UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
School of Computer Science and Applied Mathematics

Test 1: Parallel Computing (COMS 3008)
Total Marks: 50

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1 Question 1

1.1. Consider a simple cost model in which it takes $10ns$ to access L1 cache, $50ns$ to access L2 cache, and $150ns$ to access DRAM. A parallel program is running on the machine with 80% of all accesses going to L1 cache, 10% to L2 cache, and 10% to DRAM. What is the effective memory access time for this computation? [2]

1.2. Assuming that there was no cache in the preceding problem, what would be the effective memory access time for the same computation? [1]

1.3. Provide one advantage and one disadvantage of using a shared memory system. [2]

1.4. Implement a simple multi-threaded program that illustrates race conditions, and provide the fix to that problem. [3]

Subtotal: [8]

2 Question 2

2.1. Discuss the concept behind the invalidate protocol. [2]

2.2. Provide an example that illustrates the operation of the invalidate protocol. Assuming that the underlying machine has three cores each equipped with its own cache. [4]

2.3. Discuss the concept behind the false sharing and provide an example in which false sharing arises. [4]

Subtotal: [10]

3 Question 3

3.1. Implement a sequential numerical integration scheme that uses the Riemann sum with constant subinterval width to determine the value of the integral $\int_5^{50} e^x$. Choose parameter values such that the approximation is accurate within 0.001% relative error to the exact value. [6]

3.2. Extend the solution obtained from the previous problem to make use of parallelism such that performance gains in terms of execution time are obtained. [4]

Subtotal: [10]

4 Question 4

4.1. Discuss the concept behind the degree of concurrency of a parallel program and how it is affected by the number of independent processing elements in a computer. [3]

4.2. Implement a simple program to illustrate the concept discussed in the preceding question. **Hint:** think about OpenMP constructs. [4]

4.3. Implement a simple program to illustrate the concept of computational workload imbalance, then fix the problem by implementing an appropriate balancing of the workload. [8]

4.4. Provide an example in which state-space exploration can be performed in parallel, and what possible performance anomalies can arise depending on the location of the solution in the state-space. Clearly state all assumptions made in the example. [5]

4.5. Provide a scenario in which speculative decomposition would lead to wasted computation. [2]

Subtotal: [22]