Midterm examination Parallel Algorithms (WISM 459).

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

1. What is the value h of the h-relation defined by the following table?

	$P(0)$	$P(1)$	$P(2)$	$P(3)$
$P(0)$		19	10	
$P(1)$	19		5	6
$P(2)$	21	10		
$P(3)$	9	5	6	

   In the table, the value in row s and column t is the number of data words that processor $P(s)$ sends to processor $P(t)$, for $0 \leq s, t < 4$.

2. Explain the difference between local and global indices. Use the cyclic distribution of a vector for your explanation.

3. Give an efficient BSP algorithm for processor $P(s)$ (in the notation we learned) for the computation of the output vector $\mathbf{y}$ defined by $y_i = x_i + x_{n-1-i}$, for $0 \leq i < n$, starting from a given input vector $\mathbf{x}$. The length of the vectors is n. Assume both vectors are block distributed and that $n \bmod p = 0$.

4. Let $\mathbf{x}$ be an array of length n containing numerical values x_i, where $0 \leq i < n$. The first stage of the *Haar wavelet transform* replaces each pair (x_i, x_{i+1}) by the pair $(x_i + x_{i+1}, x_i - x_{i+1})$, for all even i. The original pair is overwritten. The second stage does the same for all pairs (x_i, x_{i+2}), where i is a multiple of 4. The third stage does the same for all pairs (x_i, x_{i+4}), where i is a multiple of 8. And so on for the following stages. There are $\log_2 n$ stages. Our aim is to do this in

parallel, using a suitable data distribution, and p processors. Assume that $p \ll n$, and that n and p are powers of 2. On output, the vector $\mathbf{x}$ must be in distributed form. Give an efficient BSP algorithm for processor $P(s)$ for this computation. Analyse the BSP cost.