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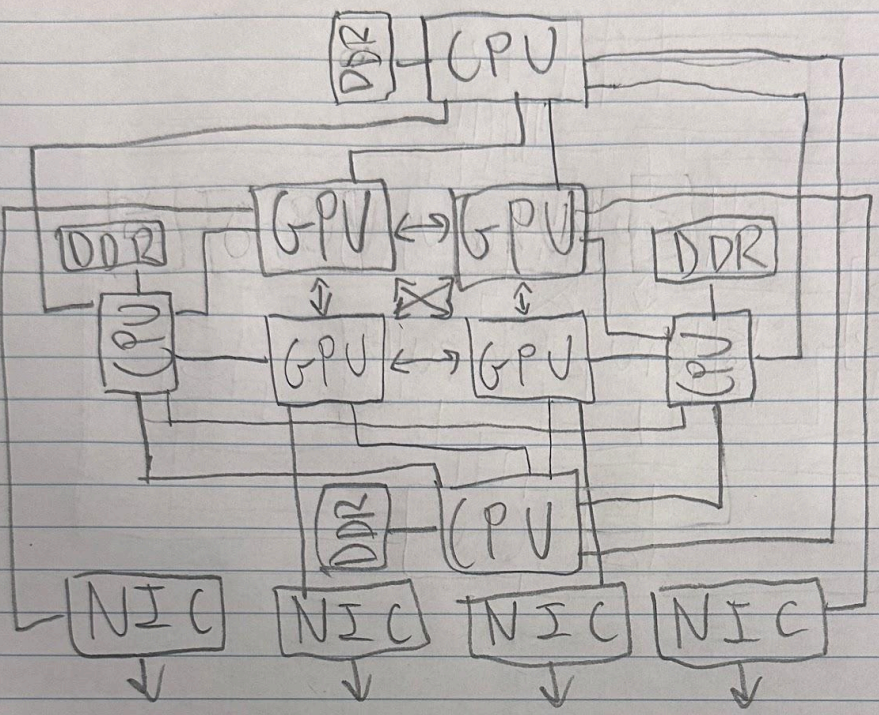
High Performance Computing
Homework 1 - Question 4

When reviewing the top ten systems on the Top500 list, the first thing that jumped out at me was their large power consumption. The lowest power consumption on this first page was over 3 megawatts, and the highest was about 38.7 megawatts. If I was running any one of these computers at my house, I would have to pay Eversource thousands per hour I had the machines on. Next, I noticed these supercomputers had a few more cores than my laptop, in the range of 1-11 millions cores. Also, three processor manufacturing company names are repeated throughout this list: Intel, AMD, and NVIDIA. With the exception of Supercomputer Fugaku, which uses a Fujitsu CPU, every processor on the list was made by one of the manufacturers listed above. Additionally, while there are multiple operating systems mentioned, they all seem to boil down to something Linux based. When I looked up TOSS and Cray OS, they all point back to being based on or built on the Linux OS. One interesting observation I made was that the clock speeds on these machines ranged from 1.8-3.1GHz, centered around 2GHz. I understand that clock speeds have essentially reached a maximum due to thermal and fanout concerns, so while initially counterintuitive, it isn't surprising that my laptop has a similar clock speed at 2.5GHz. However, I was surprised that there was this much variation in the clock speeds. To obtain maximum performance, the architects designing these machines must have determined the sweet spot carefully, meaning these computers may have different thermal performance, microinstruction execution times, or cache access speeds. Overall, most of these machines have 1-10 petabytes of total memory, with the exception of Eagle, which only had 296 terabytes. Finally, the most common interconnect used was Slingshot 11, which was created by HPE Cray specifically for high performance computing. It supports a high bandwidth, and allows for adaptive routing and congestion control. The Eagle and Leonardo use NVIDIA Infiniband interconnects, and the Supercomputer Fugaku uses the Tofu Interconnect D.

In order to create a supercomputer that could get onto this list and achieve hundreds of petaflops, I would heavily base my design on these top ten systems as seen below.

Nodes: 10,000
CPUs: 4 AMD Optimized 3rd Generation EPYC 64C CPUs @ 2GHz per node
GPUs: 4 AMD Instinct MI325X Accelerators per node
Memory: 12 Petabytes of total DRAM (distributed memory among nodes)
CPU/GPU Memory: CPUs will use DDR5 and GPUs will use HBM3E
Interconnect: Slingshot 11
Operating System: HPE Cray OS

Node Architecture



Network Diagram