DD2358 – Fundamentals of Computer Systems – Communication Layers

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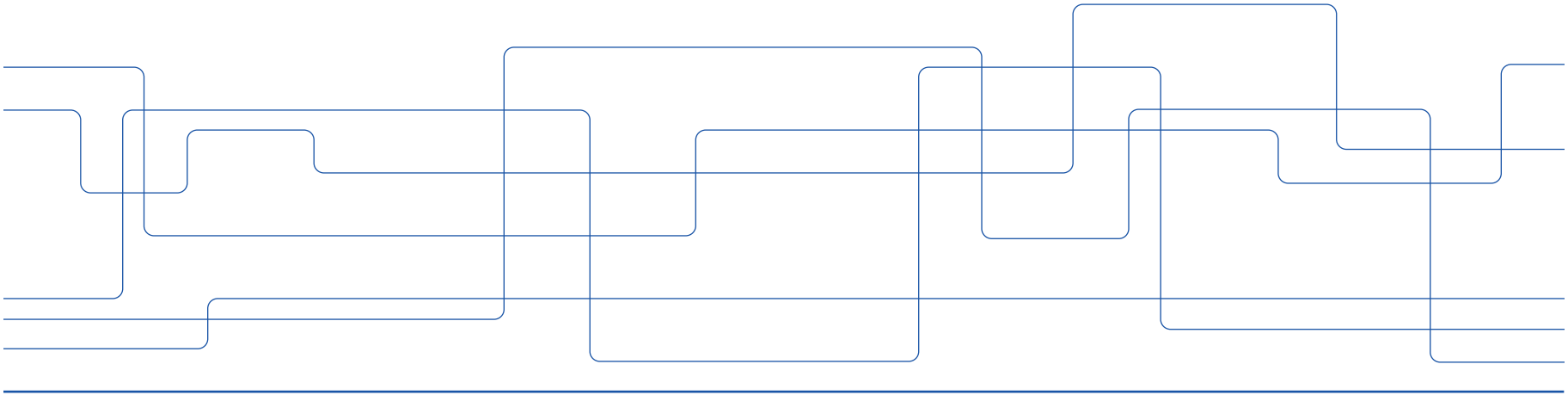
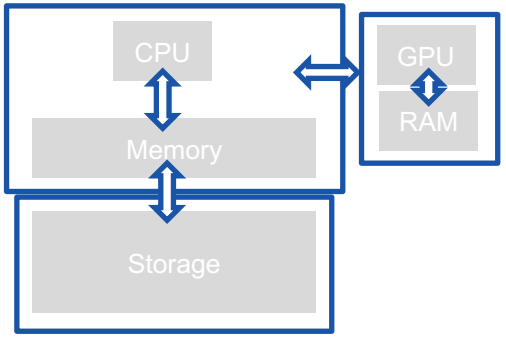


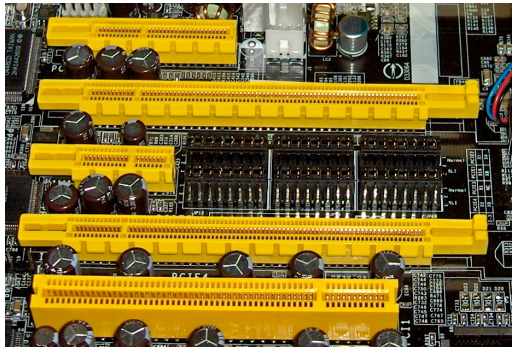
Intended Learning Outcomes

- List and describe different communication layers between different computer system components
- Describe the performance parameters characterizing the communication layers.

Communication Layers



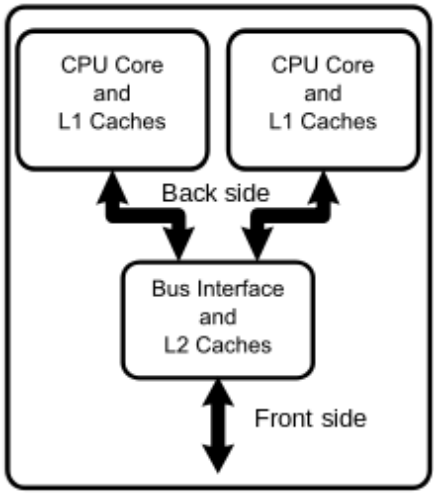
- Many modes of communication between different computer system components and devices exists
- Most of the variants of communication layers on single board are called a *bus (topology)*
  - **Bus is network topology** in which **nodes are directly connected to** a common link called a bus (bar).
- On supercomputers, there are other topologies (DD2356)
  - **Other topologies:** meshes, trees, dragon-fly, …



PCI Express Buses

Frontside Bus

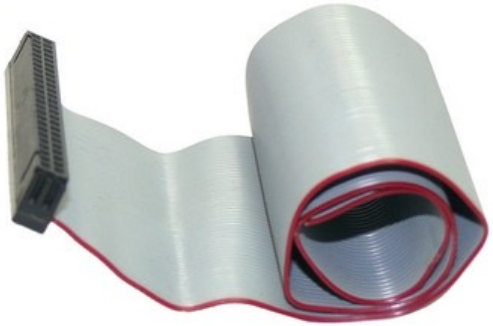
- The *frontside bus* is the connection between the RAM and the L1/L2 cache.
  - It moves data that is ready to be transformed by the processor into the staging ground to get ready for calculation, and it moves finished calculations out.
- Many of the benefits of the L1/L2 cache are attributable to the faster bus.
  - Being able to queue up data necessary for computation in large chunks on a bus (from RAM to cache) and then having it available at very fast speeds from the cache lines (from cache to CPU) enables the CPU to do more calculations without waiting such a long time



Other Buses

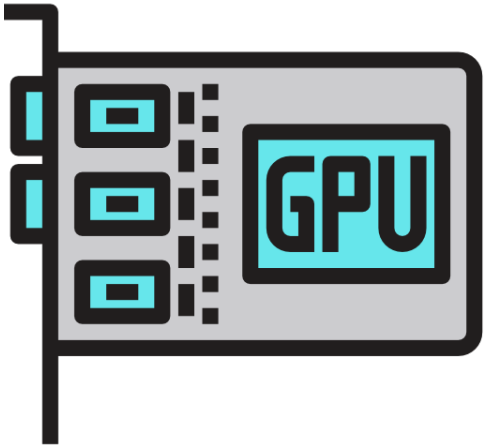
There are other buses:

- external bus that acts as the main route from hardware devices (= hard drives, networking cards and accelerators) to the CPU and system memory.
- This external bus is generally slower than the frontside bus.



Connecting GPUs & Accelerators

- Many of the drawbacks of using a GPU come from the bus it is connected on
  - the GPU is generally a peripheral device, it communicates through the PCI bus, which is much slower than the frontside bus.
    - > *Getting data into and out of the GPU can be quite a taxing operation.*
  - Computing blocks that have both a CPU and a GPU on the frontside bus, aims at reducing the data transfer cost and making GPU computing more of an available option, even when a lot of data must be transferred.



Networks

- In addition to the communication blocks within the computer, the network can be thought of as yet another communication layer.
  - This is important when dealing with supercomputers (or clusters)
  - We need to consider the cost for moving data across the supercomputer network
- Other networks:
  - A network device can be connected to a memory device, such as a network attached storage (NAS) device or another computing block.
- Network communications are **generally much slower** than the other types of communications mentioned previously.
  - While the frontside bus can transfer dozens of Gigabits per second, the network is limited to the order of several dozen megabits.

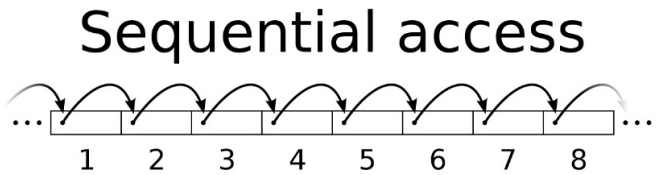
Mare Nostrum III Supercomputer Network

Bus Performance I – Bandwidth / Bus Width / Bus Frequency

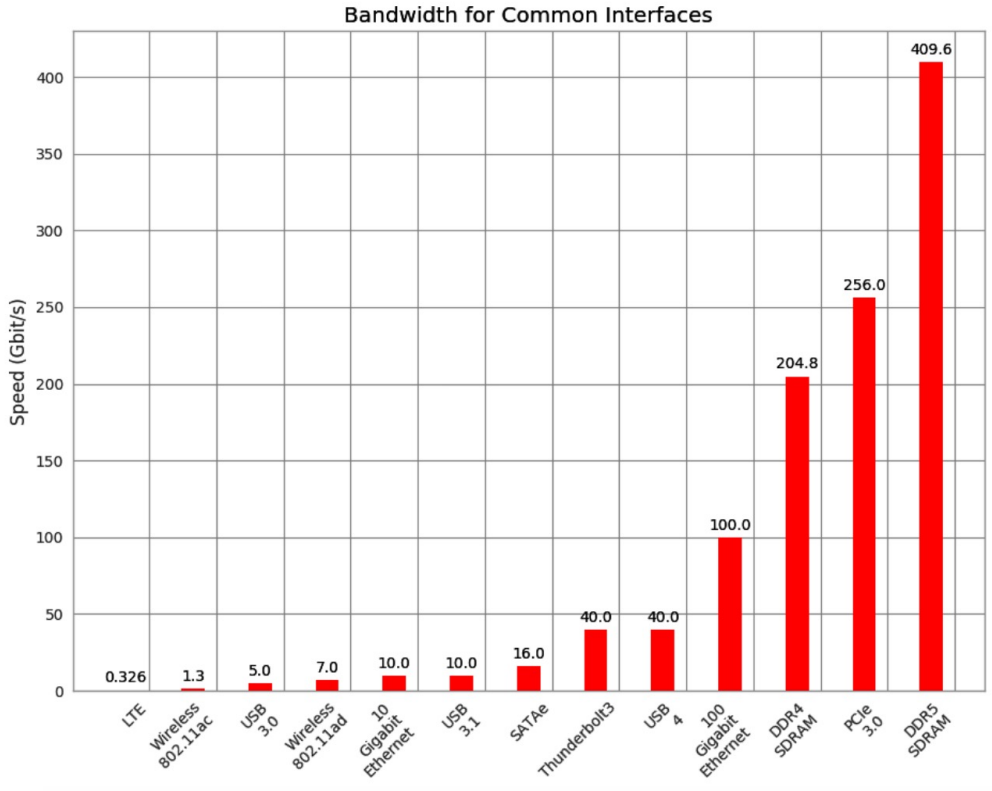
- The main property of a bus is its speed: how much data it can move in a given amount of time (**bandwidth).**
- This property is given by combining two quantities:
  1. How much data can be moved in one transfer (**bus width**)
  2. How many transfers the bus can do per second (**bus frequency**)
- Network are also characterized by latency (as we described in the memory system lecture)

Bus Performance II

- The data moved in one transfer is always sequential
  - a chunk of data is read off of the memory and moved to a different place.
- The speed of a bus is broken into bus width and frequency because individually they can affect different aspects of computation
  - **a large bus width can help vectorized code** (or any code that sequentially reads through memory) by making it possible to move all the relevant data in one transfer
  - Having a small bus width but a very high frequency of transfers can help code that must do **many reads from random parts of memory.**



Communication Layers Performance



To Summarize

- Communication layers connect different computer systems components or devices
- The most common communication layer is the bus (nodes are connected to a single link).
- Example of communication layers are the frontside bus, buses (PCI) to connect to accelerator boards and storage system, networks.
- The communication layer performance is characterized by latency, bandwidth (combining the bus width and frequency)