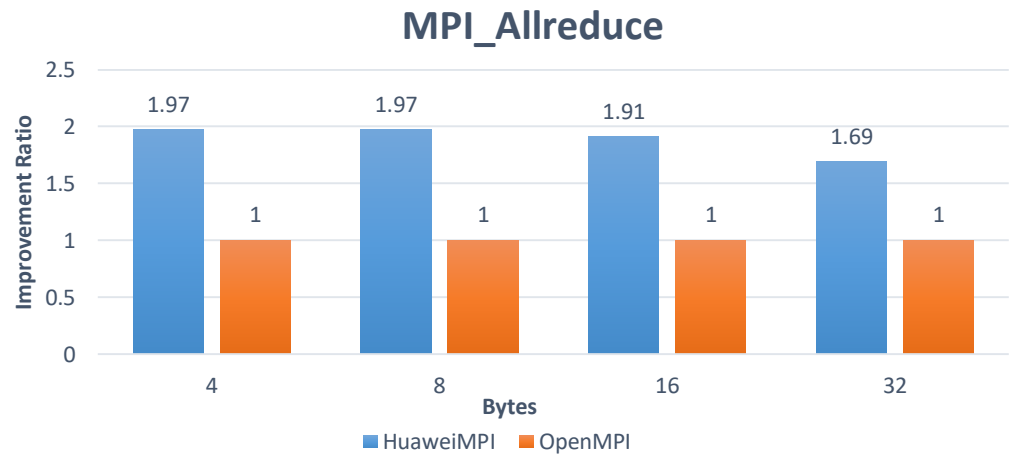
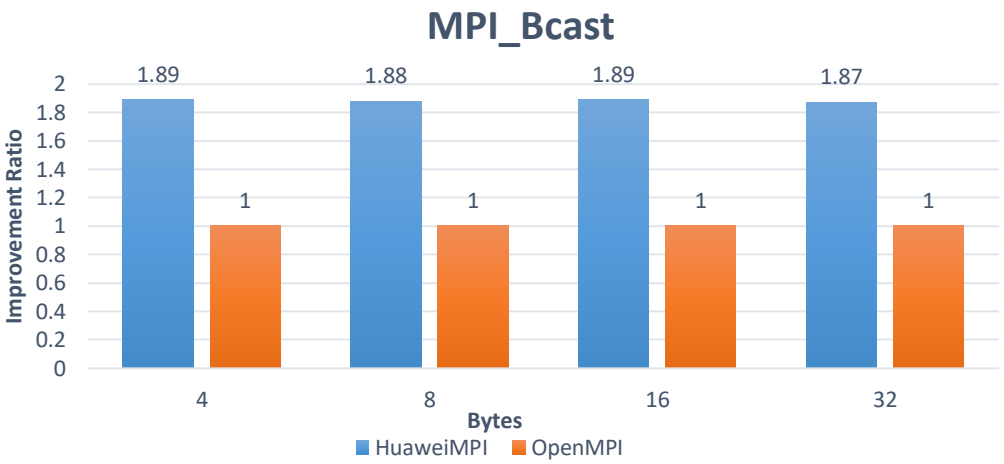
8 Nodes Small Package Benchmark

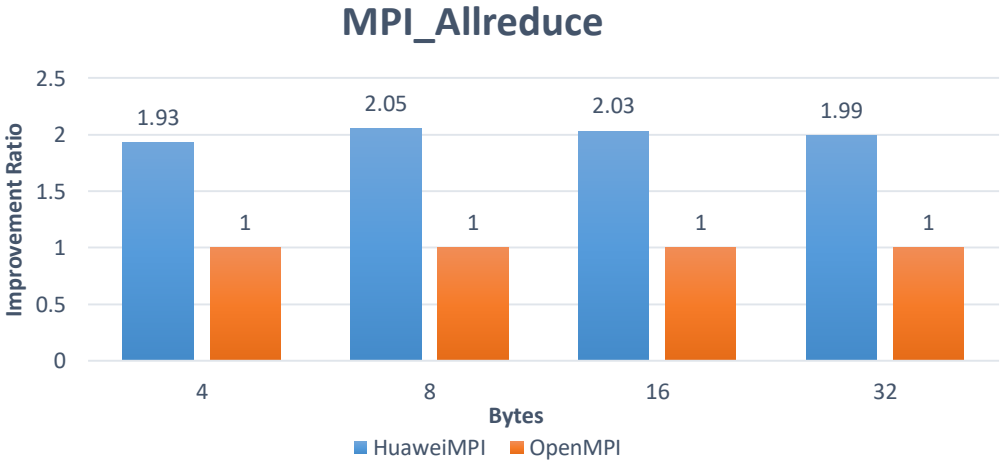
40ppn, IB, Intel Skylake 6148





96ppn, IB, KunPeng920





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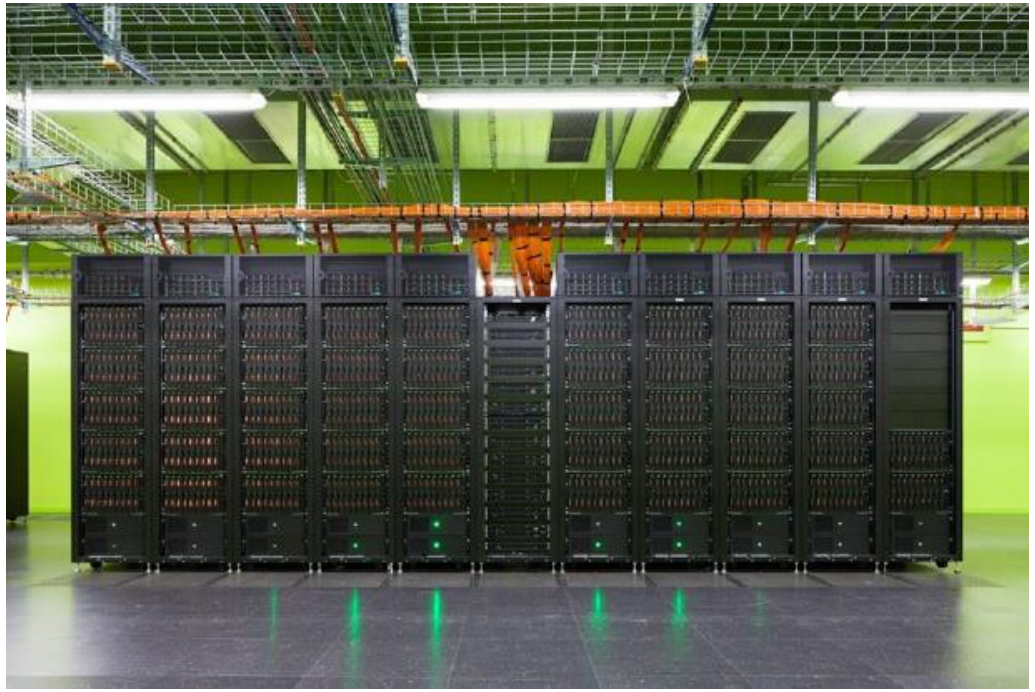
256 Nodes Benchmark



The table shows the latency (microseconds) of Allreducewith increasing message sizes (Bytes), on 256 nodes (*Intel Xeon E5-2680*CPUs @2.5GHz, Connect-X3 NIC).

Length (bytes)	**Huawei MPI** - Inline Sends		**Huawei MPI** - Buffer Copy		**Open MPI** Latency (us)
	Latency (us)	Improvement	Latency (us)	Improvement	
16	19.5	6.7%			20.9
32	22.78	1.3%			23.08
64	21.57	8.5%			23.58
128	25.79	8.1%			28.07
256			24.95	6.6%	26.7
512			28	9.9%	31.06
1024			29.66	16.0%	35.33
2048			36.03	8.7%	39.47
4096			47.21	6.4%	50.43
8192			66.68	8.7%	73.02
16384			89.07	90.4%	923.65
32768			135.4	88.2%	1142.66
65536			227.83	81.2%	1210.49
131072			442.31	66.1%	1302.86
262144			905.43	39.8%	1503.8
524288			1823.7	2.9%	1878.85

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HCC – Huawei Cloud Compiler

- Huawei Compiler Lab, 300+ people, multiple GCC and LLVM committers

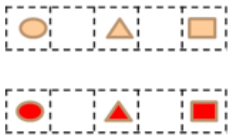
- Develop various compilers for mobile, IoT, network devices and Kunpeng
- HCC for HPC 1.0
  - Instrument Pipeline optimization for Kunpeng 920
  - Optimized mathlib
  - A series of features and optimizations for Kunpeng
- Future plan
  - Based on latest gcc
  - Optimized OpenMP runtime
  - More auto parallelization
  - llvm-based compiler

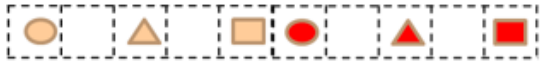
HCC – Optimized Instrument Pipeline

Code:

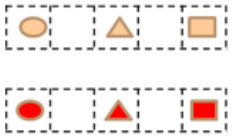
V1 = V2 + V3	K1 = K2 + K3
V0 = V1 - V2	K0 = K1 - K2
V5 = V0 * V2	K5 = K0 * K2

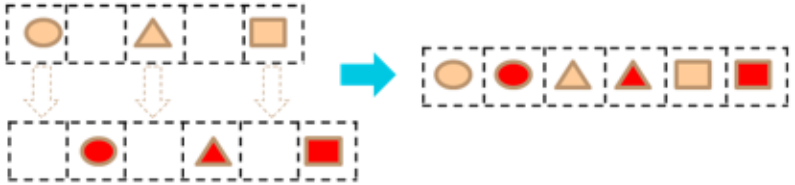
No Optimization



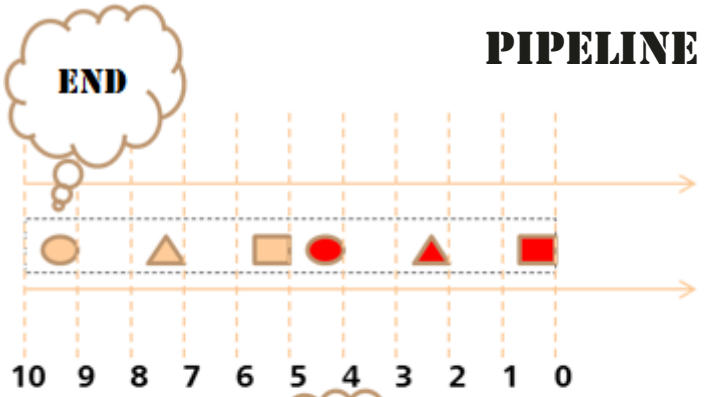


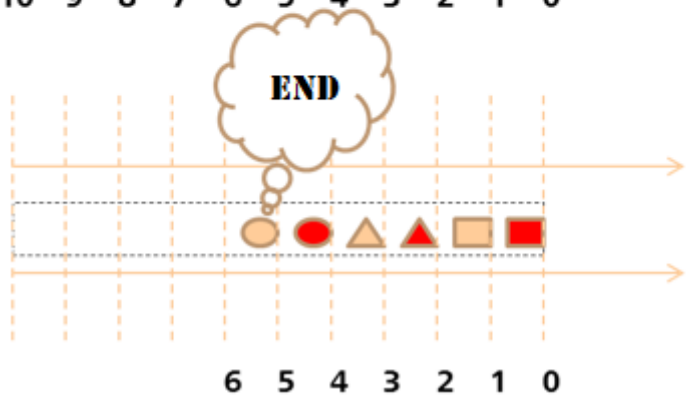
Pipeline Optimization





PIPELINE





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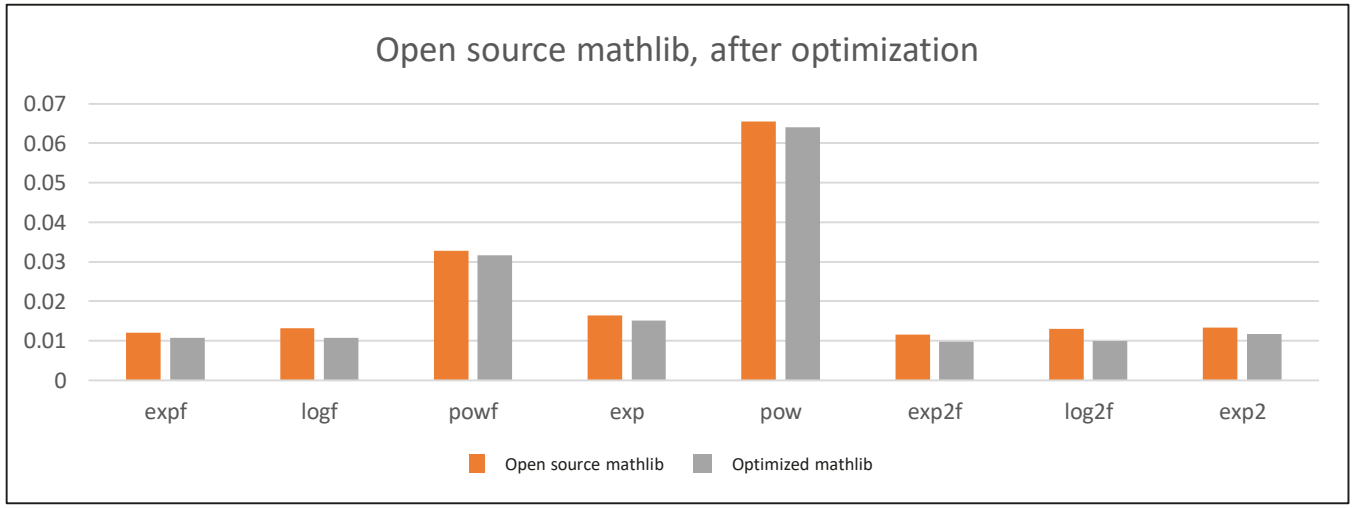
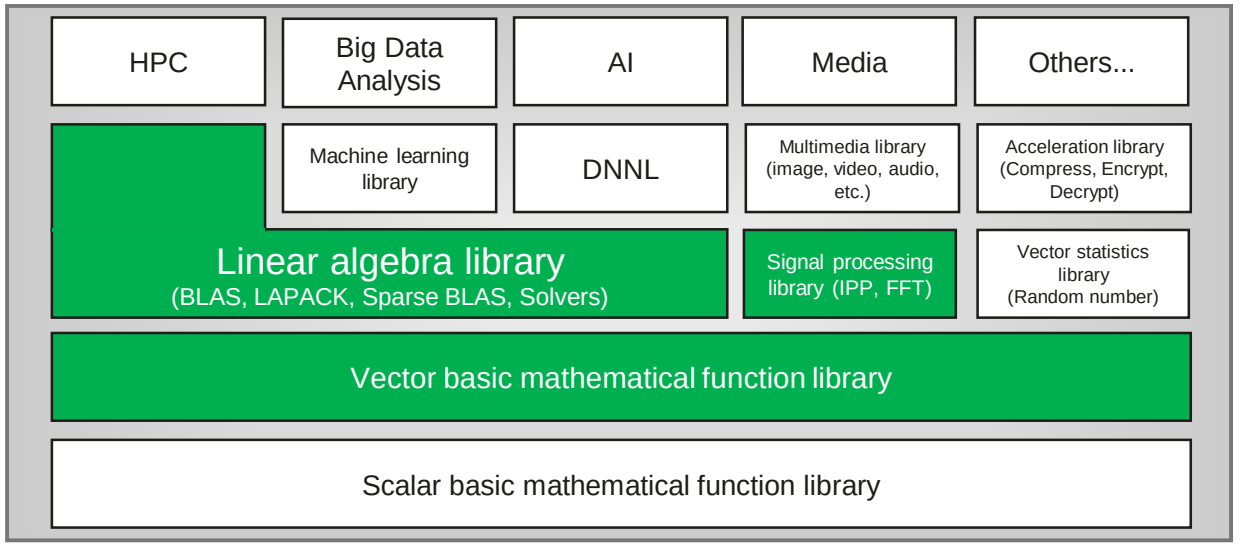
HCC – Feature Highlights

- -fhcc-gfortran-minmax
  - Uses cpu instruments to do the min/max comparison
- -mcmodel
  - Support tiny, small, medium and large
- -DAARCH64_QUADMATH
  - Support 128 bits floating
- - lstringlib -Wl,--wrap=memset
  - memset optimization
- -lmathlib
  - An optimized math library



MAL – Math Acceleration Library

- MAL is Huawei internal project launched from 2016, to provide high performance math libraries for ARM
- MAL includes BLAS, FFT, Lapack, Sparse BLAS
- Open source community also optimize code for Kunpeng, e.g., OpenBLAS



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The Challenges of Modern HPC Scheduler

- The new challenges brought by the convergence of HPC, HPDA and Deep Learning
  - More kinds of application frameworks run in same environments
    - The traditional HPC: MPI + X
    - The Bigdata: Hadoop, Spark, Flink etc.
    - The Deep Learning: Tensorflow, PyTorch, paddle etc.
  - How to run all the workload in one HPC cluster? Without changing user habits of the frameworks.

- More and more the task-based applications
  - Tasks scheduling handled by the framework: the challenge is elastic allocation
  - Task scheduling handled by the scheduler: the challenge is job throughput
  - Kunpeng920 has 128 cores, 8k nodes means 1M cores

- More new components than CPU and Job
  - Accelerator, Container job, Resource Bursting, I/O & Storage
  - Take GPU as example, it is not only a “number”, but also should be applied in the policies, fairshare/threshold/reservation/preemption, and in the monitoring & reporting

Donau Design Principle

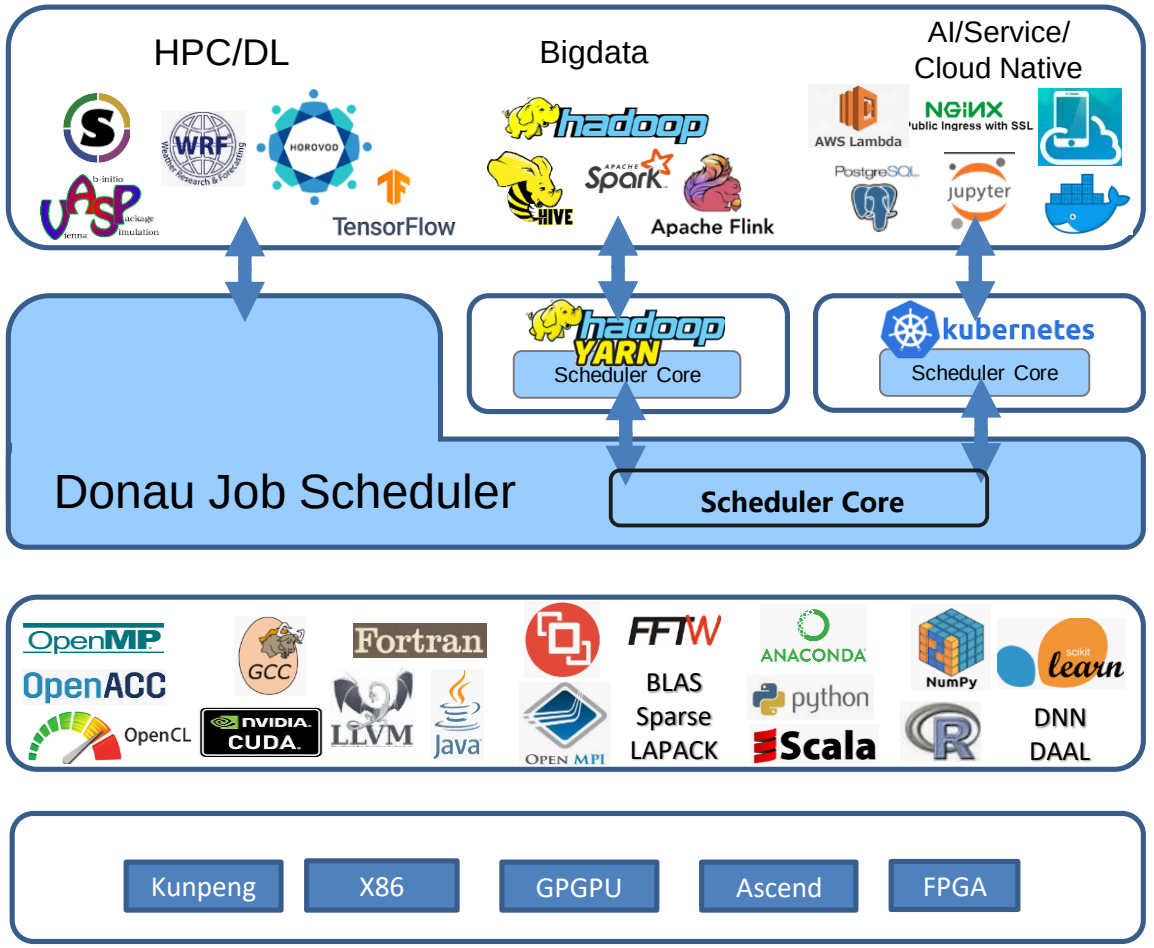
- Donau, a Huawei home-grown job scheduler, launched since 2018
- Target to be a unified scheduler for HPC/Bigdata/AI workload, but no intrusive modification for the application framework
- Extremely high job throughput, target 1M running jobs
- Natively support
  - Accelerator
  - I/O load
  - Container
- Adopt the new technologies in the implementation,
  - Micro-service architecture
  - DRF (Dominate Resource Fairness)
  - MQ & Distributed cache

Donau Scheduler

- Donau – Huawei home-grown HPC scheduler
  - ➢ The scheduler core is an independent module, can replaced the scheduler of Yarn and Kubernetes.

- Scheduling
  - ➢ Natively support elastic allocation
  - ➢ Resource quota based + user priority based fairshare;

- Features:
  - Unified Job/Allocation model: Array Job, MPI job, Bigdata job/Task, TensorFlow job, Service Job, Workflow
  - Natively support container job
  - Accelerator(co-processor) as native resource
  - Resource bursting with IaaS
  - Job-level I/O monitoring & control



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Summary

- Huawei is prompting ARM HPC ecosystem from different dimensions;
- Kunpeng 9x0 ARM-based CPU and Kunpeng mainboard;
- Release HPC Software Suite in the middle of 2020, includes MPI, Compiler, Math Libraries, Scheduler and Management Software;
- Collaborate with Community, Academic and ISV for math libraries, solvers, tool chain and applications.

Thank you.

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每个组织，构建万物互联的智能世界。

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