Midterm examination Parallel Algorithms (WISM 459).

Teacher: Rob H. Bisseling, Utrecht University

October 9, 2013

Each of the four questions is worth 10 points. Total time 60 minutes.

1. Explain the overall structure of a BSP algorithm.

2. A vector of length 57 has been distributed over 6 processors of a parallel computer by a block distribution with varying block length. $P(0)$ has the first 20 vector components; $P(1)$ has the next 12; processors $P(2)$ to $P(5)$ have 8, 7, 6, 4 components, respectively. The data are redistributed into the cyclic distribution. What is the exact BSP cost of this redistribution? What would be the cost if the redistribution is to a regular block distribution, with nearly equal block lengths?

3. Let $\mathbf{x}$ be a given vector of length n, which is distributed over p processors, with $n \bmod p = 0$. You may choose a suitable distribution. Give an efficient BSP algorithm for processor $P(s)$ (in the notation we learned) for the computation of the product $x_0^0 \cdot x_1^2 \cdots x_{n-1}^{2(n-1)}$. (Meaning every component x_i is raised to the power $2i$.) On output, every processor has to know the result. Analyse the BSP cost.

4. (Detecting a radar signal) Let $\mathbf{x}$ be a given long vector of length n, with $x_i \in \{-1, 1\}$ for all $i = 0, \ldots, n-1$, which is distributed over p processors, with $n \bmod p = 0$. You may choose a suitable distribution for $\mathbf{x}$. Let $\mathbf{y}$ be a given short vector of length m, with $y_j \in \{-1, 1\}$ for all $j = 0, \ldots, m-1$, which is available in processor $P(0)$. Assume $n \gg m$. We can consider $\mathbf{x}$ to be a long stream of incoming data, and $\mathbf{y}$ a short signal to be detected. We want to find the index $i = i_{\max}$ such that the inner product of the subvector $x(i : i+m-1)$ of length m and the complete vector $\mathbf{y}$ is maximum. For convenience you may assume that $\mathbf{x}$ wraps around, i.e. we also define $x_{i+n} = x_i$ for $i = 0, \ldots, n-1$. Give an efficient BSP algorithm for finding $i_{\max}$. Analyse the BSP cost.