Parallel Computing

18 January 2007
CMPT370
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- *Lab1 extended to next Tues 23Jan*
- *Cygwin install notes on ide_policy.html*

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Review of last time

- UI design principles:
  - Know your users
  - Be consistent
  - Use metaphors carefully
  - Use multiple levels of complexity
  - Always show the current state of the program

Some UNIX / Cygwin tips

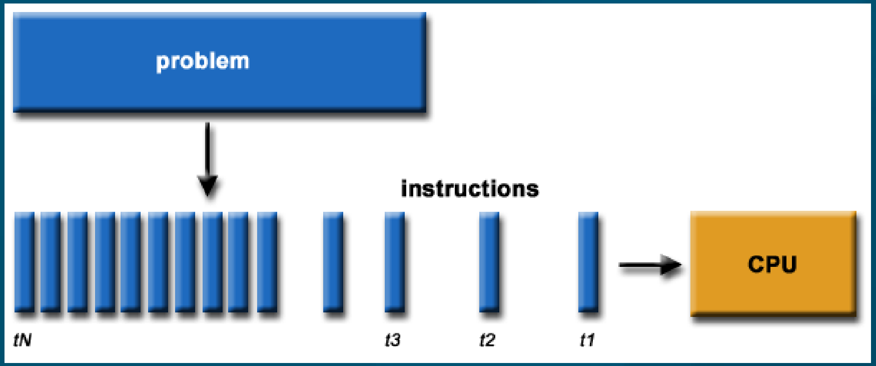
- Cygwin has command and filename completion:
  - Type first few characters and press <Tab>
- Job control:
  - When a program (e.g., fluid) is running, press Ctrl-Z in the Cygwin window to suspend it
  - Type "fg" to resume the suspended job
  - Or "bg" to let it run in the background
  - Use ampersand: "fluid &" to run in bg
  - "jobs" to show all current jobs

What's on for today

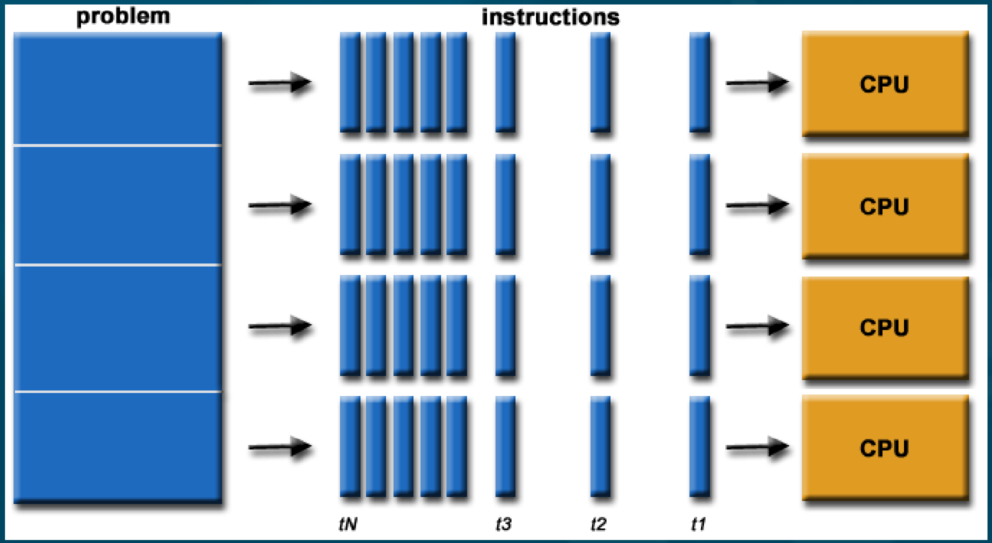
- Parallel computing concepts
  - Why do parallel?
  - vonNeumann abstraction: instructions, data
  - Flynn's taxonomy: SISD, SIMD, MISD, MIMD
  - Terms, measuring speedup
  - Design issues
- See tutorial from LLNL (Livermore) supercomputing centre

Parallel computing

- Sequential computing:
  - Divide task into instructions
  - 1 CPU executes serially



- Parallel computing:
  - Multiple tasks
  - Multiple CPUs execute in parallel
- Accomplish more in the same amount of time

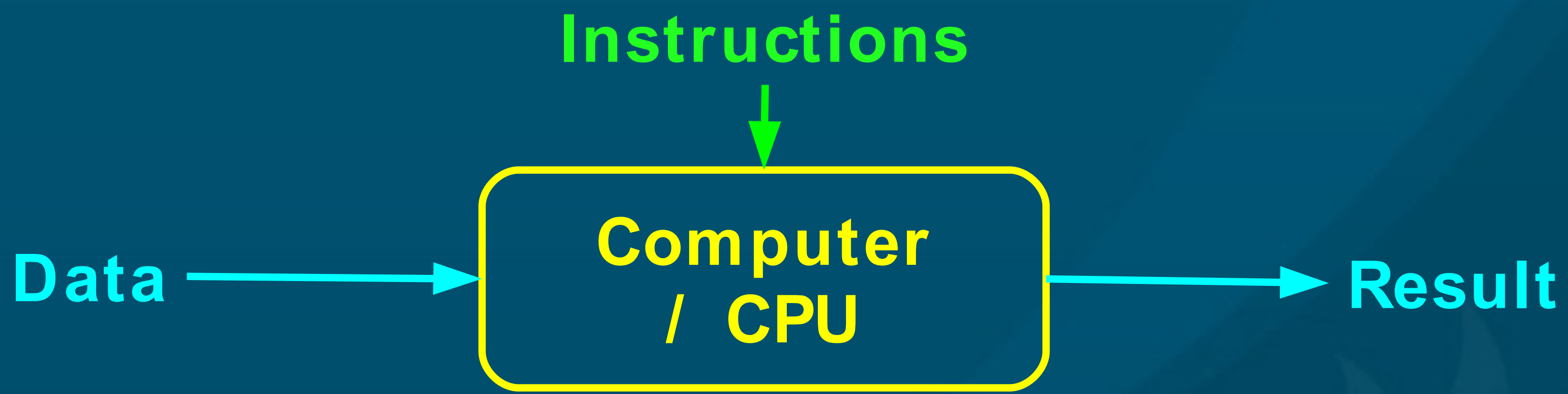


Applications of parallel computing

- Large, compute-intensive problems that can be divided up in some way
  - Weather modelling
  - Aircraft design / computational fluid dynamics
  - Modelling nuclear reactions
  - Protein folding, drug binding sites
  - 3D rendering
  - Large-scale satellite / medical image analysis
  - High-visibility website (Amazon, Google, etc.)
  - Data mining

Instructions and data

- Computers since the 1960s have used the (John) vonNeumann model of computing:



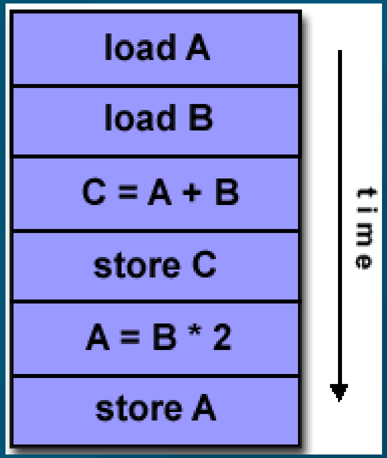
- CPU follows instructions to operate on data
- vonNeumann's abstraction:
  - Instructions and data both stored in memory
  - Self-modifying code: rewrites own instructions

Flynn's taxonomy

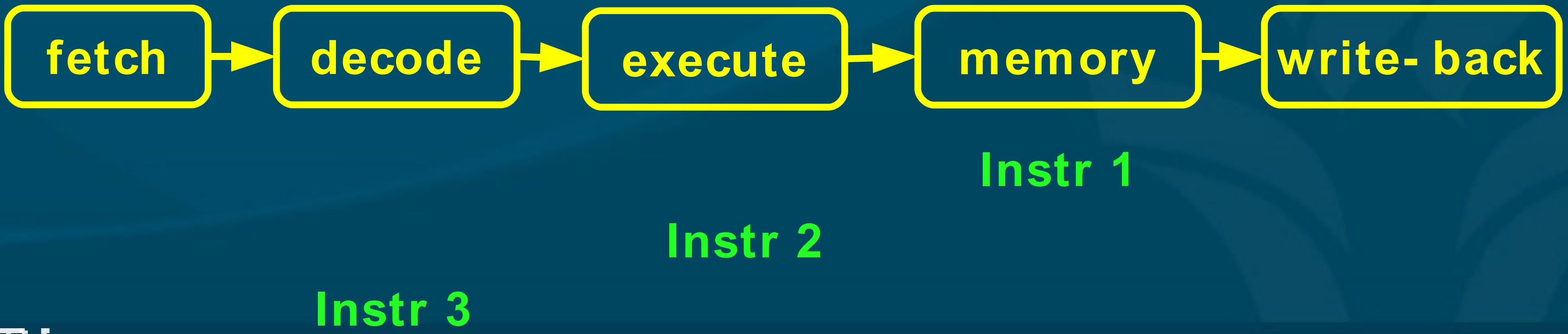
SISD: Single instr Single data	**SIMD**: Single instr Multiple data
MISD: Multiple instr Single data	**MIMD**: Multiple instr Multiple data

- Multiple data: divide up the problem by data
  - Each processor operates on a chunk of data
- Multiple instructions:
  - Each processor does a different task

SISD: single instr, single data

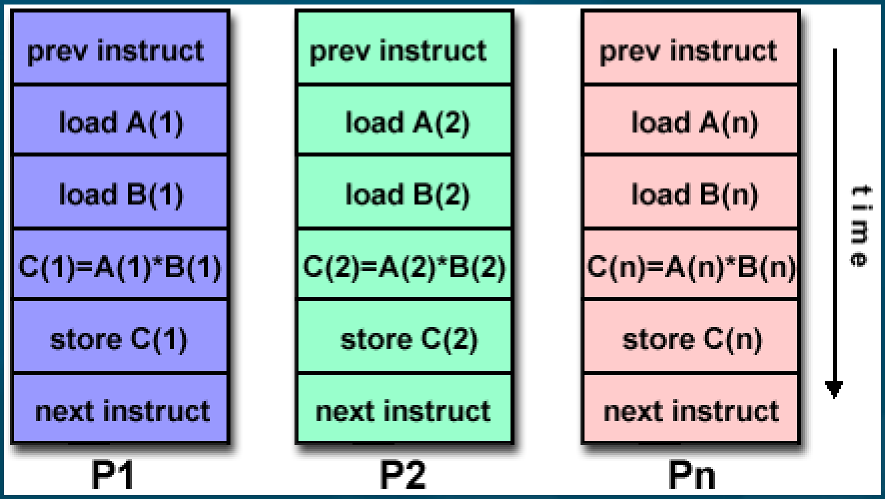


- SISD is the classical uniprocessor situation
  - Serial execution
- Processing can still be pipelined:
  - Each instruction has multiple parts
  - Each part is done by a different CPU component



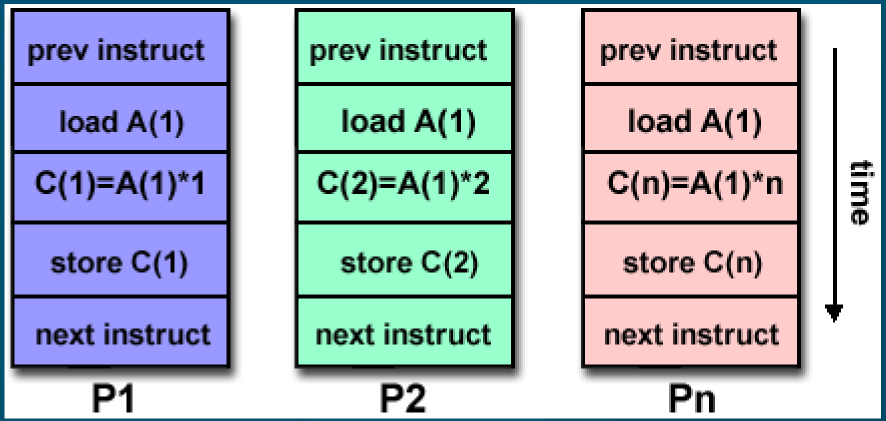
SIMD: single instr, multiple data

- SIMD: same operations on multiple data in parallel
  - Quite common on today's CPUs
  - Intel MMX, SSE, Apple Altivec
  - CM-2, Cray C90
- Vector processing: perform one operation on a whole vector of numbers
  - Add two RGBA values (128 bits each)

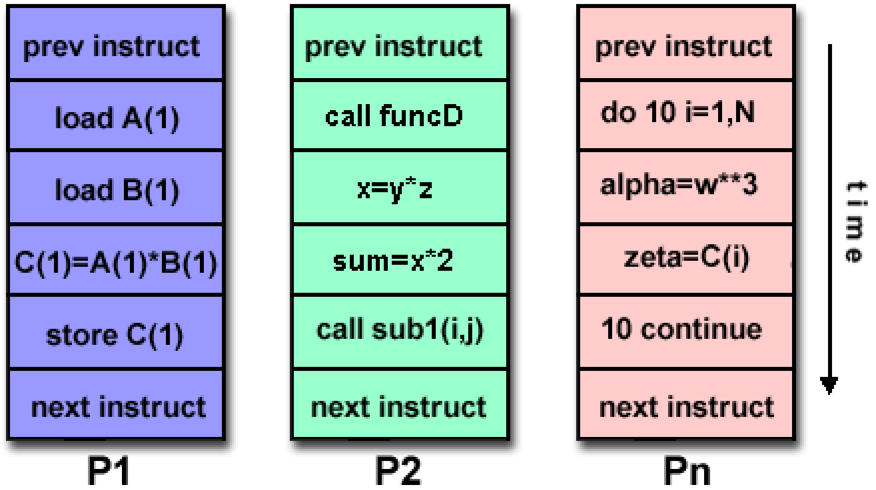


MISD: multiple instr, single data

- MISD:
  - Run the same data through different programs in parallel
  - Not often seen in hardware
  - Potential applications:
    - One encrypted message to crack; try several algorithms in parallel
    - One satellite image to process; run several image processing filters in parallel



MIMD: multiple instr, multiple data



- MIMD:
  - Each processor is independent, runs its own task on its own data
- "Parallel computer" usually means MIMD
  - Most modern supercomputers
  - Dual-core (e.g., carmel Xeon)
- MIMD is most flexible, but also most complex:
  - Synchronization between processors
  - Shared memory access

Measuring speedup

- A parallelizable task can be broken up into discrete tasks (SIMD/ MIMD), one per processor
- The parallel speedup is:

  (serial execution time) / (parallel execution time)

- Ideal speedup is linear with # processors
- Reality is not so sweet:
  - Overhead in setting up parallel tasks
  - Communication between processors
  - Synchronization points mean waiting for slowest task

Design issues in parallel computing

- Memory model
  - Shared: all CPUs access same memory (SMP)
  - Distributed: each CPU local memory (cluster)
- Granularity: how often to communicate?
  - Coarse: lots of computation between communication events
  - Fine: processors frequently talk to each other
- Scalability
  - How many processors do you want to scale to?
  - Communications network?

TODO

- Lab1 due date extended to next Tues 23Jan
  - Design + implement your own FLTK program
  - Lab write-up
  - Should be somewhat "useful"