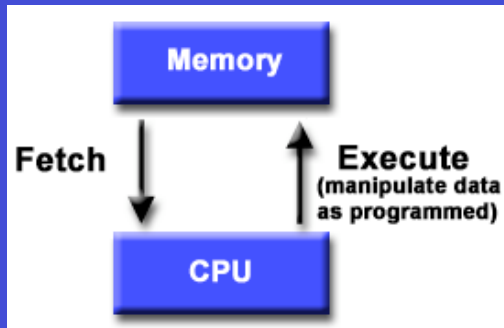


Parallel Machine Models: von Neumann

von Neumann computer

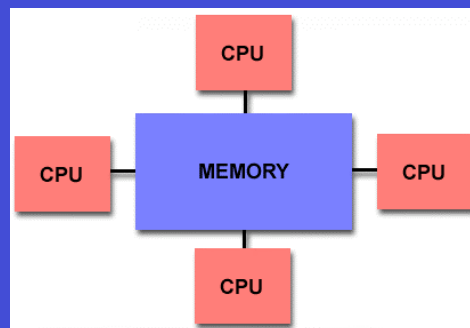


- (named after Hungarian mathematician John von Neumann)
- “stored program” concept: CPU executes sequence of instructions = read/write to memory
- Memory stores both program and data
- Instructions are coded data
- CPU gets instructions, decodes, and sequentially performs them

Parallel Machine Models: Shared Memory

Shared memory

- Many different varieties
- Multiple processors operate independently but access global memory space
- Changes in a memory location visible to all processors
- UMA – uniform memory access = SMP (symmetric multiprocessor)
 - Everything identical
 - Equal memory access
- NUMA – non-uniform
 - unequal access to memory
 - linked SMPs
- ISSUE: cache coherence

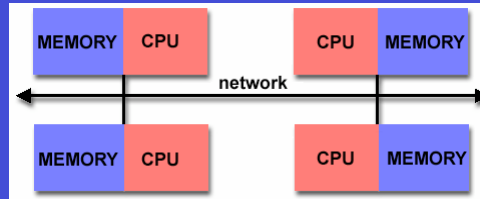


- ✓ User friendly
- ✓ Fast access: $O(1)$ connectivity
- × Lack of scalability (buses)
- × Synchronisation
- × Expense for large machines

Parallel Machine Models: Distributed Memory

- Many different varieties
- Processors have local memory
- Require communication network to connect processor memory
- No global address space: all separate
- Data from one proc must be communicated to another if required
- Synchronisation is programmer's responsibility
- Network fabric varies greatly!

Distributed memory

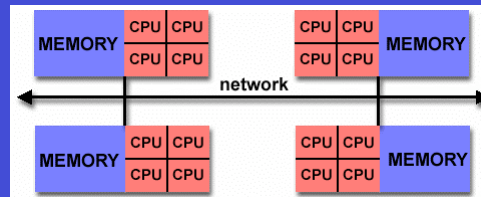


- ✓ Very scalable
- ✓ LOCAL memory access rapid
- ✓ No cache coherence
- ✓ Use commodity processors
- × Lot of programmer responsibility!
- × NUMA times

Parallel Machine Models: Hybrid Memory

- Biggest machines today have both.
- Shared memory component of cc-UMA SMP
- Distributed network of these
- Advantages and disadvantages are those of the individual parts!

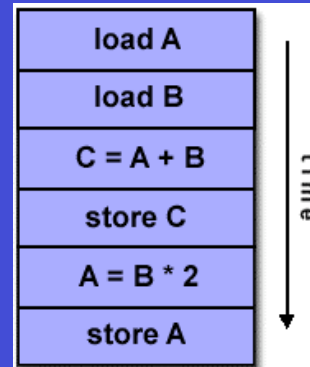
Hybrid



Flynn's Taxonomy: SISD

Single Instruction, Single Data:

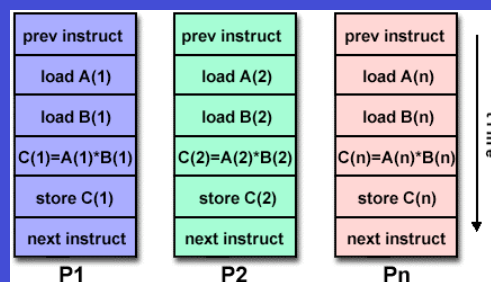
- A serial (non-parallel) computer
- Single instruction: only one instruction stream is being acted on by the CPU during any one clock cycle
- Single data: only one data stream is being used as input during any one clock cycle
- Deterministic execution
- This is the oldest and until recently, the most prevalent form of computer
- Examples: most PCs, single CPU workstations and mainframes



Flynn's Taxonomy : SIMD

Single Instruction, Multiple Data:

- * A type of parallel computer
- * Single instruction: All processing units execute the same instruction at any given clock cycle
- * Multiple data: Each processing unit can operate on a different data element



- * This type of machine typically has an instruction dispatcher, a very high-bandwidth internal network, and a very large array of very small-capacity instruction units.

- * Best suited for specialized problems characterized by a high degree of regularity, such as image processing.

- * Synchronous (lockstep) and deterministic execution

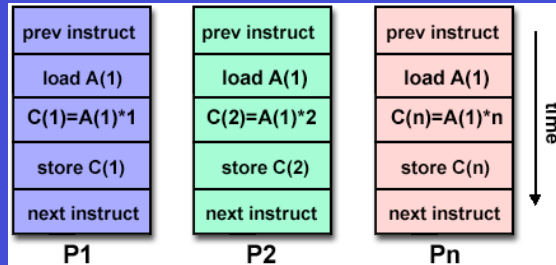
- * Two varieties: Processor Arrays and Vector Pipelines

- * Examples:

- o Processor Arrays: Connection Machine CM-2, Maspar MP-1, MP-2
- o Vector Pipelines: IBM 9000, Cray C90, Fujitsu VP, NEC SX-2

Flynn's Taxonomy : MISD

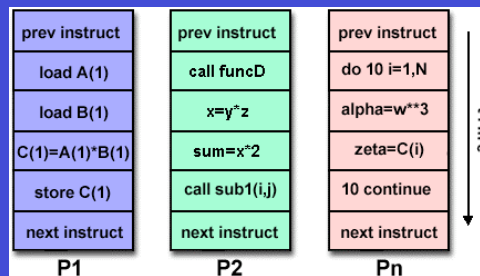
Multiple Instruction,
Single Data :



- * A single data stream is fed into multiple processing units.
- * Each processing unit operates on the data independently via independent instruction streams.
- * Few actual examples of this class of parallel computer have ever existed. One is the experimental Carnegie-Mellon C.mmp computer (1971).
- * Some conceivable uses might be:
 - o multiple frequency filters operating on a single signal stream
 - o multiple cryptography algorithms attempting to crack a single coded message.

Flynn's Taxonomy : MIMD

Multiple Instruction, Multiple Data:



- * Currently, the most common type of parallel computer. Most modern computers fall into this category.
- * Multiple Instruction: every processor may be executing a different instruction stream
- * Multiple Data: every processor may be working with a different data stream
- * Execution can be synchronous or asynchronous, deterministic or non-deterministic
- * Examples: most current supercomputers, networked parallel computer "grids" and multi-processor SMP computers - including some types of PCs.