Master Degree Program in Computer Science and Networking

High Performance Computing

2014-15

Homework 7

All the answers must be properly and clearly explained.

Exercise 1 (*Virtual Processors*):

For the following sequential program:

```
int A[M]; int B[M][M]; int x; bool y;
for i = 0 to M-1 do
      for j = 0 to M-1 do
          A[j] = F(A[j], B[i][j]);
y = true;
for i = 0 to M -1 do y = y AND if (A[i] > x)
```

where *y* is the returned result, determine a Virtual Processors parallelization.

Exercise 2 (*Parallel Prefix*):

Let us consider the following sequential computation:

```
int A[M], B[M];
B[0] = A[0];
for i = 0 to M – 1 do B[i] = A[i] + B[i – 1]
```

Verify that it can be implemented as a parallel prefix. Determine the Virtual Processors and parallelize the computation according to the Data Parallelism paradigm. Write the cost model of the completion time as a function of the number of Workers *n*.

Exercise 3 (*Parallelization*):

A computation Σ, with the OR-graph structure shown in Fig. 1, is executed on a parallel architecture with N = 32 processing nodes, each node with clock cycle τ and communication processor. Tsetup = $10^3\tau$, Ttransm = 10τ. 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 $4 \cdot 10^3\tau$. Module P_2 is identical to P_1. Module P_3 encapsulates an array *B* of 10^4 integers. For each received *x*, P_3 computes the integer *max* as follows:

```
int max = 0; int c = 0;
for i= 0 to 9999 do
      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 $10^3\tau$. P_5 executes a function with average calculation time $10^4\tau$.

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

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

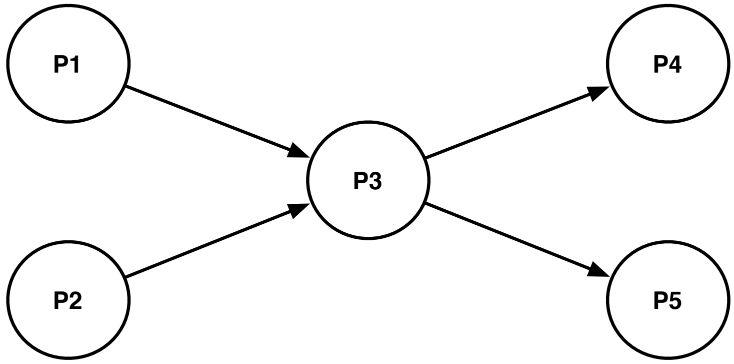

Figura 1: Computation graph of exercise 3.