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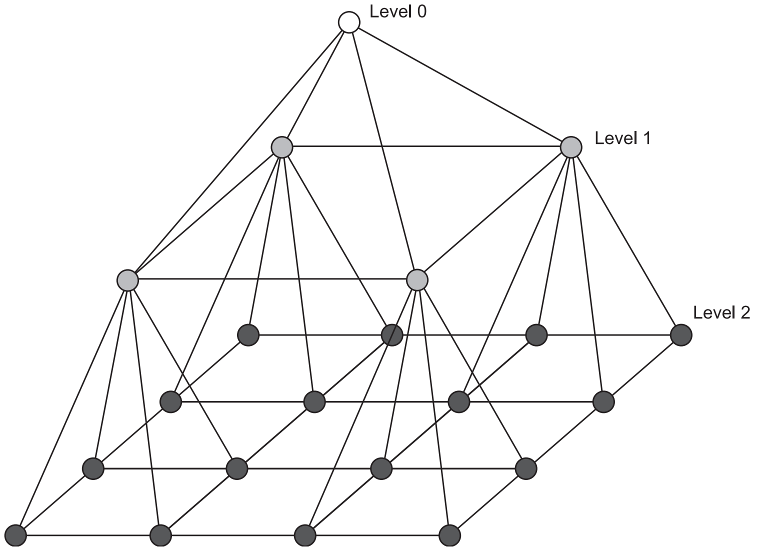
SS 2013

Parallel Programming and HPC

Exercise Sheet 6: Repetition

1 Network Topologies

The following image shows the first levels of a recursive network topology – a pyramid network. Each node has exactly four child–nodes, all child–nodes are connected through a 2–dimensional grid on the next level.



Example of a pyramid–network of height $H = 2$ and a total of $N = 21$ nodes.

a) Give a general formula, depending only on the height H, to compute the total number of nodes N in the Network. Sums should – if possible – be resolved.

b) Compute

   I. cost (meaning the number of edges)

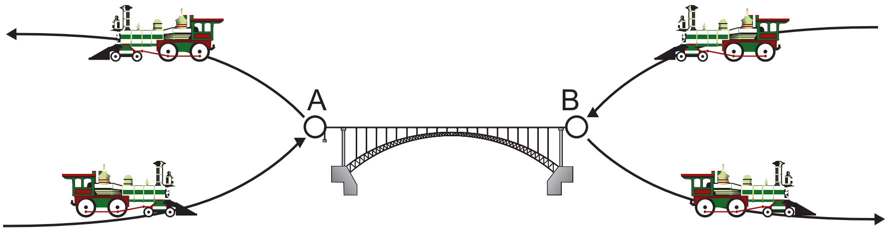
II. diameter

III. bisection width

of a general pyramid–network depending on N and H only.

2 Semaphores

A railway track between two cities contains a bridge over a canyon that can be accessed by a single train at any point in time only. Hence, this bridge is an exclusively usable resource and needs to be implemented as a critical section.



There exist two types of trains: *R–trains* that always drive from the left–hand to the right–hand side and *L–trains* that always drive from the right–hand to the left–hand side. Give a correct synchronisation (pseudo code) using as many semaphores as necessary, thus, no two trains can access the bridge at the same time <u>and</u> *R–trains* and *L–trains* access the bridge alternately, i.e. after an *R–train* always follows an *L–train* and vice versa. Also give a correct initialisation of all your semaphores!

3 Loop Dependencies

Given is the following code fragment inside two nested loops:

```
        for( i=3 ; i <= N ; i++ ) {
            for( j=1 ; j <= M ; j++ ) {
S1:              A[i-3][j] = 2 * B[i][j+2];
S2:              C[i][j]   = D[i,j+1] + A[i][j];
S3:              B[i][j-1] = C[i][j];
            }
        }
```

a) Examine these statements (according to BERNSTEIN) and name all occurring dependencies! Input dependencies may be neglected.

b) State for each dependency named in (a) both distance and direction vector in order to check if it is a *loop–carried* or a *loop–independent* dependency.

c) Could the two nested loops be (partially) run in parallel? Justify your answer!

4 OpenMP

On some quadratic meadow the grass needs to be cut. Thus, several people – each equipped with a mowing machine – have to organise themselves in order to do this work in parallel. Consider the meadow as a 2–dimensional array A of size $N \times N$ and some function `mow()` to be executed for each element α_{ij} of A. Write a parallel program using OpenMP and think about sufficient synchronisation!