

SYLLABUS

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2. Prerequisite : CS6133 Computer Architecture I.**3. Course web page :** <http://cis.poly.edu/cs614>

⇒ Course handout and recitation files are at the course web site

4. Textbook :

➤ *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.

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

➤ 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. Goals : The course 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 stream) and MIMD (multiple-instruction stream, multiple-data stream, multi-core) systems.

6. Homework : There will be six homework assignments. **An assignment submitted late will not be accepted.** Students are reminded about printing the appendices and studying the solutions provided by the textbook. **Showing work** (intermediate steps) is **required** to get full/partial credits on a question. Although, the homework does **not** affect the term grade, it can help raise grades as explained below.

Each homework assignment includes **modified** past exam questions and answers to help students understand chapters and solve homework problems. Students need to study them **before they solve homework problems**, not before exams. Also note that, these past exam questions are samples and do **not** give hints about exams this semester.

7. Exams : There will be a 150-minute midterm exam and a 150-minute final exam. Students will be allowed to use their own material, i.e. their books, notebooks and handouts during the exams : “**open book**” exams. Students are expected to solve exam questions as they are shown in past exam solutions and class. **Showing work** (intermediate steps given in past exam solutions and class) is required to get full credits on a question. The reason is that not only the final answer of the question is important, but also the approach, the technique used to get the solution.

8. 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 considered is student’s attendance record. If they are **all** good, the grade will be raised. Thus, students are strongly suggested that they fulfill the requirements of the course, i.e. the lectures and homework assignments. Finally, the professor may change the term grade computation. Thus, students are strongly suggested that they fulfill the requirements of the course, i.e. labs, lectures and homework assignments.

9. 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. Students need to use a Polytechnic email address and include their name and section in their email. Broadcast messages will be sent to class to make announcements. Students are strongly suggested that they **see** the professor to ask questions, instead of sending email. Note that grades are **not** given out to students via email or telephone. Students need to see the professor to learn their grades.

10. 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. We will cover PRAMs which are theoretical systems to help understand real parallel systems better. Then, we will 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). We will move on to distributed memory MIMD systems and 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 systems.

11. Material Coverage : Chapters from Hennessy and Jordan books will be covered. 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 22	Introduction ; Computer layers ; Computational methods ; Popular scientific applications ; MIPS FP instructions ; CS613 Integer pipeline ; (Chp 1 ; Appendix A, B) ; (Chp 1)
Jan 29, Feb 5, 12, 19	MIPS FP pipeline ; Advanced pipelining : Speculative execution, superscalar execution, VLIW computation ; (Chp 2, 3, Appendix A, B, G) ; (Chp 7)
Feb 26	Vector processors ; (Appendix F)
Mar 5, 12	Flynn's classification ; Interconnection networks ; (Chp 2, 3, 4 ; Appendix E, H) ; (Chp 1, 4, 6)
Mar 26	Midterm Exam : Lectures on Jan 22 - Feb 26 ; HW : 1 - 3
Apr 2	Parallel processing overview ; Dependency analysis ; Levels of parallelism ; Parallelism issues ; Algorithm complexity ; PRAMs ; (Chp 2, 3, 4 ; Appendix H) ; (Chp 2, 4, 7)
Apr 9	SIMD machines ; (Chp 2, 4, Appendix H) ; (Chp 1, 3, 5, 7)
Apr 9, 16, 23	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 23	Distributed Memory MIMD systems ; (Chp 2, 4, Appendix H) ; (Chp 4, 5, 7, 8, 9, 10)
Apr 30	Current parallel processing system issues ; (Chp 2, 4, Appendix H) ; (Chp 2, 7, 9, 10)
May 7	Final exam : Jan 22 - Apr 30 ; HW : 1 - 6

12. References : Students are suggested that they study recent computer architecture and parallel processing books since the field advances fast.

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. Lippasi, 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 Algorithms and Architectures : Arrays. Trees. Hypercubes*, F. Thomson Leighton, Morgan Kaufman, 1992.

20) Numerous research papers from journals and conference and workshop proceedings on computer architecture, parallel processing, supercomputing, operating systems, algorithms, programming languages and compilers.

13. Reminder about the course : Read the material for students at the Poly web site under “Current Students,” such as “University Code of Conduct” and the Poly NYU Syllabus Addendum on MyPoly under “Polytechnic Community -> Policies & Rules.” In addition, keep the following in mind :

a) Students are strongly suggested that they **concentrate on learning**, not on grades (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 make up (learn) quickly, without thinking about the grade.

b) 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 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 and labs 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, attending the lecture help students focus on the topics better and students learn more and remember more.

c) 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 on the student provided by the 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. That is, 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.

d) 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.

e) Students are strongly recommended that they **not** make assumptions and decisions on the course without asking the professor : exams, lectures, the homework and attendance.

f) It has been observed that a student pays unnecessary penalty, because he/she does not know/follow Polytechnic University and course rules and regulations. They also do not seek advice from Polytechnic staff. Students are, therefore, strongly suggested that **they speak with the professor**, the TAs, the personnel of the Student Development Office, and the Counseling Center when they experience difficulties/problems.

g) 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.