Master Program in Computer Science and Networking

High Performance Computing

2012-13

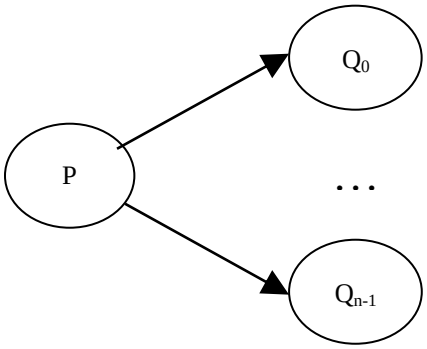
Homework 4

Submit the written answer. Deadline: lecture of October 22, or send an *e*-mail. The work has to be discussed at Question Time.

All the answers must be properly and clearly explained.

Question 1

Consider a computation Σ with the following OR-graph structure:



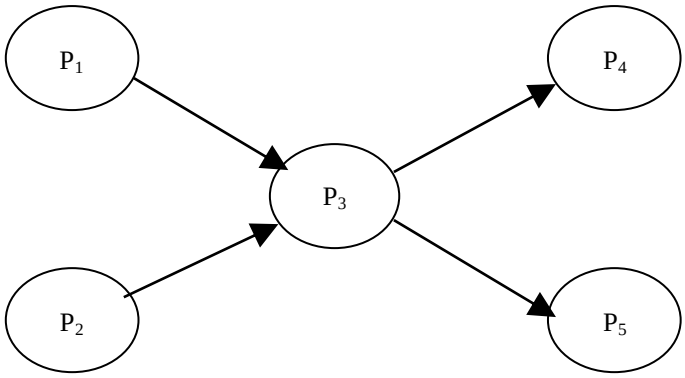
Module P produces a stream of elements with interdeparture time T_P. For $i = 0 \ldots n-1$, let T_i be the ideal service time of Q_i, and p_i the probability that an element is sent from P to Q_i, with $\sum_{i=0}^{n-1} p_i = 1$.

Derive formally the relation among T_p, $\{T_i\}$, $\{p_i\}$ such that the effective bandwidth of Σ is equal to the ideal bandwidth.

Provided that such relation among T_p, $\{T_i\}$, $\{p_i\}$ holds, evaluate the ideal service time, effective service time, and relative efficiency of Σ, P, Q_0, …, Q_{n-1}.

Question 2

Consider a computation Σ with the following OR-graph structure:



The computation has to be executed on a parallel architecture with N = 32 processing nodes, each node with clock cycle τ and communication processor. Moreover $T_{setup} = 10^3\tau$, $T_{transm} = 10\tau$.

Module P_1 encapsulates an array *A[M]* of integers. For *each i = 0 ... M-1*, P_1 sends the value *G(A[i])* to P_3. Function *G* has an average calculation time of $4*10^3\tau$. Module P_2 is identical to P_1.

Module P_3 encapsulates an array *B* of 10^4 integers. For each received element *x*, P_3 computes the integer value *max* as follows:

```
max = 0; c = 0;
for (i = 0; i< 10000; i++) {
        c = c + x * B[i];
        if (c > max)
                max = c
        }
```

The final value of *max* is sent to P_4 or to P_5 with the same probability. A *for* iteration has an average calculation time equal to 10τ.

P_4 executes a function with average calculation time $10^3\tau$.

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a) Evaluate the ideal service time, effective service time, and relative efficiency of Σ, P_1, P_2, P_3, P_4, P_5, and the completion time of Σ, without further parallelization of modules.

b) Evaluate the ideal service time, effective service time, and relative efficiency of Σ, P_1, P_2, P_3, P_4, P_5, and the completion time of Σ, trying to eliminate/reduce possible bottlenecks. In so doing, *all the feasible parallelization versions* must be studied, evaluated and compared.

Question 3

Consider the following sequential program:

```
int A[M], B[M];
for (i = 0; i< M; i++)
        for (j = 0; j< M; j++)
                A[i] = F (A[i], B[j])
```

The initial values of arrays A and B are local variables of a module IN. At the end of the computation the new value of array A is assigned to a local variable of a module OUT.

a) Explain how it can be parallelized by the data-parallel *map* paradigm: which modules compose the parallel program, what is the behavior of each component module, which collective communications are used, how the data structures are organized, and how the optimal degree of parallelism is determined.

Design *all* the modules by LC concurrent language.

b) The same questions of *a)* for a data-parallel *stencil* paradigm.