

Embedded Systems FS 2012

Exercise 8: Integer Linear Programming

Issue Date: 23. May 2012
 Discussion Date: 30. May 2012

Aufgabe 1: Integer Linear Programming

Given the sequence graph in Fig. 1.

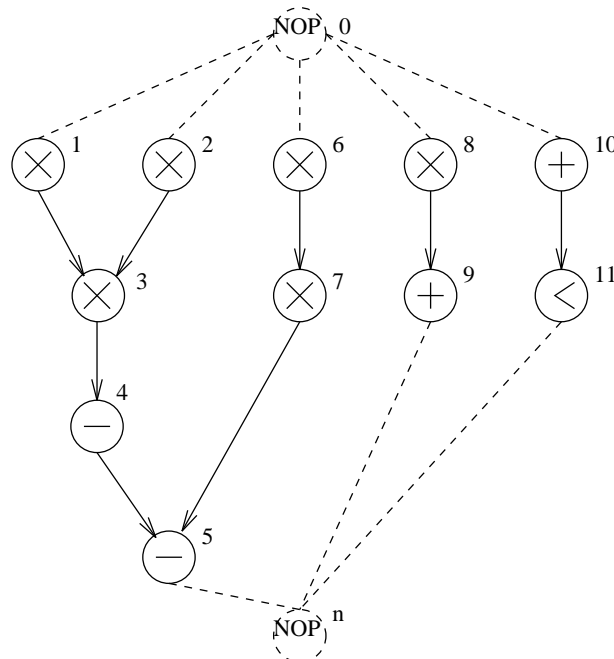


Figure 1: Sequence graph.

For the execution times of the operations assume: $D_* = 2$, $D_+ = 1$. Two units of the resource type r_1 (multiplier) and two units of the resource type r_2 (ALU) are allocated.

- a) Formulate the problem of latency minimization with restricted resources as an integer linear program (ILP). Hint: Compute the earliest and the latest start times of the operations using the ASAP and the ALAP algorithm, respectively.

- b) Give reasons for the latency bound that you used with the ALAP algorithm. And why does the stated optimization model solve the problem of latency minimization with restricted resources?
- c) In an analogous manner try to formulate an ILP that solves the problem of cost minimization with latency limitation. Hint: We assume that the cost of a realization is the sum of the costs c of the multipliers with $c(r_1) = 2$ per allocated unit, and of the ALUs with $c(r_2) = 1$ per allocated unit. For the latency bound, we choose $\bar{L} = 6$.

Aufgabe 2: Iterative Algorithms

Given the following iterative algorithm:

```
FOR l IN 1 TO N LOOP
  x_1[l] = f_1(x_1[l-1]);
  x_2[l] = f_2(x_1[l], x_2[l-1]);
  x_3[l] = f_3(x_1[l], x_2[l], x_3[l-1]);
END LOOP;
```

- a) Illustrate the data dependencies of the algorithm in an extended sequence graph.
- b) Depict a schedule of the operations f_i during 5 iterations, under consideration that the execution times of the operations are specified as follows: $D_1 = 2, D_2 = 2, D_3 = 3$.
- c) Shortly describe, what functional pipelining is.
- d) How large is the smallest possible iteration interval P ?
- e) State the formulation of resource constraints in ILP notation, that considers pipelining and loop folding in the given example. Assume $P = 3$ and $L = 8$.
- f) Also state the ILP notation for the data dependencies, and consider the fact that there exist data dependencies between iterations.