CSE141 Winter 2014

Discussion Section 1: MIPS and Performance
Administrative

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- Mailing List
- Homework due Friday!
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Overview of MIPS

- 32-bit [4 byte] fixed-size instructions
- 3 instruction formats:
  - r-type [register: room for 3 register names]
  - i-type [immediate: 16-bit immediate]
  - j-type [jump: 26-bit target]
- 32 32-bit general purpose registers.
- special registers:
  - $0 = $zero [always zero]
  - $31 = $ra [return address]
  - $29 = $sp [stack pointer]
- branches are pc-relative, jumps are direct
Performance

- Latency vs. Throughput
- CPI/IPC
- How do you calculate execution time given:
  - IPC: Instructions per Cycle
  - IC: Instruction Count
  - CPI: Cycles per Instruction
  - CCT: Clock cycle time in seconds/cycle
- Execution Time = IC * CPI * CCT
# Units

<table>
<thead>
<tr>
<th>Name</th>
<th>Measured In...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Execution Time</td>
<td>seconds</td>
</tr>
<tr>
<td>CPI</td>
<td>cycles/instruction</td>
</tr>
<tr>
<td>IPC</td>
<td>instructions/cycle</td>
</tr>
<tr>
<td>Clock Rate = Frequency</td>
<td>cycle/second = hertz</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>seconds/cycle</td>
</tr>
<tr>
<td>Giga/Mega/Micro/Nano</td>
<td>10e9/10e6/10e-6/10e-9</td>
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Amdahl's Law

- Achievable speedup from using parallel processors on a problem vs. one serial processor
  - Speedup(S) = \frac{T(1)}{T(j)}
  - \frac{[\text{Time to execute the program with 1 processor}]}{[\text{Time to execute the program with } j \text{ processors}]}$

- Portion of the program [P], Speedup [S]

$$\frac{1}{(1 - P) + \frac{P}{S}}$$
Example 1:

1) 30% of a program is speed up by a factor of 2, what is the overall improvement?

\[
\frac{1}{(1 - P) + \frac{P}{S}} = \frac{1}{(1 - 0.3) + \frac{0.3}{2}} = 1.1765
\]
Example 2:

How long will it take to execute one billion instructions on a 100MHz processor with an average CPI of 2?

\[
1 \cdot 10^9 \cdot \frac{2\text{cycles}}{1\text{instruction}} \cdot \frac{1\text{second}}{100 \cdot 10^6\text{cycles}} = 20\text{seconds}
\]