

LUMI

A white wolf is the central focus, standing in a futuristic, blue-toned digital environment. The background is filled with vertical light beams, floating particles, and a grid-like structure, creating a high-tech, cybernetic atmosphere. The wolf is looking slightly to the right of the viewer.

LUMI Architecture

Emanuele Vitali
LUMI User Support Team (LUST)
CSC

April 2026
Slides originally authored by Kurt Lust
(LUST, UAntwerp)

Why do I need to know this?

Q: “I only want to run, why do I need to know about system architecture?”

A: An HPC system is not a big smartphone or big PC

- Built for large parallel jobs
 - Scaling is not for free
 - Not in Hardware, neither in Software!
- Often those application needs to be mapped on the hardware to run efficiently.
- Which requires an understanding of
 - The hardware: This section
 - The middleware between the application and the hardware: Several sessions during this course
 - The application: Very domain-specific and hence not the topic of a general course
 - The specific problem you’re trying to solve
- 20% unused performance = several millions of EUROS

LUMI is...

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... a (pre-)exascale supercomputer ...

- ... and not a superfast PC ...
- ... and not a compute cloud infrastructure.
- Each of these infrastructures have their own trade-offs
- A supercomputer is:
 - Build for scalable parallel applications in the first place
 - A shared infrastructure with lightweight management
 - Principle: Reduce hardware costs by clever software
 - Build for streaming data through the machine at all levels, not for random access to small bits of data

Lumi spec sheet: A modular system

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LUMI-C:

2048 nodes with 2 64-core AMD EPYC 7763 CPUs (1888x 256GB, 128x 512 GB and 32x 1TB)

LUMI-K:

Microservice platform:
34 compute nodes (with single EPYC 7742 CPU and 512GB RAM, 5*1,6TB SSD disk)
7 storage nodes (with Rome CPU, 128 GB RAM and 12 3,8TB SSD)

LUMI-O:

Object Storage Service 30 PB encrypted object storage (Ceph) for storing, sharing and staging data.

High-speed interconnect

Possibility for combining different resources within a single run. HPE Slingshot technology.



LUMI-G:

2978 nodes with 1 AMD EPYC 7A53 CPU and 4 AMD MI250x accelerators (512 GB + 4x128 GB RAM)



LUMI-D:

8 4TB CPU nodes
8 nodes with 8 A40 GPUs each for visualization



LUMI-F:

Accelerated Storage
8 PB Flash-based storage layer with extreme I/O bandwidth of 2 TB/s and IOPS capability.

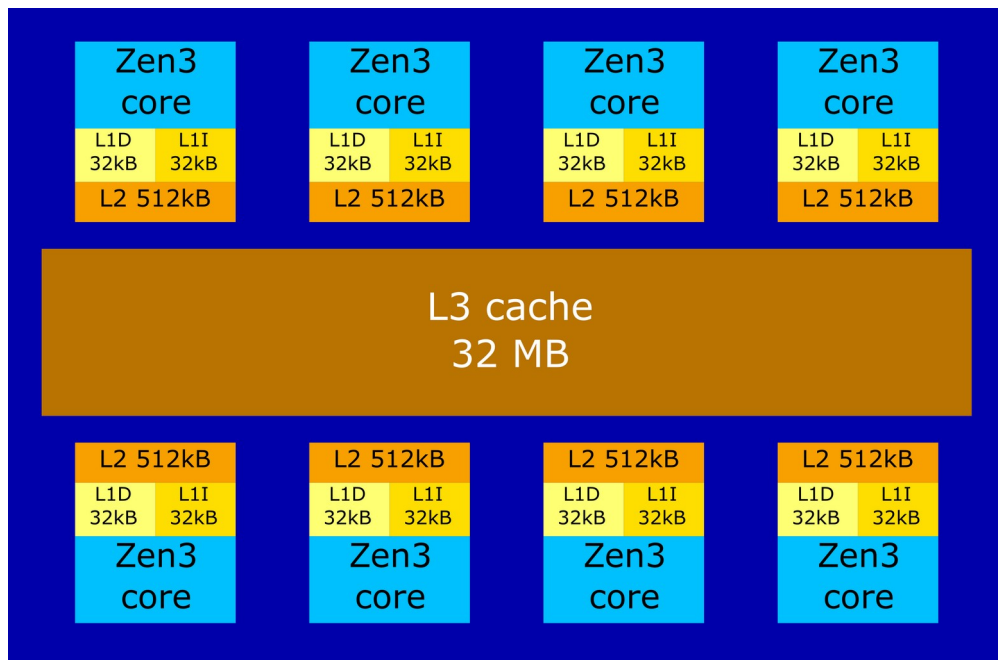


LUMI-P:

Lustre Storage
4*20 PB parallel file systems (4x 240 GB/s).

The AMD EPYC 7xx3 (Milan/Zen3) CPU

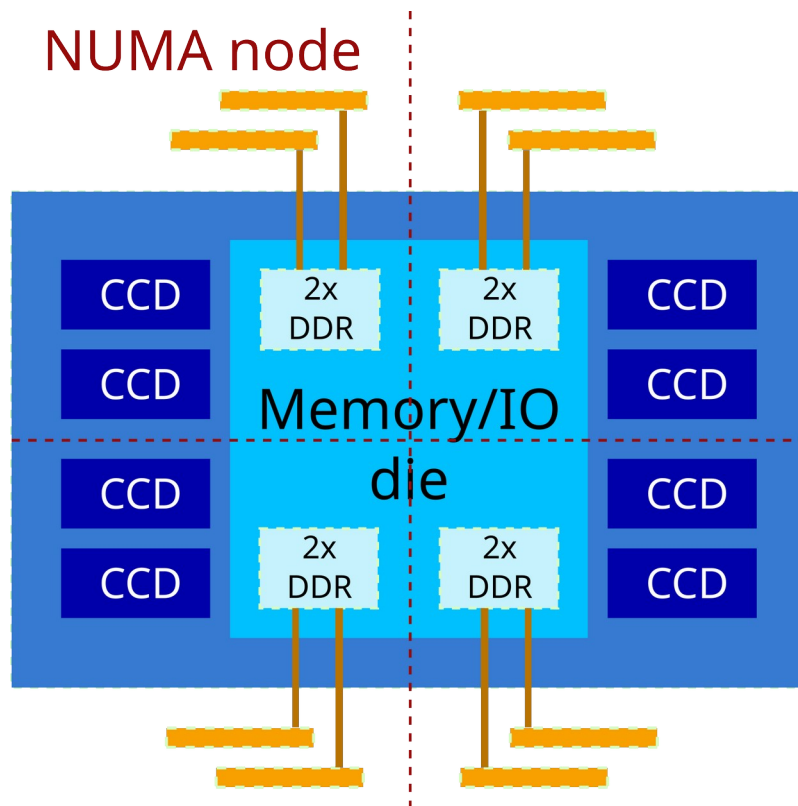
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- Building block: a Core Complex Die (CCD)
- 8 cores
 - Each core has private L1 and L2 caches
 - L3 cache shared
- Instruction set equivalent to Intel Broadwell generation and Rome/Zen2
 - AVX2+FMA, no AVX-512
- *Rome/Zen2 has 2 4-core core complexes per die.*
 - *Milan architecture simpler*

The AMD EPYC 7xx3 (Milan/Zen3) CPU

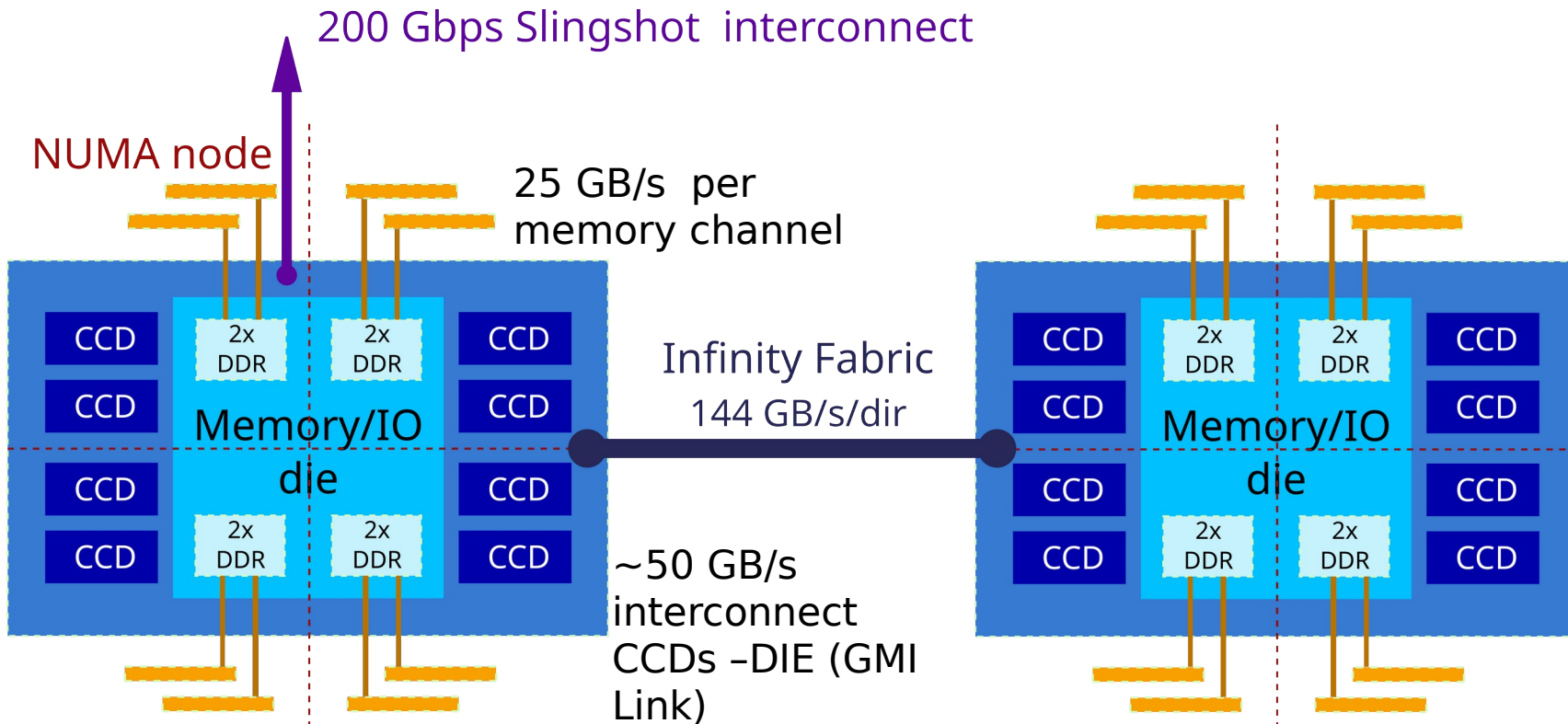
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- 8 CCDs or 8 L3 cache regions
- Memory/IO die logically split into 4 NUMA domains with
 - 2 CCDs (16 cores)
 - 2 DDR4 controllers
- Memory/IO die also provides the PCIe links and intersocket links
- *Comparison with Rome/zen2:*
 - *Rome/zen2 has 16 L3 cache regions with 4 cores each (in the 64-core variant)*

LUMI-C node

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Strong hierarchy

hierarchy layer		per	sharing	distance	data transfer delay	data transfer bandwidth
1	2 threads	core	L1I, L1D, L2, execution units, rename registers			
2	8 cores	CCD	L3 Link to I/O die			
3	2 CCDs	NUMA node	DRAM channels (and PCIe lanes)			
4	4 NUMA nodes	socket	inter-socket link			
5	2 sockets	node	inter-node link			

Delays in numbers

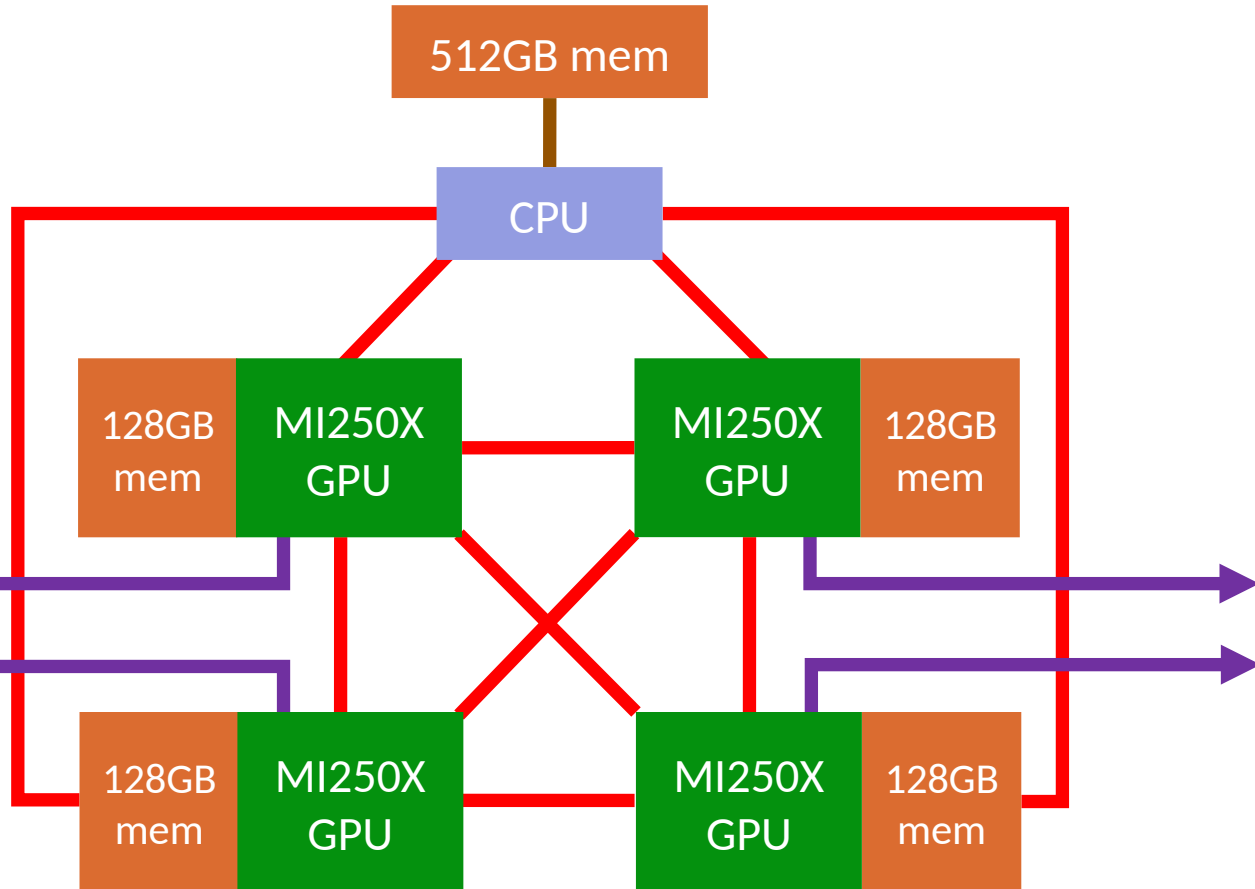
		NUMA nodes CPU 1				NUMA nodes CPU 2			
		0	1	2	3	4	5	6	7
NUMA nodes CPU 1	0	10	12	12	12	32	32	32	32
	1	12	10	12	12	32	32	32	32
	2	12	12	10	12	32	32	32	32
	3	12	12	12	10	32	32	32	32
NUMA nodes CPU 2	4	32	32	32	32	10	12	12	12
	5	32	32	32	32	12	10	12	12
	6	32	32	32	32	12	12	10	12
	7	32	32	32	32	12	12	12	10

- NUMA behaviour not that pronounced within a socket
- but definitely something to take into account between sockets

Concept LUMI-G node

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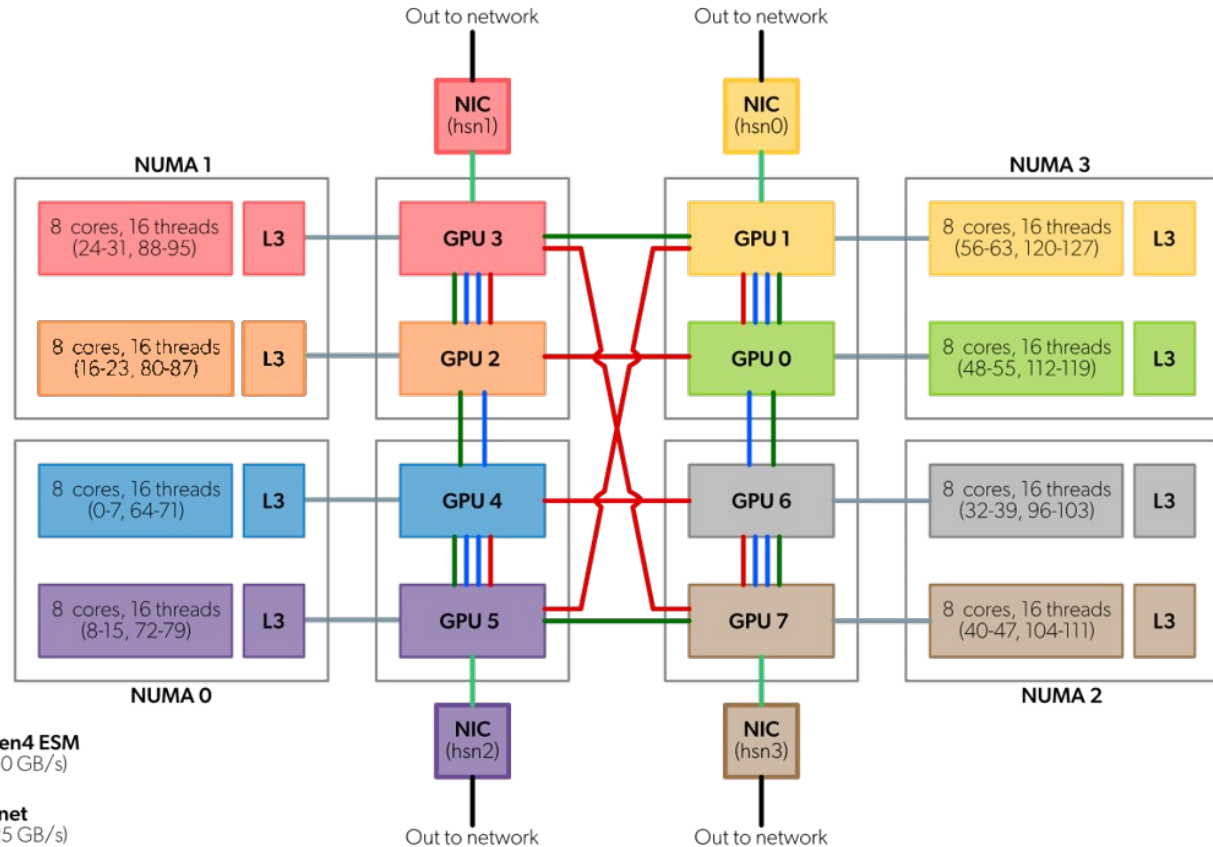
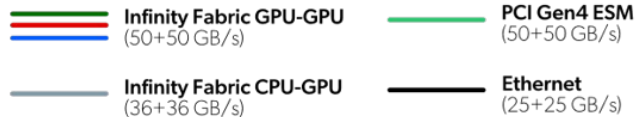
- “GPU first” system with unified memory and partial cache coherency
- Compute accelerator (CDNA2), not a rendering GPU (RDNA architecture)!



Real LUMI-G node

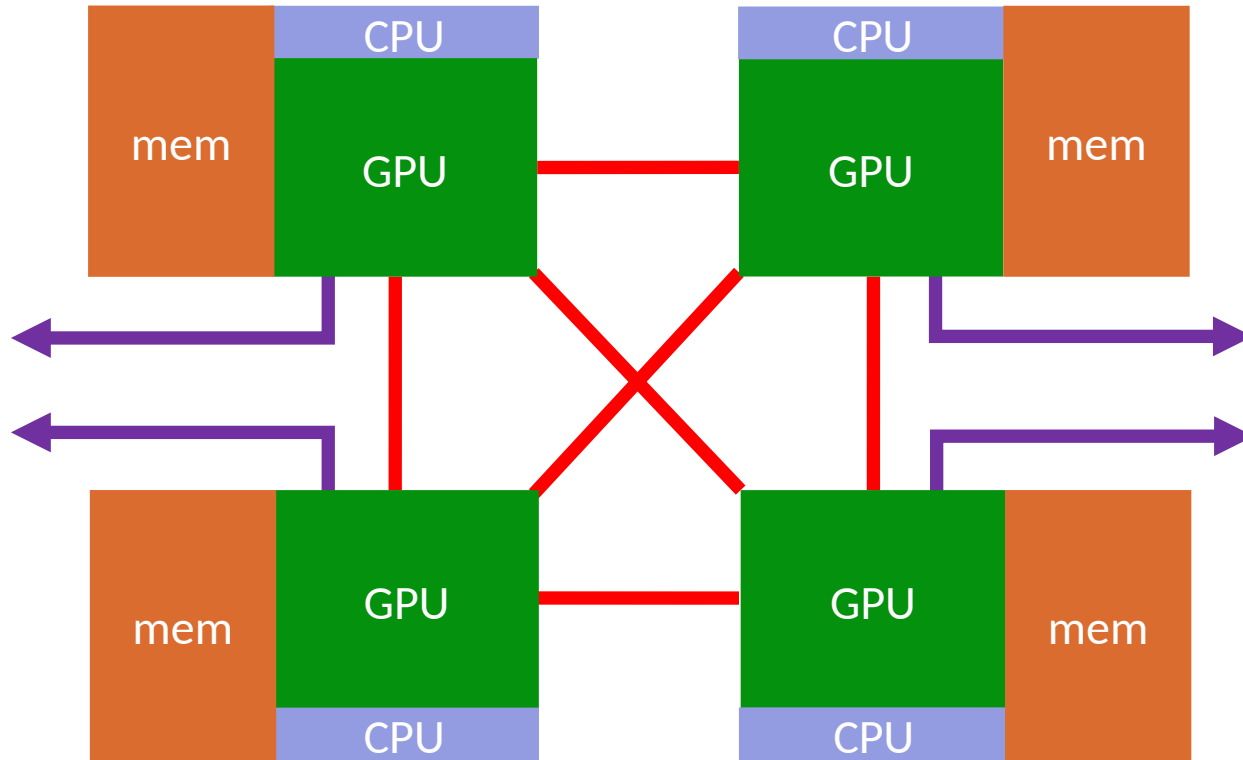
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- MI250X is built with 2 chiplets
- Chiplet memory has 64GB each, 1.6TB/s Bandwidth
- Bandwidth between chiplets is only 200GB/s



The next gen: El Capitan

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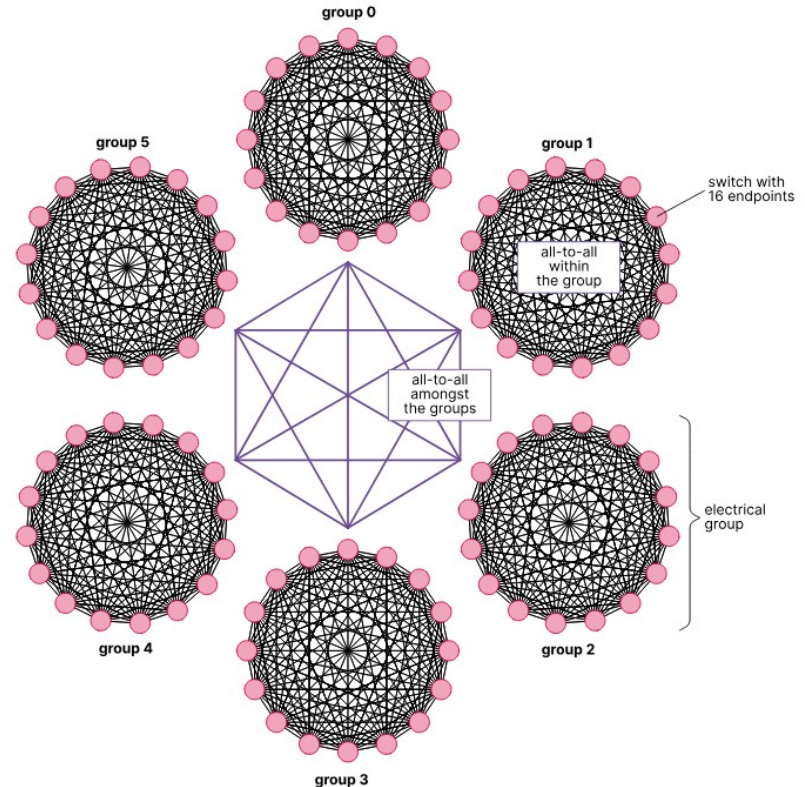
- AMD MI300A
- 13 chiplet design:
 - 4 memory/IO,
 - 6 GPU,
 - 3 CPU
- CPU and GPU share the memory controllers
- 128 GB memory capacity per package may be a bit disappointing
- Current TOP500 #1

Slingshot interconnect

- 200 Gb/s (25 GB/s/dir) interconnect based on Ethernet but with proprietary extensions for better HPC performance
 - Adapts to Ethernet devices in the network
 - Lot of attention to adaptive routing and congestion control
 - MPI acceleration
- Not your typical Mellanox/NVIDIA software stack with ucx but libfabric...

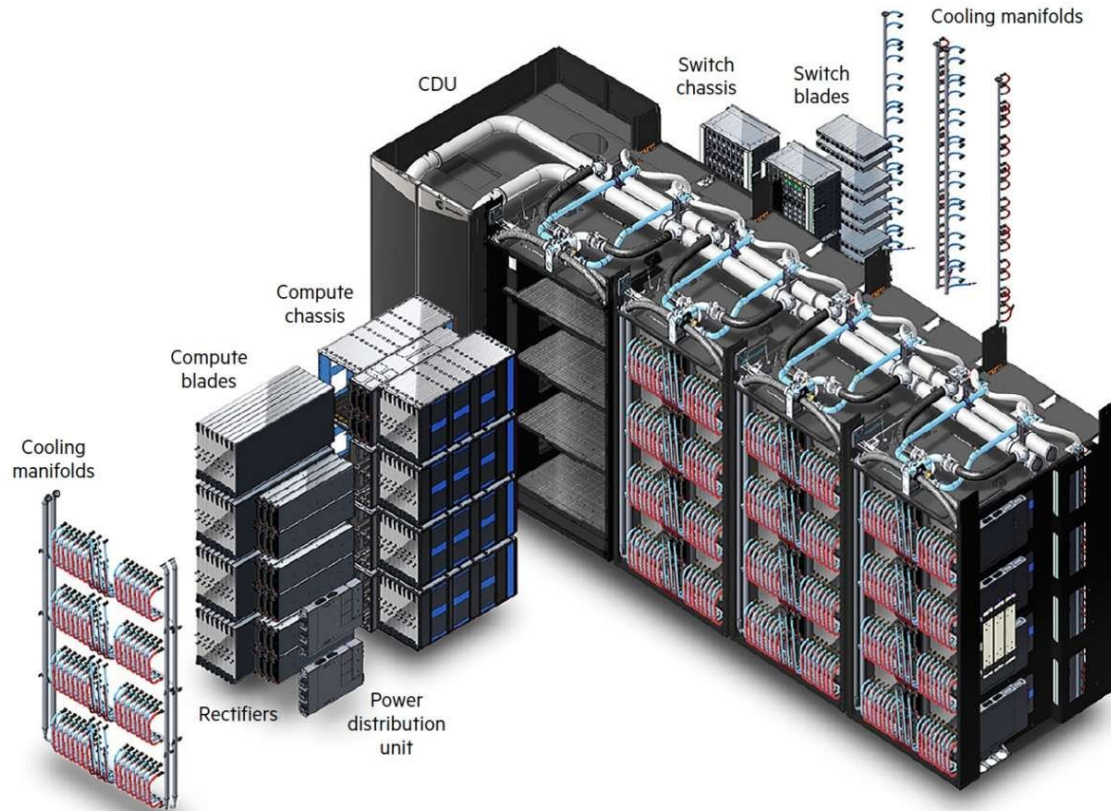
Slingshot interconnect

- Dragonfly topology
 - 16 switch ports connect to nodes, 48 to other switches
 - 16 or 32 switches in a group with all-to-all connection between the switches in a group
 - Groups are then also connected in an all-to-all way
 - Possible to build large networks where nodes are only 3 hops between switches away on an uncongested network



HPE Cray EX system

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- LUMI-C
 - 1 network port/node
 - 4 nodes/compute blade
 - 2 switch blades/chassis
 - 4 nodes on a blade distributed over 2 switches!
- LUMI-G
 - 4 network ports/node
 - 2 nodes/compute blade
 - 4 switch blades/chassis
 - 2 nodes on blade on other switch pair!

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Questions?

