Date and Time: CSIS PhD Preliminary Exam for CS-track will be held on Friday February 10, 2012. The exam will start at 10:00 a.m. There will be a two hours time per subject area. For the location of the exam, please contact the CSE Office the week prior to the exam date.

Guidelines for the 2012 CSIS PhD Preliminary Examination

Algorithms

Basic Background:

The Algorithms preliminary examination will not go beyond material covered in the (excellent and readable) textbook "Algorithm Design" by Kleinberg and Tardos. http://www.aw-bc.com/info/kleinberg/toc.html

Computer Architecture

1. The syllabus for Advanced Computer Architecture, CSC 5593 provides general information about the course that may help you prepare for the preliminary exam:

http://carbon.ucdenver.edu/~galaghba/csprojects/CSC5593/Organization/Syllabus.html

2. The lecture notes, projects and homework assignments for CSC 5593 provide further insight into the topics. Some literature references used in lecture notes and homework assignments are also helpful to expand your knowledge and apply them to various subjects. For information regarding how to access the FTP site for lecture notes and supplemental material, please contact Professor Alaghband.

3. Topics: Knowledge and familiarity with the following topics is expected:

- Instruction Sets
- Addressing Techniques
- Fetch and Execute Cycle
- Basic Pipelining, Pipeline hazards and handling
- Pipelining and Performance
- Memory Hierarchy
- Caches
  - Mapping Techniques (direct, set associative, fully associative)
  - Cache Misses, Miss penalty, cache hit, Techniques for handling and reducing misses, allocation and Replacement strategies
- Compiler optimization techniques for reducing cache misses
- Virtual Memory
- Instruction Level Parallelism (ILP)
- Dynamic Execution
  - Types of dependencies (flow, anti, and output dependence, control dependence)
  - Hazards, Methods for handling them
  - Out-of-order execution
  - Dynamic Scheduling: Tomasula's Algorithm

Register Renaming (with register files)
Reorder Buffer (ROB)
Advantages

Branch Prediction Methods
1-bit Branch-Prediction Buffer
2-bit Branch-Prediction Buffer
Correlating Branch Prediction Buffer
Tournament Branch Predictor
Branch Target Buffer

Overall Familiarity with Definition of Modern Processor Technologies and their distinctions
Superscalar
Superpipeline
Hyper Threading
SMT
SMP
CMP
Processor Core

4. Recommended Textbooks:

Hennessey and Patterson, Computer Architecture: A Quantitative Approach, 4th Ed., 2006 ISBN: 978-0-12-370490-0 (Book) ISBN10: 0-12-370490-1 (Paperback)

Reference Book: J.P. Shen & M. Lipasti "Modern Processor Design: Fundamentals of Superscalar Processors", McGraw-Hill, 2005 ISBN: 0-07-057064-7

Operating Systems

The goal of test is to assess a student's understanding of the fundamental concepts in operating system area. Exam questions will be a mixture of problem solving and short essay questions. Essay questions could include asking design choices, asking system/algorithm evaluations, or/and designing OS functions or systems.

The exam may cover the following topics:

1. Operating system structures and basic concepts including OS functions and goals
    a) What OS does?
    b) What are the main function of OS
    c) Types of OS
    d) Monotonic-Kernel OS vs. Micro-Kernel OS
    e) What is a virtual machine? Types of Virtual machine
2. Process and thread management and scheduling algorithms
    a) Concept of process and thread
    b) Process scheduling algorithms
    c) Context switching issues
    d) Inter-process communications
    e) Types of threads and usage of threads
3. Process synchronization, concurrency control and deadlocks
    a) Race-Condition and Critical Section

b) Peterson's Solution
c) Semaphore
d) Synchronization
e) Deadlock conditions
f) Handling deadlock
g) Banker's algorithm
h) Recovery of deadlock

4. Main memory and virtual memory management
    a) Static allocation vs. dynamic allocation
    b) Internal & external fragmentation
    c) Memory allocation algorithms
    d) Paging and Segmentation
    e) Kernel memory allocation
    f) Demand paging
    g) Memory replacement algorithms
    h) Belady's anomaly
    i) Thrashing
    j) Working set and resident set
5. File systems and Storage Management
    a) File structure
    b) File access methods
    c) File allocation strategies
    d) File sharing, protection, efficiency, performance and recovery
    e) Types of file systems including VFS
    f) Free space managements
    g) Disk access latency
    h) Disk scheduling
    i) RAID
    j) Disk attachment: DAS, NAS, and SAN
6. I/O Management
    a) Types of I/O implementations: polling, interrupt, and DMA
    b) Block and Character devices
    c) Kernel I/O subsystem
    d) Error handing and protection
    e) Performance
7. Protection & Security
    a) Protection
    b) Access matrix
    c) Access Control
    d) Capability
    e) Security
    f) Threats & attacks

Reference books: (One of the following books should be enough)

1. Silberschatz, Galvin, and Gagne, Operating System Concepts, 7th ed., John Wiley & Sons, 2004. Chapter 1 – 15
2. Tanenbaum, Modern Operating Systems, 3rd ed., Prentice-Hall. Chapters 1- 6 & 9.

3. Stallings, Operating Systems: Internals and Design Principles, 6th ed, Prentice-Hall, Chapters 1-12

Tips for preparing exam:

1. Thoroughly understand basic concepts each topics
2. Practice all problem questions at the end of each chapter

Theory

The reference book "Essentials of Theoretical Computer Science" by F. D. Lewis is recommend source for study. The textbook is on-line at
http://www.cs.uky.edu/~lewis/texts/theory/title.pdf

1. FINAL REVIEW

(1) Informally show that there are infinitely many Turing machines which not only diverge on infinitely many inputs, but also halt for infinitely many inputs.
(2) Informally show that there are infinitely many Turing machines which diverge on infinitely many inputs, but halt for finitely many inputs.
(3) Informally show why the number of total functions is greater than the number of Turing machines.
(4) Suppose that the sets A, B, and their complements A', B', are recursively enumerable (r.e.). Is the set $C = A' \bigcup B$ recursive ? Present a formal proof.
(5) Suppose that the set D is only r.e. Is the set $E = D \bigcup D'$ recursive? Present a formal proof.
(6) Show that for any positive integer k, the line segment $(1/2k, 1/k)$ contains uncountably many irrational numbers.
(7) Informally prove the statement: *A Turing machine cannot verify the divergence of another Turing machine.*
(8) Is the number of total boolean functions greater than the number of recursive functions ? Justify your answer.
(9) Is the cardinality of the set of partially recursive functions greater than the cardinality of the set of recursive functions? Justify your answer.
(10) Can a set and its complement BOTH be non-r.e.?
Can a set and its complement BOTH be r.e.? Explain.
(11) Is $L = \{$ i such that M_i accepts only one string $\}$ an r.e. set?
(12) Show that the set K has an undecidable membership problem.
(13) How would one go about proving that a given set is not computable.
(14) Is following a regular set $\{1^p$ where p is a prime and $p > 10000\}$? Prove your answer.
(15) Show that every infinite regular set has an infinite regular subset.
(16) Justify the claim that the question *Does a PDA accept everything?*
is undecidable.
(17) Show that every finite regular set has an infinite regular complement.
(18) Is the language consisting of binary strings x such that x MOD $x = 0$ regular?
Prove your answer.
(19) Show that every infinite regular set has a finite regular subset.
(20) Give a regular expression for odd-length strings (over the alphabet {0,1}) that contain 11 as a prefix or as a suffix (or both).
(21) Do there exist finite sets that can be recognized by PDA but not by FSA? Prove your answer.
(22) Are regular, CFL, CSL, and r.e. sets closed under union?
Are regular, CFL, CSL, and r.e. sets closed under concatenation?
Are regular, CFL, CSL, and r.e. sets closed under intersection?
Prove your answers.
(23) Can ambiguity always be eliminated from Context Free Grammars?

(24) Is it true that every CFL is also a CSL?
(25) Is it true that every CFL is also regular?
(26) Is the language 1^{n^2} regular? CFL? Prove your answers.
(27) Change the grammar below to Chomsky's Normal Form.
S $\rightarrow$ CB
C $\rightarrow$ aCb
C $\rightarrow$ ab
B $\rightarrow$ cB
B $\rightarrow$ c

(28) What is a direct implication of the G.N.F. for C.F.Gs?
(29) Discuss the closure of r.e., recursive, CSL, CFL, and Regular sets under the operation of Complementation.
(30) Describe a problem which you think is harder than the Halting problem.
(31) Is $L = \{ < i, j > \text{ s.t. } M_i \text{ and } M_j \text{ accept different sets } \}$ an r.e. set? Prove your answer.
(32) Is the problem of determining if a Turing machine M_i will execute exactly fifteen steps on input 99 solvable? (Justify).
(33) Is the membership problem for an intersection of finitely many infinite sets solvable? (Prove).
(34) Is the set of indices of Turing machines that accept at least k inputs an r.e. set? (Prove).
(35) Discuss the concept of ambiguity in *regular expressions*. What does it mean ? Is it desirable? Can it always be eliminated?
(36) What is harder to detect: the *Union* or *Concatenation* ambiguity? (Explain).