Parallelizing Compiler Qualifying Exam May 30, 2008

1. (20%) Please illustrate step by step in detail how to compute control dependence graph for a general program? Compute the control dependence graph for Figure 3.29 of the textbook. (Hint: you can do any assumption to this problem.)

2. (20%) Do Exercise 5.8 of the textbook.

3. (20%) Do Exercise 7.7 of the textbook.

4. (20%) Do Exercise 8.9 of the textbook.

5. (20%) Do Exercise 13.8 of the textbook.

2008 May NCKU CSIE PH.D. Qualification Examination
Computer Archtecture

1. Some operations on two operands (e.g., subtraction) are not commutative. What are the advantages and disadvantages of the stack, accumulator, and load-store architectures when executing noncommutative operations? (15 points)

2. Please classify instruction set architectures into three classes based on whether the operands are used explicitly or implicitly. One of the instruction set architectres is general purpose register (GPR) architecture. What are two major instruction set characteristics that can further GPR into three classes? And show the advantages and disadvantages of these three further divided classes. (20 points)

3. Consider the following four MIPS code fragments each containing two instructions: (20 points)

```
i:    DADDI   R1, R1, #4      ;Add
      LD      R2, 7(R1)       ;Load
ii:   DADD    R3, R1, R2      ;Add
      SD      R2, 7(R1)       ;Store
iii:  SD      R2, 7(R1)       ;Store
      S.D     F2, 200(R7)     ;Store
iv:   BEZ     R1, Place       ;Branch
      SD      R1, 7(R1)       ;Store
```

   (a) For each code fragment, identify each type of dependence that exists or that may exist (a fragment may have no dependence) and describe what data flow, name reuse, or control structure causes or would cause the dependence. For a dependence that may exist, describe the source of the ambiguity and identify the time at which that uncertainty is resolved..
   (b) For each code fragment, discuss whether dynamic scheduling is, may be or is not sufficient to allow out-of-order execution of the fragment.

4. Describe the cache coherency problem for a distributed shared memory multiprocessor. (15 points)
   a. In a cache coherent non-uniform memory access machine (CC-NUMA), the existing directory schemes fall into two categories, bit-map and linked list protocols. For each category, describe one popular protocol and its read and write operations for hits and misses in the local cache.

5. Describe what are the RAW, WAW, and WAR hazards. (15 points)

6. The following loop has multiple types of dependences. Find all the true dependences, output dependences, and antidependences, and eliminate the output dependences and antidependences by renaming (15 points)

```
for (i=1; i<100; i++) {
    y[i] = x[i] / c;    /* S1 */
    x[i] = x[i] + c;    /* S2 */
    z[i] = y[i] + c;    /* S3 */
    y[i] = c – y[i];    /* S4 */
}
```

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Theory of Computation

May 29, 2008
Ph.D. Qualify Examination
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Ph.D. Qualify Examination

- This examination is closed books, closed notes
- Please turn off your cell phones
- Write legibly. What can't be read will not be graded
- Good luck!

1. Deterministic Finite Acceptors (DFAs) (5 pts each)

   Draw Deterministic Finite Automata to accept the following sets of strings over the alphabet {0,1}:

   a. All strings whose binary interpretation is divisible by 5.
   b. All strings that contain the substring 0101.

2. Nondeterministic Finite Acceptors (NFAs) (5 pts each)

   Draw Non-deterministic Finite Automata with the specified number of states to accept the following sets:

   a. All strings containing exactly 4 "0"s or an even number of "1"s. (8 states)
   b. All strings such that the third symbol from the right end is a "0". (4 states)

3. Give regular expressions for the following languages on $\Sigma = \{a, b, c\}$. (5 pts each)

   I. All strings containing exactly one a
   II. All strings containing no more than three a's

4. Prove that the following languages are not regular (10 pts)

   L $\{a^n b^l a^k : k \geqq n+l\}$

5. Show that the following grammar is ambiguous. (10 pts)

   S → AB|aaB
   A → a|Aa
   B → b

6. Transform the grammar with productions into Chomsky normal form (10 pts)

   S → abAB
   A → bAB|λ
   B → BAa|A|λ

7. Construct nondeterministic pushdown automata that accept the following languages on Σ(a, b, c) (10 pts)

   $L = \{w: n_a(w) = n_b(w) + 1\}$

8. Prove that the following languages are not context-free (10 pts)

   $L = \{a^n b^j c^k : k > n,\ k > j\}$

9. Show that the class of Pushdown Automata with two stacks are equivalent with the Turing machines (10 pts)

10. Construct Turing machines that will accept the following languages on {a, b}(5 pts each)

I. L = {w: |w| is even}
II. L = {w: |w| is a multiple of 3}