Flynn’s Taxonomy

Classification based on instruction and data streams

- SISD – single instruction & single data stream
- MISD – multiple instruction streams & one data stream
- SIMD – single instruction stream & multiple data streams
- MIMD – multiple instruction streams & multiple data streams

- Flynn introduced this scheme in a 1972 paper

  Does not cover topology or interconnection techniques

SISD Systems

An instruction stream is a sequence of instructions

Fetched using a single program counter register

- SISD systems execute instructions sequentially
- Pipelining or multiple execute units may be used

Data operands are obtained one at a time from memory as a single stream of values

SIMD Systems

A single instruction stream is applied to multiple data

- Includes vector type instructions
- MMX multi-media extensions (Intel processors)
- A single control unit fetches and decodes instructions
- Multiple PEs act on separate operands in parallel
  - PEs are processing elements

Operands can be sub-sets of bits within a word or register

MISD Systems

Multiple instruction streams act on one data stream

- Few, if any, systems follow this model

A possible use is in highly fault tolerant systems

- Multiple processors produce results from the same data
- Majority vote determines the result used
- Example use is in fly-by-wire aircraft

MIMD Systems

Multiple instruction streams act on multiple data streams

- Multiple instructions are fetched and decoded in parallel
- Instructions may be vector or scalar type
- Each control unit directs one or more execute units (PEs)

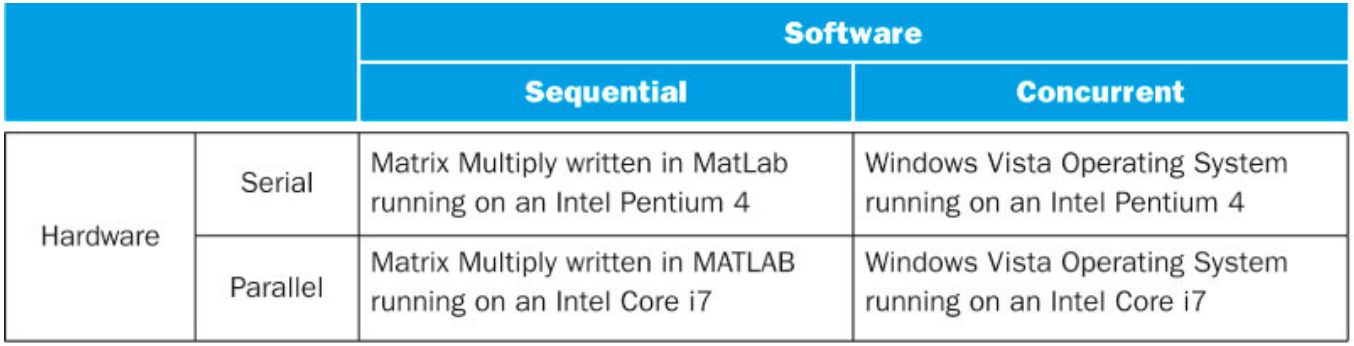
Based on shared memory or on message passing

- May employ board level or chip level multiprocessors
- Chip level multiprocessors are also called multi-core
- Distributed systems require a high speed interconnect
- The interconnection scheme determines the topology

MIMD Systems

Collaborating programs can run on different processors

- One program can run on all processors of a MIMD system
- Conditional statements determine when different processors should execute different sections of the program
- This is known as SPMD (single program multiple data)



		Software	
		Sequential	**Concurrent**
Hardware	Serial	Matrix Multiply written in MatLab running on an Intel Pentium 4	Windows Vista Operating System running on an Intel Pentium 4
	Parallel	Matrix Multiply written in MATLAB running on an Intel Core i7	Windows Vista Operating System running on an Intel Core i7

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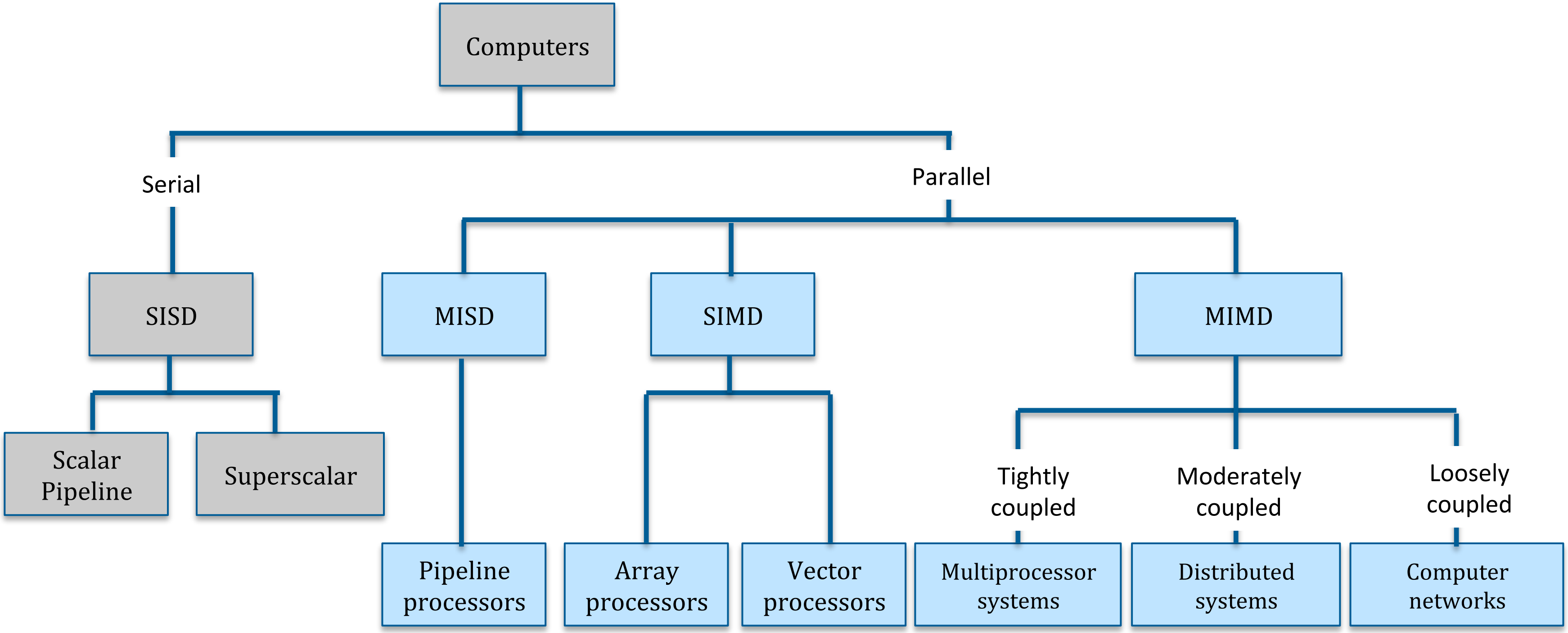
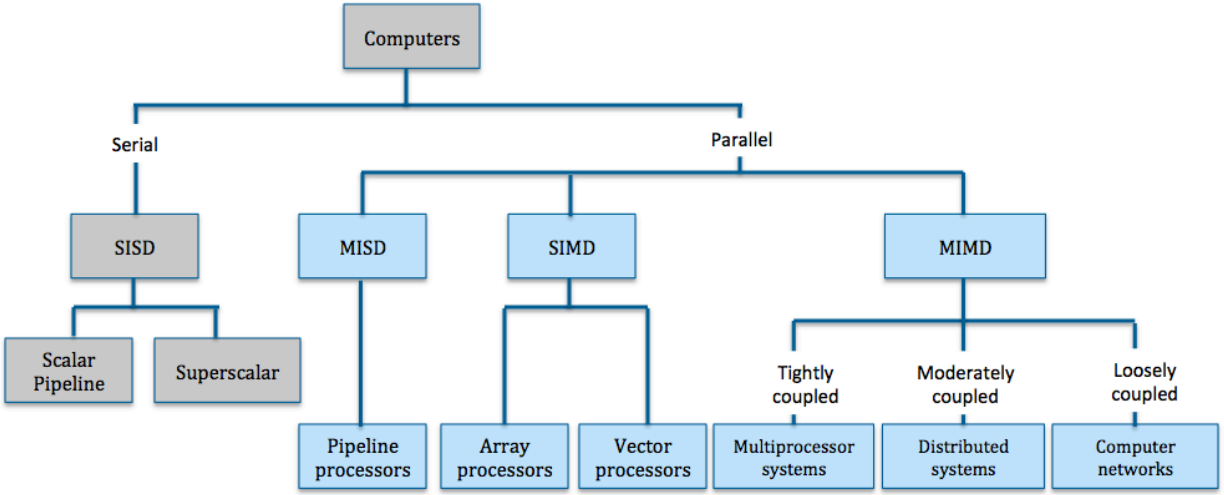


Multiprocessor Coupling

Multiprocessors can contain thousands of PEs

- Typically many fewer PEs are used due to coupling issues
- Goal is to efficiently increase performance
  - Avoid extremely high clock rates
  - Reduce heat and power dissipation

Coupling describes the degree of interconnection



Multiprocessor Coupling

- Loosely coupled systems employ message passing
  - Exchange data slowly relative to CPU clock speed
  - Connecting via the internet is one extreme example
  - Granularity of data is high (entire files)

- Tightly coupled systems use shared memory
  - Provide high data bandwidth and low latency
  - Use fine grained granularity
  - Processors can operate on the same data structure
    - For example: on different elements within an array

Multiprocessor Coupling

- There are issues related to sharing memory
  - Synchronization
  - Cache consistency
  - Access order

- These issues will be addressed later