

Parallel Computing

Homework Assignment 1

[Total: 30 points]

1. a. [2 points]

```
quotient = n / p;  
my_n_count = quotient;  
my_first_i = my_rank * my_n_count;  
my_last_i = my_first_i + my_n_count;
```

b. [2 points]

One way of doing it is as follows: (There are other correct way too).

```
quotient = n / p;  
remainder = n % p;  
if (my_rank < remainder) {  
    my_n_count = quotient + 1;  
    my_first_i = my_rank * my_n_count;  
}  
else {  
    my_n_count = quotient;  
    my_first_i = my_rank * my_n_count + remainder;  
}  
my_last_i = my_first_i + my_n_count;
```

2. [8 points: 2 points for each one of the four phases.]

Yes, need to make changes to each of these three phases, as follows:

- Fetch phase: Must be able to fetch several instructions at the same time.
- Decode phase: Must be able to decode several instructions at the same time.
- Issue phase: Must be able to check instructions coming from the decoding phase to see which ones are independent from each other and issue them in parallel whenever there are enough idle execution units.
- Commit phase: Must ensure that the instructions' results must be written in-order.

3. [6 points, 1 for each item: 1 point for #threads and 1 point for justification]

a) Each core is superscalar but not hyperthreading	16 threads maximum	Without hyperthreading, each core can execute one thread maximum at a time.
b) Each core is superscalar and four-way hyperthreading	64 threads maximum	Each core can execute up to four threads simultaneously.
c) Each core is neither superscalar nor hyperthreading	16 threads maximum	Like the first case, each core can execute one thread at a time. But without superscalar, it will be slower than the first case.

4. [3 points total: 1 for needed/not needed and 2 for justification]

Speculative execution is not needed for correct working for superscalar. Superscalar means executing several instructions at the same time, which the superscalar can do without speculative execution. However, speculative execution (i.e. branch prediction) makes superscalar more effective if there are many conditional branches.

5. [3 points]

With the two-way hyperthreading, instructions from two different threads can use the execution units. However, in the superscalar case, all instructions using the execution units come from the same thread.

6. [6 points, 1 for each factor and 2 for each reason]

Factor	Reason
Increase in processor frequency	The higher the frequency the more work a CPU can do in one cycle, hence, potential higher frequency.
The ability of a single core processor to exploit instruction-level parallelism using techniques such as: pipelining, superscalar capability, speculative execution, etc.	These techniques enable the hardware to exploit several instructions at the same time, leading to higher performance.

[If you put pipelining, superscalar, ... as separate factors, it will be considered correct.]