CS6143 COMPUTER ARCHITECTURE II SPRING 2010

SYLLABUS

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2. Prerequisite : CS6133 Computer Architecture I.

⇨ Students who took CS2214 at Polytechnic can take the course

3. Course web page : **http://cis.poly.edu/cs614**

⇨ Course handout files are at the course web site

4. Textbooks :

a) *Computer Architecture : A Quantitative Approach*, **4th edition**, J. L. Hennessy and D. A. Patterson, Morgan Kaufmann Publishers Inc., 2007.

⇨ Publisher's web site, **http://books.elsevier.com** and the CD that comes with the book have a large amount of material. Students are strongly suggested that they study the web site material and the CD and print the appendices that will be used especially during the exams.

➢ Students are reminded about printing the appendices !

b) *Fundamentals of Parallel Processing*, Harry F. Jordan & Gita Alaghband, Prentice-Hall, 2003.

c) Students will also read other books and papers, especially on multi-core, parallel random access machine (PRAM) and single-instruction stream, multiple-data stream (SIMD) machines.

5. What the professor is looking for :

➜ The professor wants to see that you **care for the course** and show with your own actions.
➜ **Learning is your target**, not the grade
➜ You understand and **follow his messages** :

1) You must realize that every action you take or not take has consequences now and later.
2) You are who you are because of how you write now and later in your career.

➢ Homework and exams encourage you to think about writing : Students will have to show work, not just the final answer

➜ Students understand and satisfy the **goal** of the course :

⇨ Acquiring skills to be **systems oriented** and a **problem solver** as well as acquiring the necessary course content which is **parallelism** :

➢ CS6143 introduces **parallelism** techniques to improve computer performance and capacity :

⇛ **Advanced pipelining** techniques to improve the uniprocessor system performance by exploiting instruction-level parallelism (ILP) and loop-level parallelism of application programs.

⇛ **Parallel processing** techniques to improve the performance and capacity, by utilizing multiple processors or processing elements to exploit loop-level and higher-levels of parallelism : thread-level, task-level and process-level parallelisms. The focus will be on PRAM, SIMD (single-instruction stream, multiple-data streamand) and MIMD (multiple-instruction stream, multiple-data stream, multi-core) systems.

6. A successful course experience : In order to benefit from the course as much as possible, students first need to keep in mind "What the professor is looking for." Students need to achieve the goal of the course, be **committed** to the course. **Learning** the material, not going for the grade, needs to be the objective.

⇨ **Attending classes** and **doing the work** are needed.

➢ It is **not** OK to miss a lecture! You **cannot** make it up even if you study the notes a lot.

⇛ Lectures are **dependent** on each other.

⇨ **Study** the notes, books, handouts and homework. But, just reading does not mean studying !

⇛ **Also do not study past exams.**

7. Homework : There will be six homework assignments. **An assignment submitted late will not be accepted.** Students are reminded about studying the solutions provided by the textbook.

- ⇨ Students will form teams by the *third* week of the semester. The homework will be submitted by teams.
- ⇨ *Students who do homework are faster at solving problems.* **Showing work** (intermediate steps) is **required** to get full/partial credits on a question. Although, the homework will **not** affect the term grade, it can help raise grades as explained below.
- ⇨ Homework assignments have **modified** past exam questions and answers to help learn chapters and solve homework problems. Students need to study them **before they solve homework problems**, not before exams. Note that, these past exam questions are samples and do **not** give hints about exams this semester.

8. Exams : There will be a 150-minute midterm exam and a 150-minute final exam.

- ⇨ **Showing work** (showing intermediate steps) is required to get full credits on a question. That is, both the final answer and the steps to get it, the **approach**, are important.
  - ➢ These steps are given in class and past exam solutions. Therefore, students are expected to solve exam questions as such. Showing the approach also helps students acquire and improve their **documentation** skills, critical for the technical world.
    - ⇛ In order to facilitate this, the exams are **open book** exams : students can use their own material, i.e. their books, notebooks and handouts during the exams. Note that once the exam starts there is **no** sharing.

9. Term Grade : The term grade is based on the weights of the exams :

40% Midterm Exam

60% Final Exam

- ⇨ The homework does **not** affect the term grade directly but it is taken into account when a student's term grade is near a grade "border." Also, taken into account is student's attendance record. If they are good, the grade is raised. Finally, the professor may change the term grade computation. Thus, students are strongly suggested that they fulfill the requirements of the course, i.e. lectures and homework assignments.

10. Office Hours : The professor has an **open-door** policy that if he is not busy, students can ask questions in his office. If the door is closed, he might be teaching or at a meeting. If a student wants to see the professor at a certain time, he/she makes an appointment with the professor.

- ⇨ Students can use email. But, they are strongly suggested that they **see** the professor to ask questions, instead of sending email. If email is sent, a Polytechnic email address must be used and student's name and section must be included. Broadcast messages wiil be sent to class to make announcements. Note that grades are **not** given out to students via email or telephone. Students need to see the professor to learn their grades.

11. The Theme of the Course :

i) CS6133 introduces a uniprocessor computer with an integer pipelined CPU and a hierarchical memory of caches, physical and virtual memories.

ii) CS6143 explores designs for higher computer performance and higher capacity through a more rigorous exploitation of parallelism. In CS6143, parallelism on several layers of computers is targeted. The layers we will target are the computational method, algorithm, high-level language, architecture and microarchitecture.

iii) The first half of the semester is on low-level parallelism, including the instruction-level parallelism, **ILP**, and loop-level parallelism, that are on the architecture and microarchitecture layers. These two forms of parallelisms have been extensively exploited in the form of dynamic pipelining, superscalar execution, vector processing and VLIW (EPIC used by the Intel Itanium is a version of VLIW).

iv) The second half of the semester is on parallel processing, especially massively parallel processing, i.e. SIMD and MIMD computers. We will start with interconnection networks used in SIMD and MIMD computers. Then, we will cover PRAMs which are theoretical systems to help understand real parallel systems better. We will then discuss SIMD machines. We will continue with shared-memory MIMD systems and the related topic of cache coherency (current multi-core systems are shared-memory MIMD systems). This is followed by distributed memory MIMD

systems. We will discuss their properties and why today's fastest supercomputers are distributed memory MIMD systems. Finally, we will sum up the semester by studying current conference and workshop papers that outline issues for now and future for parallel processing systems.

12. Material Coverage : Chapters from Hennessy and Jordan books will be covered. Also, students will study other books and papers. They will be also given additional material in class. The **tentative** schedule is as follows :

Day(s)	Subject
Jan 21	Introduction ; Computer layers ; Computational methods ; Popular scientific applications ; MIPS FP instructions ; CS613 Integer pipeline ; (Chp 1 ; Appendix A, B) ; (Chp 1)
Jan 28, Feb 4, 11, 18	MIPS FP pipeline ; Advanced pipelining : Speculative execution, superscalar execution, VLIW computation ; (Chp 2, 3, Appendix A, B, G) ; (Chp 7)
Feb 25	Vector processors ; (Appendix F)
Mar 4, 11	Flynn's classification ; Interconnection networks ; (Chp 2, 3, 4 ; Appendix E, H) ; (Chp 1, 4, 6)
Mar 25	Midterm Exam : Lectures on Jan 21 - Feb 25 ; HW : 1 - 3
Apr 1	Parallel processing overview ; Dependency analysis ; Levels of parallelism ; Parallelism issues ; Algorithm complexity ; PRAMs ; (Chp 2, 3, 4 ; Appendix H) ; (Chp 2, 4, 7)
Apr 8	SIMD machines ; (Chp 2, 4, Appendix H) ; (Chp 1, 3, 5, 7)
Apr 8, 15, 22	MIMD machine overview ; Shared-memory MIMD systems ; Cache coherency; Shared Memory MIMD systems ; Synchronization ; Programming ; (Chp 2, 4, Appendix H) ; (Chp 1, 3, 4, 5, 7. 8, 9, 10)
Apr 22, 29	Distributed Memory MIMD systems ; (Chp 2, 4, Appendix H) ; (Chp 4, 5, 7, 8, 9, 10)
Apr 29	Current parallel processing system issues ; (Chp 2, 4, Appendix H) ; (Chp 2, 7, 9, 10)
May 6	Final exam : All lectures : Jan 21 - Apr 29 ; HW : 1 - 6

13. References : Students are suggested that they study recent computer architecture and parallel processing books since the field advances fast. **Using the web to gather information is strongly discouraged !**

The following references are recommended with respect to their relevance to the course and the textbooks :

1) *MIPS RISC Architecture*, G. Kane and J. Heinrich, Prentice-Hall, 1992.
2) *See MIPS Run*, D. Sweetman, Morgan Kaufmann, 1999.
3) *Advanced Computer Architectures*, Sajjan G. Shiva, CRC Press, 2006.
4) *Modern Processor Design : Fundamentals of Superscalar Processors*, John P. Shen and Mikko H. Lippasti, McGraw-Hill, 2005.
5) *Speculative Execution in High Performance Computer Architectures*, D. A. Kaeli and Pen-Chung Yew, Editors, CRC Press, 2005.
6) *CPU Design : Answers to Frequently Asked Questions*, Chandra M.R. Thimmannagari, Springer Verlag, 2005.
7) *Computer Architecture : From Microprocessors to Supercomputers*, Behrooz Parhami, Oxford University Press, 2005.
8) *Advanced Computer Architecture and Parallel Processing*, H. El-Rewini and M. A. El-Barr, John Wiley, 2005.
9) *Interconnection Networks : An Engineering Approach*, Jose Duato, Sudhakar Yalamanchili and Lionel Li, Morgan Kaufman, 2003.
10) *The Art of Parallel Programming*, Bruce Lester, 2/e, 1st World Publishing, 2006.
11) *Sourcebook of Parallel Computing*, Jack Dongarra, et.al. Editors, Morgan Kaufman, 2003
12) *Parallel Computer Architecture : A Hardware/Software Approach*, D. E. Culler and J. P. Singh with A. Gupta, Morgan Kaufmann, 1999.
13) *Highly Parallel Computing*, G. S. Almasi and A. Gottlieb, 2/e, Benjamin/Cummings, 1994.
14) *Processor Architecture : From Dataflow to Superscalar and Beyond*, Juric Silc, Borut Robic and Theo Ungerer, Springer -Verlag, 1999.

15) *Scalable Shared-Memory Multiprocessing*, Daniel E. Lenoski and Wolf-Dietrich Weber, Morgan Kaufman, 1995.
16) *Scalable Parallel Computing*, Kai Hwang and Zhiwei Xu, McGraw-Hill, 1998.
17) *Computer Architecture : Pipelined and Parallel Processor Design*, M. J. Flynn, Jones and Bartlett, 1995
18) *Parallel Computing : Theory and Practice*, Michael J. Quinn, McGraw-Hill, 1994.
19) *Introduction to Parallel Computing*, Anant Grama, Gerge Karypis, Vipin Kumar and Anshul Gupta, 2/e, Addison-Wesley, 2003.
20) Numerous research papers from journals and conference and workshop proceedings on computer architecture, parallel processing, supercomputing, operating systems, algorithms, programming languages and compilers.

14. Reminder about the course : Students are required to read the handout prepared by the Dean of Student Affairs at the CS2204 web site : *NYU-Poly Student Affairs Syllabus Addendum.* This handout is also on MyPoly. Other material for students to read include *University Code of Conduct* at the Poly web site : Under "Current Students. In addition, keep the following in mind :

a) Students need to realize that every action they take or not take has consequences as mentioned on the first page. They also should **not** make assumptions and decisions on the course (the exams, lectures, the homework and attendance) without asking the professor. The following points are based on observations of most common cases of taking or not taking actions and making assumptions :

b) Students are strongly suggested that they **concentrate on learning**, not on the grade (tests). This guarantees a good experience on the course and a solid foundation for the follow up courses. If a student falls behind, the student needs to try to learn quickly, without thinking about the grade.

c) Students are asked that the professor does his assigned job : **Teaching** ! Any time the professor is not doing it means students are not benefitting from the course. Examples of when the professor is **not** doing teaching include discussions involving submitting late homework, late attendance, missing exams, etc.

d) A reason for a low grade on CS6143 is **missing classes**. Even if one gets the notes, it does **not** help. This is because, first, on average, during each lecture more than 100 pages from the two textbooks will be covered. Second, the notes are not perfect. Third, someone taking the notes may not write down all the verbal comments and suggestions made by the professor. Fourth, attending classes forms better memory because of visual (seeing the writing on the board), audio (listening to the professor) and tactile (writing down the notes) inputs. In addition, during lectures, the professor refers to earlier lectures (past topics, comments, suggestions, etc.) which refreshes students' memory and further reinforces their knowledge. Finally, since their memory is fresh, students save time when they study for the exams. Overall, students learn more and remember more. Finally, since their memory is fresh, students save time when they study for exams.

e) Missing an exam is **not** a minor case. A careful assessment is made to excuse a student or to grant an incomplete to a student. The professor makes the decision. The decision is made also based on the information by the student's academic department and the Student Development Office. One of the requirements to excuse a student is that at the time the student is not able to take the exam, he/she be **in good standing in class**, i.e. has good attendance, a good homework performance, and a good exam performance : The professor wants to see that the student has been committed to the course and learning the material has been his/her main objective.

A student who is excused from a midterm exam will **not** be given a make-up exam. The weight of the midterm exam will be calculated at the discretion of the professor. The make-up exam for the final exam will be harder than the one given to the whole class.

If a student experiences health/personal problems, he/she must immediately contact Cheryl McNear who is the director of the Student Development Office : cmcnear@poly.edu. Her number is (718) 260-3800.

f) For a course, the semester is over when the final exam is over. Students will **not** be given extra work, a project, a make-up exam or any other kind of special treatment to raise their grade during or after the semester.

g) It has been observed that a student pays unnecessary penalty, because he/she does not know/follow Polytechnic University and CS6143 rules and regulations. They also do not seek advice from Polytechnic staff. Therefore, students, especially, **transfer students**, are strongly suggested that **they speak with the professor**, the personnel of the Student Development Office, and the Counseling Center.

h) Students are advised that they be cautious about web sites used when they gather information related to the course. Many web sites contain erroneous material and are not reliable. Students can contact the professor for web site links. They can also access web sites of academic people who specialize in the area of CS6143.