University of the Saarland
Department 6.2 - Informatik
Prof. Dr. W.J. Paul

Computer Architecture I - WS 03/04
(due: 26.11.2003)

Exercise 1: (weight of nodes in the addition tree) (5 points)

In the lecture we defined the weight $w(\nu)$ of a node ν in the addition tree of multipliers by:

- For leaves: $w(\nu) = \begin{cases} 3 \text{ for } 3/2 \text{ adders} \\ 4 \text{ for } 4/2 \text{ adders} \end{cases}$

- For an inner node ν with left father x and right father y:

$$\begin{aligned} L(\nu) &= w(x) \\ R(\nu) &= w(y) \\ w(\nu) &= L(\nu) + R(\nu) \end{aligned}$$

Show by induction on the level l in the addition tree, that for two nodes ν and ν' on the same level l, such that the node ν is left of ν' we have:

$$w(\nu) \leq w(\nu')$$

Exercise 2: (cheapest full adder) (4 points)

The full adder we use has cost 14 (see lecture). Can you find a cheaper one? You can use NOT, AND, NAND, OR, NOR, XOR, NXOR, MULTIPLEXOR (MUX) gates in your construction. The costs of these gates is defined in the following table:

gate	NOT	AND, NAND	OR, NOR	XOR, NXOR	MUX
Cost	1	2	2	4	3

Exercise 3: (top-level connection) (4 points)

In the lecture we considered the construction of an addition array in a simple VLSI hardware model[1]. The layout was based on two kinds of boxes: a box for an inner full and a box on the top of array. Also we specified connections between them inside of the array. Specify connections on the top of the array and give the height of a whole column of the matrix.

Exercise 4: (CLA in VLSI model) (3+5+4 points)

Realize an n-bit Carry Look Ahead adder in the VLSI model:

- by specifying boxes needed the constructing (geometries, inputs/outputs location, cost)

- and specifying an arrangement and connections of these boxes to build carry look ahead adder

- compute cost and delay for your construction

Note:

1. cost of a small circuit S
   $C(S) \leq 20$

2. relation height/width
   $1/2 \leq \frac{h(S)}{b(S)} \leq 2$

---

[1]see also *On the complexity of Booth Recoding* in our internet page under Bibliography