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High Performance Computing - Programming Paradigms and Scalability

Exercise Sheet 1: Performance Measurement

1 Memory Access

a) In this task we analyze the number of time steps necessary to execute the i^{th} operation of the following for-loop:

```
1 for i = 0 to N do
2     a[i] = ( 1 + s ) · b[i] + t · c[i] · d[i] + e[i]
3 od
```

You can assume that all scalar quantities are kept in registers during the entire program execution. We assume to have a processor with certain limitations. It can read/write data and execute arithmetic operations simultaneously. However, it is **not** possible to simultaneously load **and** store data within one execution step. The incrementation of the loop counter can be ignored.

How many (machine) cycles are necessary in order to execute the i^{th} full iteration, if

i) a scalar processor is used which in each cycle is able to **load two words** *or* to **store one word** as well as to execute **one multiplication** *or* **one addition**,

ii) a superscalar processor (MULT & ADD) is used which is able to **load** *or* to **store one word per cycle**,

iii) a superscalar processor (MULT & ADD) is used which is able to **load** *or* to **store two words per cycle**?

b) Interleave two evaluations of the function using the feature set of processor a.iii). How many cycles are necessary?

2 Speedup and Parallel Efficiency

The speedup S for solving a problem on p processing elements compared to one processing element can be calculated with Amdahl's law

$$S = \frac{p}{\sigma \cdot p + (1-\sigma)}$$

where σ denotes the percentage of serial work to be done. The efficiency E of this parallel approach can be calculated with $E = \frac{S}{p}$.

Consider some parallel program with a percentage of serial work of 4%. Calculate the maximum amount p of processing elements, thus, the parallel efficiency E is at least 90%.