GEMM SUP Optimizations

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Contents

Introduction

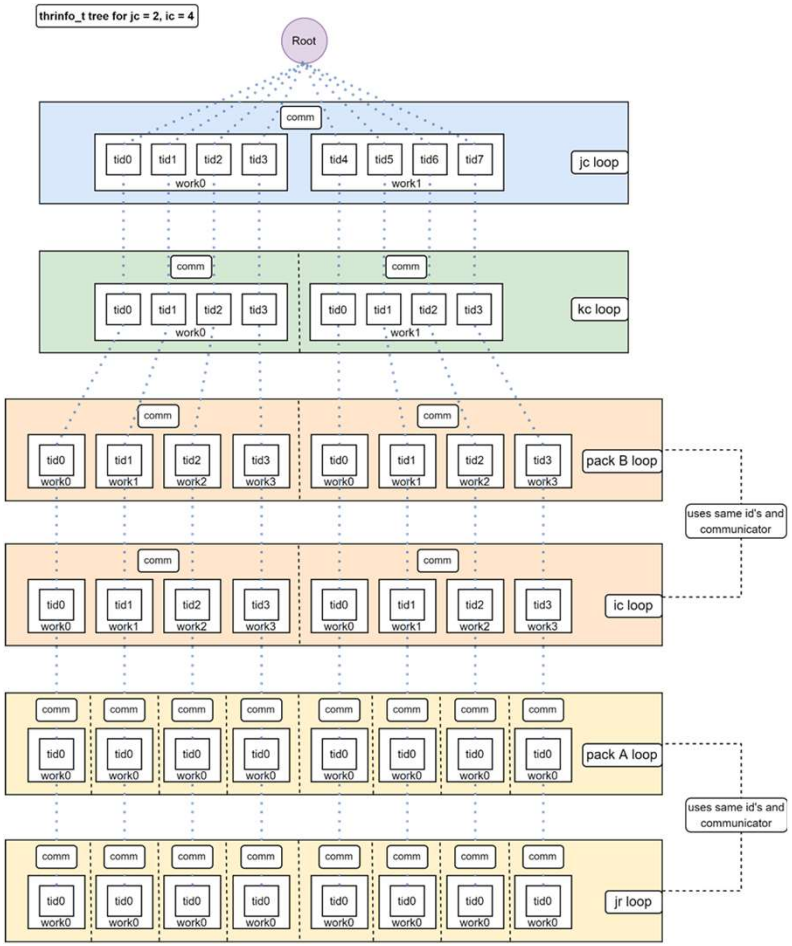
- AOCL (AMD optimizing CPU Libraries) is AMD's CPU Math Library tuned for AMD EPYC™ processor family.
  - AOCL-BLIS is a fork of BLIS library optimized as part of AOCL.

- Multi-Thread GEMM performance was not optimal:
  - SUP performance, especially for smaller matrices, was not scaling well with greater number of threads.
  - In SGEMM native path, packing costs were not amortized when per thread matrix blocks were small, thereby decreasing overall performance.
    - Packing costs consists of cost of packing the matrix + cross thread synchronization costs (required for memory allocation, pack buffer propagation).

- Solution was two phased:
  - Identification of scaling bottlenecks in SUP path and removal of the same.
  - Native vs SUP path selection based on per thread matrix blocks.

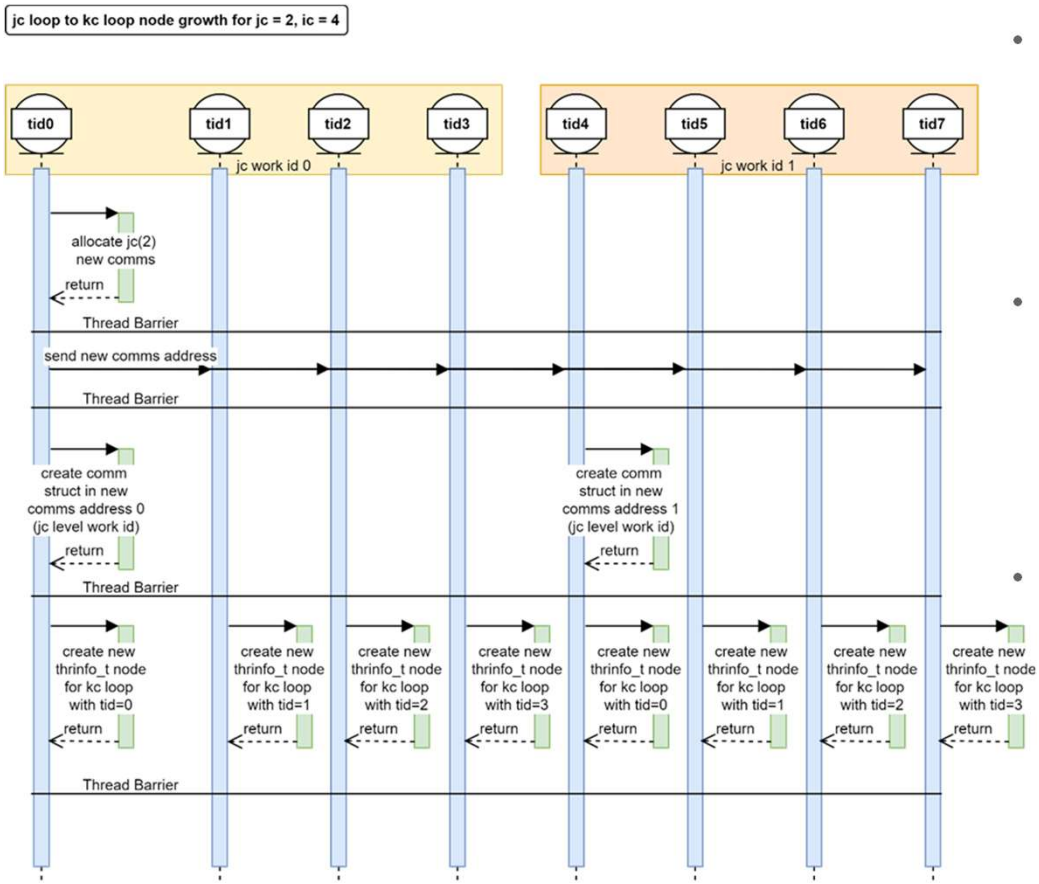
- Multi-Thread GEMM performance improved greatly for SUP inputs with smaller k dimension.

SUP thrinfo_t tree - Overview



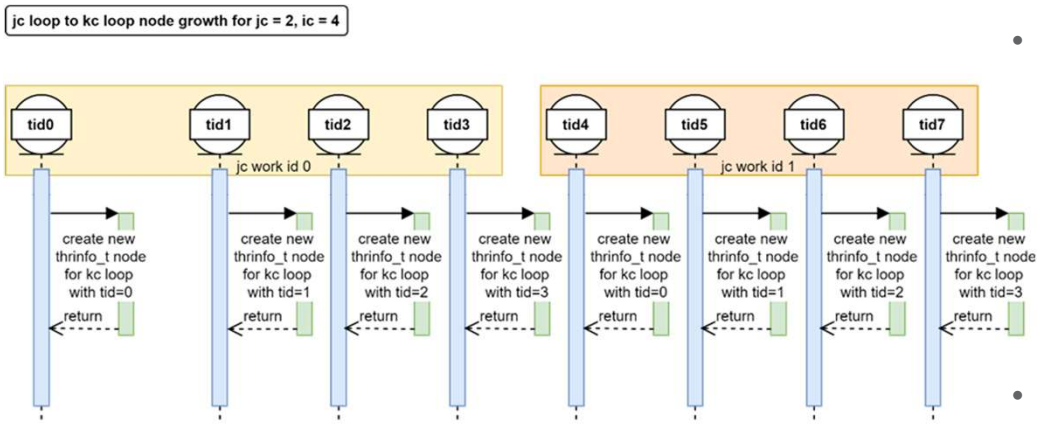
- thrinfo_t tree used to facilitate division of work among threads in multi-thread gemm.
  - 1-ary graph with multiple levels to represent either a loop of 5 loop algorithm or A/B packing.
  - Each level contains communicator for inter-thread communication.
    - Pack buffer broadcast.
    - Barriers for thread synchronization.
- Threads use tree node attributes to identify its work group and sub block/panel of matrix to work on.

SUP thrinfo_t tree - Creation



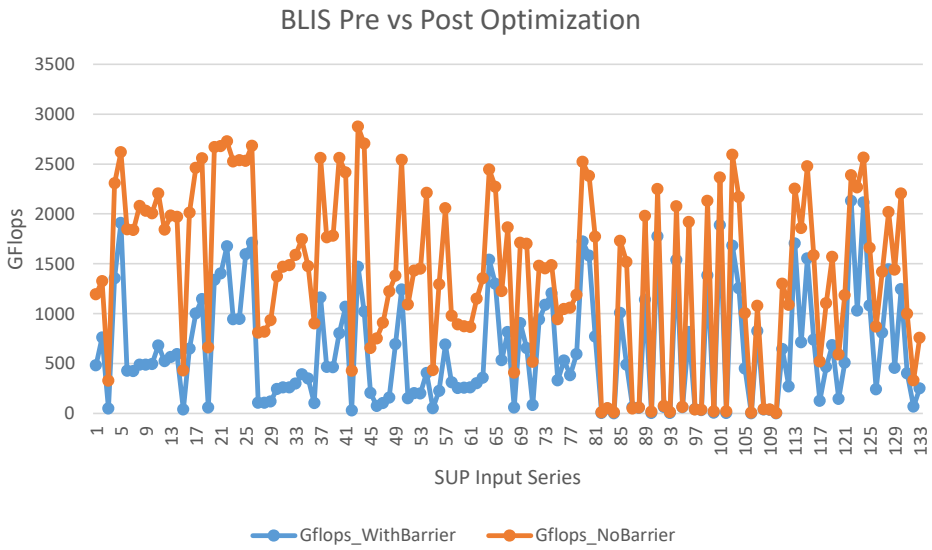
- Nodes/levels in thrinfo_t tree created in iterative fashion.
  - New level (child) created as algorithm progress through the different loops for the first time.
- Chief nodes (threads) of a level responsible for thread safe actions:
  - Memory allocation for communicators.
  - Broadcasting the communicator address.
- Barriers used for thread synchronization during communicator creation and broadcast.

SUP thrinfo_t tree optimization - Barrier removal



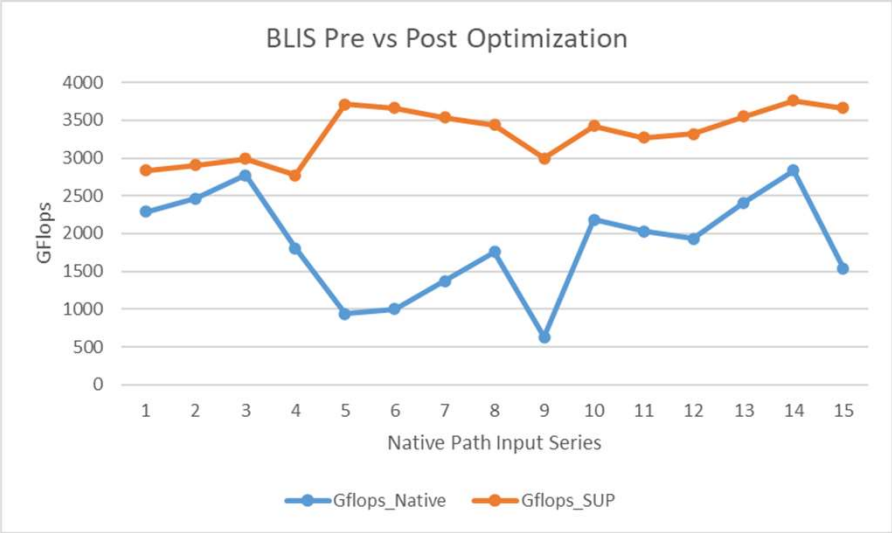
- Communicators only required when optional packing (A or B) is enabled in SUP path.
  - Pack buffer allocation by chief thread and broadcast among threads in work group.
  - Thread synchronization using barriers for thread safe packing within a work group.
- Communicator creation and associated barriers can be avoided if packing is not enabled.
  - thrinfo_t tree creation is faster and avoids multi-thread bottleneck at barriers.

SUP thrinfo_t tree optimization - Impact



- sgemm SUP Gflops doubled for smaller matrix sizes.
  - sgemmt also improved as part of it.
- Performance improvements observed for gemm across data types.

Moving native path inputs to SUP path



Example								
m	n	k	Gflops_Native	ic	jc	m_ic	n_jc	Gflops_SUP
1024	1024	845	2291.95	4	16	256	64	2836.57
1152	1024	845	2468.51	8	8	144	128	2909.5
4096	256	512	1759.13	32	2	128	128	3439.39
Original			**MT = 512**	**NT = 200**	**KT = 240**			

- Native or SUP path taken based on input dimensions.
  - Does not consider per-thread dimensions in multi-thread gemm.
    - Within SUP limits even when input dimensions are above it.
- Packing A and B matrix results in overhead when per thread dimensions are small.
- Modifying existing path selection logic to a per-thread dimension-based logic.
  - Per thread SUP limits observed to be less than original SUP limits.

B matrix packing in SUP path

Example								
m	n	k	Gflops_Native	ic	jc	m_ic	n_jc	Gflops_SUP
4096	1024	845	3365.56	8	8	512	128	3970.67
8192	1024	845	3746.91	32	2	256	512	3873.37
8192	512	1024	3464.17	16	4	512	128	3895.92
Original			**MT = 512**	**NT = 200**	**KT = 240**			

- B packing in SUP path results in performance improvement when per thread dimensions are sufficiently large.
  - B packing is multi-threaded with ic threads per B panel.
- B packing gains offsets the thread synchronization costs.

questions?

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