ECSE 420-Parallel Computing
Assignment 1

1-Describe briefly the following terms, expose their cause, and work-around the industry has undertaken to overcome their consequences:

- Memory wall
- Frequency wall

Explain the following terms and produce example for each of them:

1. SISD,
2. SIMD,
3. MIMD,
4. SIMD

2- You should extend Amdahl's and Gustafson-Barsis bound and make it slightly more realistic. Assuming the fixed overhead *o* in the communication and the setup of parallel processes, derive the expressions for both bounds that take the overhead into account.

3-Gaussian elimination is a well-known technique for solving simultaneous linear systems of equations. Variable are eliminated one by one until there is only one left, and then the discovered values of variable are back-substituted to obtain the value of other variables. In practice the coefficients of the unknowns in the equation system are represented as a matrix A, and the matrix is first converted to an upper-triangular matrix (a matrix in which all elements below the main diagonal are 0). Then back-substitution is used. Let us focus on the conversion to an upper triangular matrix by successive variable elimination. Pseudocode for sequential Gaussian elimination is shown in the Fig 1. The diagonal element for a particular iteration of the k loop is called the pivot element, and its row is called the pivot row.

a) Draw a simple figure illustrating the dependences among matrix elements.
b) Assuming a decomposition into rows and an assignment into blocks of contiguous rows, write a shared address space parallel version using the primitives used for the equation solver.

```
procedure Eliminate (A)            /*triangularize the matrix A*/
begin
for k ← 0 to n-1 do                /*loop over all diagonal (pivot) elements*/
   begin
      for j ← k+1 to n-1 do        /*for all elements in the row of, and to the right of,
                                   the pivot element*/
         A[k,j] = A[k,j] / A[k,k]);  /*divide by pivot element*/
      A[k,k] = 1;
      for i ← k+1 to n-1 do         /*for all rows below the pivot row*/
         for j ← k+1 to n-1 do      /*for all elements in the row*/
            A[i,j] = A[i,j] - A[i,k]* A[k,j];
         endfor
         A[i,k] = 0;
      endfor
   endfor
end procedure
```

Fig.1 Pseudocode Describing Sequential Gaussian Elimination

4. Suppose we have a machine with the message start-up time of 20000 ns and the asymptotic peak bandwidth of 900 MB/s. The machine is sending the messages with *n* bytes. The start-up time includes all SW and HW overhead on the two processors, accessing the network interface and cross the network – it can be thought of as the time to send the zero-length message. At what message length is machine reaching the half of the peak bandwidth?

5- We are going to find the average of elements in grid of (n*n). Each element of this grid may be a mathematical expression. Therefore, every element of this grid requires computation. Based on the Amdhal's law compute the speed up of using K processors in these two following situation:

a. Each processor has its own private value for holding the sum.
b. The processors have to use one shared value to keep tracking of the sum. That is, every processor should sum its result to the shared variable of sum.