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Introduction to High Performance Computing
Term 2014/2015 (Winter)

Exercise 3

- **Return electronically until Monday, 10.11.2014 23:55**
- **Include name on the top sheet. Stick several sheets together.**
- **A maximum of two students is allowed to work jointly on the exercises.**

3.1 Moores Law

- Apply Moore's Law (or one of the derived ones, see lecture) to the currently fastest supercomputer worldwide (see http://www.top500.org). In which year will the performance of the fastest supercomputer exceed one Exaflop? (1 Exa = 10^{18} or 1000 Peta)
- Determine the growth rate of the TOP500 list by using the fastest system from 11/2007 and 1/2011. According to this growth rate, when (which year) will a supercomputer exceed one Exaflop?

(5+5 points)

3.2 Amdahl's Law

- The CPU of a webserver is to be improved. For web applications, the new CPU is 10 times faster than the old one. Consider the case that the old CPU is spending 40% of its execution time for calculations and the remaining time for IO, which performance improvement can be expected according to Amdahl's law?
- A common floating-point (FP) operation is the square root operation (FPSQR). In a complex calculation, 20% of the execution time is spent for calculating square roots. For an optimization, two possibilities do exist: (1) Improve only the implementation of FPSQR, so that it is accelerated by a factor of 10. (2) Improve all FP operations by a factor of 1.6. Assume that half or the execution time is spent for FP operations. Compare both alternatives and identify the optimal solution.
- An application is to be implemented as parallel program for an execution on 128 processors. In order to achieve a speedup of 100x, how big (in percent) can the serial fraction of the application be?

(5+5+5 points)

3.3 Measure Latency

- Latency is a very important metric for an interconnection network. There are two kinds of latencies:
  1. Full round-trip: Time between sending (source) and receiving an appropriate response (source). Because different nodes have no shared clock this is the only possibility to determine the time required for a message exchange.
  2. Half round-trip: The full round-trip latency divided by two. This is usually the amount of time refered to as latency.

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- Write a MPI ping-pong test program to measure the roundtrip latency. Execute your program both on one node (with two processes) and on two nodes of the creek[01-08] cluster. Choose two idle nodes for measurement. Do your experiments with several message sizes e.g. 1KB, 2KB, 4KB, 8KB, … , 1MB. Vary the message size within your program. Choose an appropriate number of iterations to yield stable results.
- Plot your results for several message sizes in a graph and interpret them. Do the same for execution on one and two nodes.

(25 points)

3.4 Measure Bandwidth

- Another metric for interconnection networks is bandwidth. Bandwidth describes how many data can be transferred within a given time.
- To measure bandwidth you have to write another MPI test program called flood test. Send as much data to another process as possible. You should vary the message size in the same way as described in exercise 1.3. Execute your program both on one and on two nodes (choose two idle nodes of the creek[01-08] cluster).
- Write two flood test programs by using different MPI send operations:
  1. non-blocking send
  2. blocking send
- Plot your results for several message sizes in a graph and interpret them. Choose an appropriate number of iterations to yield stable results. Compare the bandwidth of blocking MPI send and non-blocking MPI send. Do the same for execution on one and two nodes. Do you observe a difference between message sizes and if so why?

(30 points)

Total: 80 points