## **CS6843 Program Analysis at IIT Madras** EndSem July 4, 2014

Total Marks: 25Number of questions: 9 compulsory questionsDuration: 120 minutesMarking: Q1 carries 1 mark, all others carry 3 marks each

- 1. Write a suggestion to improve one aspect in the department.
- 2. For the following code, write down the equations in Ax <= B matrix format for achieving parallelization, that is, satisfying true dependence.

for (i = 4; i <= N; ++i) a[i-3] = a[2 \* i + 3] - 4;

3. A barrier ensures that all the participating threads reach a program point before any one of them can execute the next instruction. Can you think of a reason to break this definition in a sound way? That is, even though some threads may not have reached a barrier, some threads that have reached the barrier are allowed to execute their post-barrier instructions, without changing the functionality of the original program with barriers.

(a) Write the weakest pre-condition for x = y \* 2 where the post-condition is  $\{x < 10\}$ . [1]

4.

(b) Write the strongest post-condition for if (y == x) then y = ++x; else x = y; where the precondition is  $\{y > 2 \text{ and } x > 5\}$ . [2]

5. Design an analysis to check for dangling pointers for C programs. A pointer is dangling if it points to a freed or unallocated memory. Make suitable assumptions (and mention those).

6. Compute a backward slice of the following program for criteria <11, sum> where 11 is the line number. Don't write how you got the slice. Write/mark only the statement numbers.

```
1: void main() {
2:
       int sum = 0;
3:
       int i = 0;
       int j = 1;
4:
       while (i < N) {
5:
              i = ++j;
6:
7:
               sum += i;
8:
              i = sum / 2;
9:
       }
       if (sum >= 100)
10:
              printf("%d\n", sum);
11:
12:
       else
13:
               printf("sum is less than hundred.\n");
14: }
```

7. Develop an analysis to detect out-of-bounds array access.

8. For a concurrent union-find data structure, implement the find() function. A find(x) should return the representative of the set containing x. Threads may execute find() and union() in arbitrary order at arbitrary times; you need to protect the concurrent accesses. You are allowed to use only atomic CAS(compare and swap) function or its variants, but no locks. Write the pseudo-code.

9. An arbitrary graph (e.g., facebook) may have arbitrary memory access pattern while traversing for breadth-first search (BFS). For what kind of graphs is the BFS memory access pattern optimal with-respect-to spatial locality? Explain.