

Assignment 2: Multithreaded Programming Concepts

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Course: Parallel Computing

March 11, 2021

Problem 2.1. Threads and Processes

1) Consider the following code and identify the segments in which the following variables/data live, assuming that they are not cached in a register.

```
static int n = 10240;

double dotProduct(double * a , double * b , int n)
{
    double res = 0.0;

    for(int i=0;i<n;i++){
        res += a[i]*b[i];
    }

    return res;
}

int main(int argc ,char** argv){

    double * a = new double[n];
    double * b = new double[n];

    for(int i=0;i<n;i++){
        a[i] = (i+1.2)/2.5;
    }

    for(int i=0;i<n;i++){
        b[i] = 1.2/(3.2*i+1.0);
    }

    std::cout << dotProduct(a,b,n) << std::endl;

    delete [] a;
    delete [] b;

    return 0;
}
```

- a and b inside *main*
- the data element $a[i]$ for some $0 \leq i \leq n - 1$
- the *main* and the *dotProduct* function

2) What is wrong with the following code?

```
double * add(double a , double b)
{
```

```

    double res = a+b;
    return &res;
}

int main(int argc, char** argv)
{
    double * c_ptr = add(3.0, 4.1);

    std::cout << *c_ptr << std::endl;

    return 0;
}

```

4) Suppose that you need to allocate an arrays of a large size. Why might the following code fail?

```

void someFunction(...)
{
    //some other code
    ...
    ...
    double myArray[ARRAY_SIZE];
    //some other code
    ...
    ...
}

```

5) Are the following statements true or false?

- Context switches across threads within the same process are more lightweight than ones across processes.
- Threads of the same process share the same stack pointer.
- Threads of the same process share the virtual address space.
- Threads of the same process have their own instruction counters.
- Threads of the same process share the same general-purpose registers.

6) What are the advantage(s) and disadvantage(s) of multithreaded programming over multiprocess programming?

Problem 2.2. Multithreading

1) Define what a race condition is.

2) Given the following code snippet, demonstrate how a race condition can occur from running the code. Assume that the *runnerA* and the *runnerB* function are running in two threads, Thread *A* and Thread *B*, respectively.

```

int counter = 0;

void runnerA() //run by Thread A
{
    int i = 100;
    while(i>0){
        counter++;
        i--;
    }
}

void runnerB() //run by Thread B

```

```
{  
    int i = 100;  
    while(i>0){  
        counter—;  
        i—;  
    }  
}
```

- 3) Explain the difference(s) between a mutex implemented using a sleep-and-wake-up mechanism and one implemented using a busy-waiting mechanism.
- 4) Explain why spinlocks are not useful in uniprocessor systems.
- 5) In an I/O-intensive application, where threads periodically perform blocking I/O operations, how can oversubscription of threads improve the performance?