Multiprocessor

Chapter - 9

Introduction

- **Multiprocessor:**
- -- A multiprocessor is a composed of many single chip uniprocessors.

Why multiprocessor?

- Software is scalable: can be designed with a variable number of processors. So, some multiprocessors can support operation in the presence of broken hardware (if a single processor fails in a multiprocessor with n processors, the system provides continued service with n-1 processors).
- May have the highest absolute performance – **FASTER THAN THE FASTEST UNIPROCESSOR.**
- **Most cost effective processor.**

- **Parallel Processing program:**
  - A single program that runs on multiple processors simultaneously.

- **How do parallel processors share data?**
  - Shared-memory processor
  - Message passing

- **Shared-memory processor**
  - Offer the programmer a single memory address space that all processors share.
  - Processor communicate through shared variables in memory, with all processors capable of accessing any memory location via loads and stores.
  - **Come in two states:**
    - Uniform memory access (UMA) multiprocessor or Symmetric multiprocessor (SMP)
    - Nonuniform memory access (NUMA) multiprocessor.

- **Uniform memory access (UMA) multiprocessor or Symmetric multiprocessor (SMP):**
  - Takes the **same time to access main memory** no matter which processor requests it and no matter which word is asked.
- **Nonuniform memory access (NUMA) multiprocessor:**
  - Some memory accesses are faster than others depending on **which processor asks for which word.**
  - More programming challenges to get highest performance. But NUMA machines can scale to larger sizes and hence are potentially higher performance.

- **How do parallel processors coordinate when operating on shared data?**
  - Coordination is must, otherwise one processor could start working on data before another is finished with it.
  - This coordination is called **synchronization**.
  - **Lock:** (When sharing is supported with a single address space) Only one processor at a time can acquire the lock, and other processors interested in shared data must wait until the original processor unlock the variable.

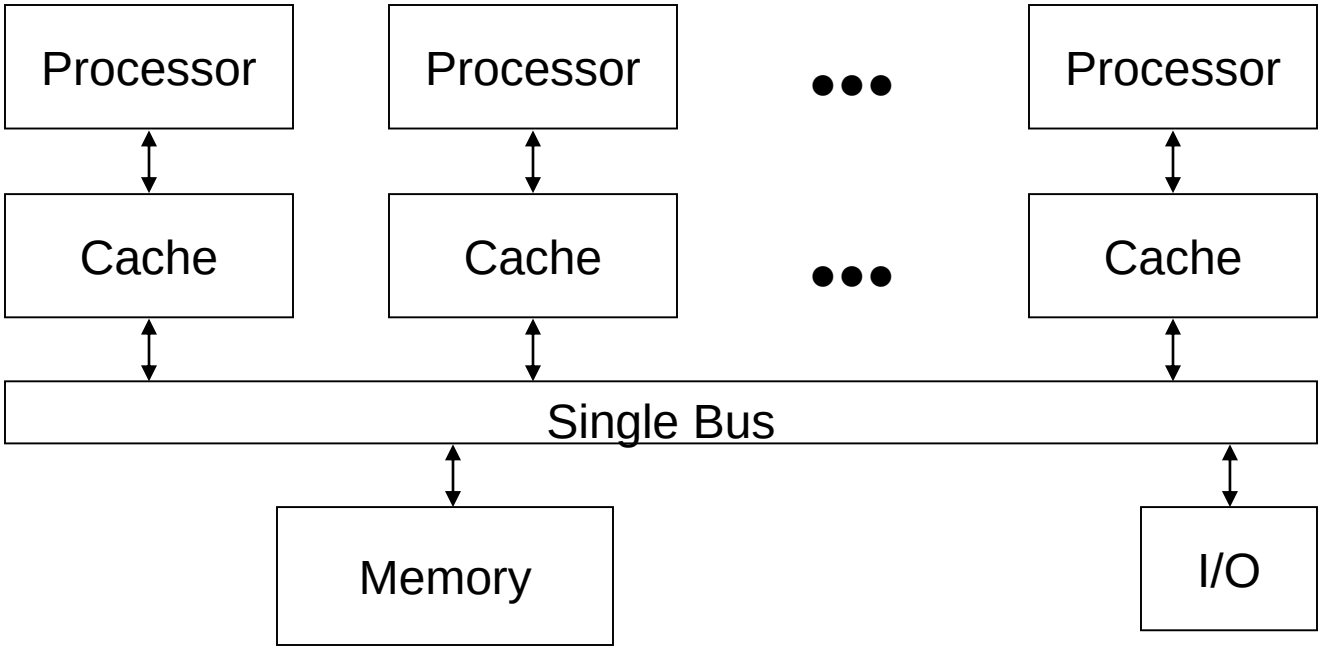
- **Message passing:**
  - Uses message passing for communicating among processors.
  - Required for machines with private memories in contrast to shared memory.
  - Example: processors in different computers communicating by passing messages over a local area network (LAN).

Programming Multiprocessors

- **Why should parallel processing programs be so much harder to develop than sequential programs?**
  - We must get good performance and efficiency from the parallel program on a multiprocessor.
  - The programmer must know a good deal about the hardware.

- **Multiprocessors are constructed in two basic organizations:**
  - Processors connected by a single bus.
  - Processors connected by a network.

Multiprocessors connected by a single bus



- Traffic per processor and the bus bandwidth determine the useful number of processors
- Caches reduce the latency on data and reduce the memory traffic on the bus

Multiprocessors connected by a single bus

- Several multiprocessors can usefully be placed on a common bus for several reasons:
  - Each multiprocessor is much smaller than a multichip processor.so, more processors can be placed on a bus.
  - Caches can lower bus traffic.
  - Mechanisms were invented to keep caches and memory consistent for multiprocessors.

Multiprocessor Cache Coherency

- **The most popular cache coherency protocol: Snooping.**
  - All cache controller monitor, or snoop, on the bus to determine whether or not they have a **copy of the shared block.**
  - Caches were added to **improve the performance of each processor**. Have to keep the caches up to date by snooping on the information over that shared bus.
  - Maintaining coherency has two components**: read and write**.
  - Multiple copies are not a problem when reading, but a processor must have exclusive access to write a word. Processors must have a recent copy when reading an object, so all processors must get new values after a write.

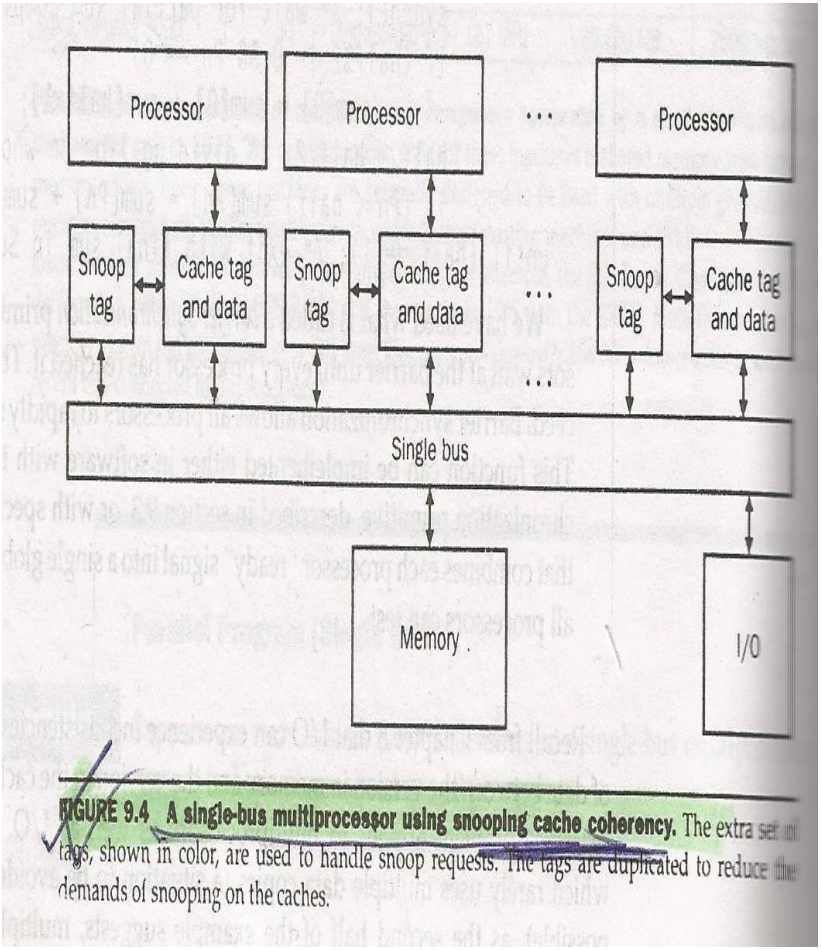


FIGURE 9.4 A single-bus multiprocessor using snooping cache coherency. The extra set of tags, shown in color, are used to handle snoop requests. The tags are duplicated to reduce the demands of snooping on the caches.

Multiprocessor Cache Coherency

Snooping protocol are of two types, depending on what happens on a write:

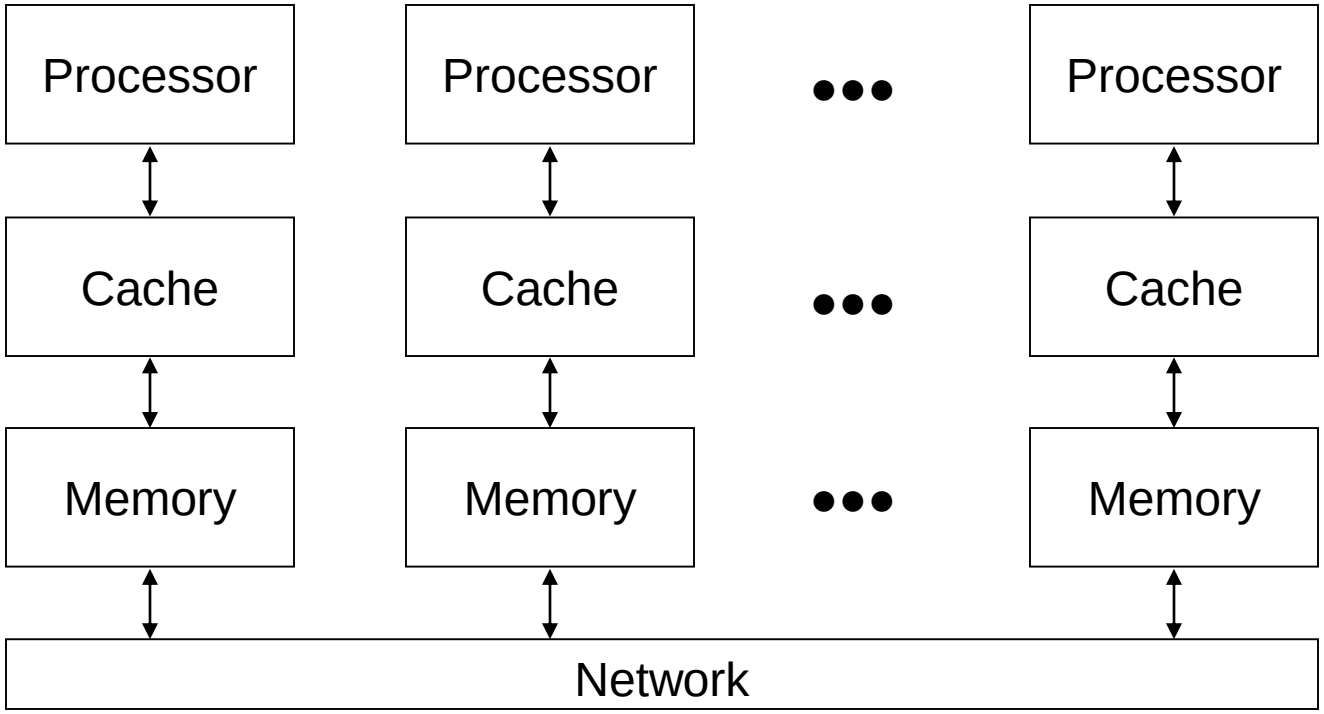
Write-invalidate:

- The writing processor issues an invalidation signal over the bus and all caches check to see if they have a copy, if so they must invalidate the block containing the word. Thus, it allows **multiple readers but only a single writer**.

Write-update (write-broadcast):

- The writing processor broadcasts the new data over the bus, all copies are then updated with the new value. Write update is like write through because all writes go over the bus to update copies of the shared data.

Multiprocessors connected by a Network



- Memory is attached to each processor.
- The connection medium- the network – between these combined nodes.
- Use distributed memory (when physical memory is divided into modules and it also refers the physical location of the memory).

Multiprocessors connected by a single bus	**Multiprocessors connected by a network**
The connection medium – the bus – is between the processors and memory	Memory is attached to each processor, and **the connection medium** – the network – is between these combined nodes
The medium is used on every memory access	It is used only for inter processor communication
Shared memory or centralized memory	Distributed memory

Multiprocessors connected by a Network

- **Disadvantages of Single-bus design:**
  - Attractive, but limited because the three desirable bus characteristics are incompatible: **high bandwidth, low latency, and long length.**
  - There is also a limit to the bandwidth of a single memory module attached to a bus.
  - Thus, a single bus imposes practical constraints on the number of processors that can be connected to it.
  - If the goal is to connect many more processors together, then the computer designers needs to use more than a single bus or use multiprocessors connected by a Network

Clusters

- A computer cluster is a group of linked computers, working together closely so that in many respects they form a single computer.
- Components of a cluster are commonly, but not always, connected to each other through fast local area networks.

Clusters

- Drawbacks:
  - The cost of administering a cluster of N machines is about the same as the cost of administering N independent machines, while the cost of administering a shared address space multiprocessor with N processors is about the same as administering a single machine.
  - Clusters are usually connected using the I/O bus of the computer, whereas multiprocessors are usually connected on the memory bus of the computer. Memory bus has higher speed.
  - A cluster of N machines has N independent memories and N copies of the OS, but a shared address multiprocessor allows a single program to use almost all the memory in the computer.

- **Advantages of Server Clustering**
- clustering is specifically designed for high availability solution. In case, if a computer is having a problem another computer from the cluster takes over the computer having issue. This ensures the high availability of the web applications.
- clustering is completely a scalable solution. Resources can be added to the cluster accordingly.
- If a dedicated computer from the cluster requires maintenance, it can be stopped while other computers handles its load. Thus, makes the maintenance more easier. The clustered computers can be configured and managed easily without any trouble.

- **Disadvantages of Server Clustering**
- clustering usually requires more servers and hardware to manage and monitor, thus, increases the infrastructure. Some web hosting providers may afford it.
- clustering is not much flexible, as not all the server types can be clustered. There are many applications which are not supported by the clustered design.
- It is not a cost-effective solution, as it needs a good server design which can be a bit expensive.

MEMORY INTERLEAVING

- A category of techniques for increasing memory speed. For example, with separate memory banks for odd and even addresses, the next byte of memory can be accessed while the current byte is being refreshed.