CSCE 496/896: Performance Analysis of Object-Oriented Systems

Monday, Wednesday & Friday 1:30 - 2:20 pm
113 Ferguson Hall

1 Contact Infomation

Instructor: Dr. Witawas Srisa-an
213E Ferguson Hall
Tel: 472-5004
Email: witty@cse.unl.edu
Hours: Monday 2:30 - 4:00 pm & Wednesday 10:00 am - 11:30 am.

Teaching Assistant:
Mulyadi Oey
501 Bldg. Room 5 cubicle 7
Tel: In person only
Email: moey@cse.unl.edu
Hours: Monday 9:00 - 11:00 am.

2 Overview

This course is designed to address the performance issues in today's Object-Oriented languages and platforms. Microsoft .NET for example, provides many attractive features that include garbage collection, dynamic compilation, language level support for threading, etc. These features allow programmers to be more productive since they are no longer burden by the tedious tasks of managing memory and synchronizing threads. On the other hand, such features are notorious for incurring substantial performance penalties. In addition, the introduction of these features in a system can greatly affect the overall performance since the runtime systems such as garbage collection and threading support do not work together well. Thus, the performance shortcomings are greatly magnified in heavy-duty server systems that mainly rely on multiple threads to service heavy workload.

In this class, we will address these issues from theoretical and practical perspectives. The major topics in this class will include automatic dynamic memory management (garbage collection), thread synchronization, Just-In-Time compilation, dynamic class loading, and the performance of these runtime systems on different computing platforms (e.g embedded systems and distributed systems). The lecture materials will be based on a combination of textbooks and research publications. The participants will also independently examine on-going research efforts to solve these performance issues.

For assignments, students will examine the actual implementation of these runtime systems. We will use Microsoft CLR engine which is the core runtime infrastructure for .NET platform. Students will also work closely with the provided profiling interface (when available) or instrument the source code of the CLR engine to get information such as object behaviors, execution time of each runtime component, etc. The information will then be used in trace-driven simulations to evaluate the overall performance of these runtime tasks.

3 Course Organization

We will spend the first half of the semester discussing basic information about various runtime components in today's virtual machines. The components that we will discuss include dynamic memory management, dynamic class loading, thread synchronization, and Just-In-Time compilation. Since my area of expertise is dynamic memory management, we may spend more time on this topic. I will assign a warm-up exercise during this period that would explore the runtime behaviors of different memory allocators. It is also possible that we may not be able to cover all the topics listed due to time constraint.

We will have an examination based on the information presented in the first half of the class. During the second half, we will research more advanced topics in the areas covered. In each area, I will suggest two or three performance issues. In each issue, I will provide three papers that represent recent solutions to the performance issue in the area. For each paper, you will need to write a two-page summary (11-point font, times new roman, 1.5 space, and 1 inch margin all around) and a set of slides for 15-20 minutes presentation. I will provide an example of slides that summarize a research

effort. Expect to complete this part of the assignment by week 10 or 11.

The last part of the class will be spent on conducting research in the area that you have surveyed. There are three potential research efforts that you can undertake. They are:

- repeating an experiment performed in one of the paper.
- proposing an extended improvement to an existing solution.
- proposing a new solution to the existing problem.

You are allowed to work as teams with at most three members per team. I **will not allow** any team with more than three members. You need to provide your basic research plan around week twelve. The result of your research effort will be presented at the end of the semester. You can use the slides created for the survey assignment as your background section. Each team will have 25 minutes to present the results. You also need to submit a report that can be no more than 8 pages in IEEE standard publication format. The report must be submitted by the end of Wednesday during the final week.

4 Objectives

Since the research experience for students in this class can greatly vary, it would be unfair for me to expect the same level of research productivity from everyone. Due to such constraint, I have organized this class to be more flexible to the students' needs and research maturity. I have classified our students into two basic groups. The first group contains students with very little or no research experience. Such students may include undergraduates and first year graduate students. The second group contains the students who are either conducting research with their advisor or have already published their work. I suggest this group to take more ambitious project even if it may extend beyond the end of this class.

For seniors and first year graduate students, the objective of this class is to prepare you for graduate study. Thus, you may choose to repeat the research effort in one of the papers surveyed. This should allow you to learn

the common practice in conducting systems research. For advanced students, you may choose to provide improvement to the current solution or propose a new solution. Before you decide on this approach, you have to consider how much time you can spend on this project as well as your availability after the semester is over. It is very possible that your work cannot be finished by the end of the semester. If your proposed solution is worth pursuing, I will set a short term goal that can be accomplished within the semester. The rest of the work can be done as an independent study during the summer. The ultimate goal for this type of effort is to publish the results in high quality conferences.

5 Materials

We have one official textbook, one highly recommend optional text, and several documents that will be distributed on-line. The two textbooks are:

- *Garbage Collection: Algorithms for Automatic Dynamic Memory Management*, by Richard Jones and Rafael Lins, Wiley, 2003 (REQUIRED TEXT, available from the bookstore).
- *Shared Source CLI*, by David Stutz, Ted Neward, and Geoff Shilling, O'Reilly, 2003 (OPTIONAL TEXT but will be very useful for the projects).

I will also provide several conference and journal publications as part of the reading as well as project assignments. You should also browse through our on-line help and download course notes prior to each week. On-line help page is at:

www.cse.unl.edu/~witty/sp2004/csce496/howto.html

Weekly lecture notes can be downloaded at:

www.cse.unl.edu/~witty/sp2004/csce496/materials.html

Assignments can be found at:

www.cse.unl.edu/~witty/sp2004/csce496/assignments.html

6 Prerequisite

CSCE 310 (or background in data structures and algorithm) and familiarity with advanced concepts in operating system, programming language, and object-oriented programming is useful but not required.

7 Credit Information

Upon the completion of this course, students can earn 3 credits.

- For undergraduates, this course satisfies the software track for Computer Science majors and system level architecture track for Computer Engineering majors.
- For graduate students, this course satisfies the systems track.

8 Grading

Your final grade will be composed of:

1. Class participation (5%) - If you are active in class, active on the forum, or active outside of class, you can earn up to 5 points. Typically, it is difficult to clearly define the criteria for giving out points in class participation. In the past, I've used the following criteria to assign points:
    - common beginning—everyone begins the semester with three points. So if you show up to class every time but never participate in any activities, you would stay at three points.
    - familiarity with the students—if you are active in forum participation, make frequent visit during office hours, or/and actively participate in the classroom, you have earned 1 or 2 positive points.
    - absence of the students — if you are not present during random attendance check, not picking up graded material, sleeping in class (trust me, I remember), you have earned 1 or 2 negative points.

- different ending—you final score is based on the sum/difference of positive/negative points.

2. Assignments (45%) - Warm-up Exercise 15%, Homework 15% and project 30%. The distribution within this category is still tentative.

3. Examination (20%) - Will occur during the week before dead week. It will focus on the main objective of the course which is in depth understanding of concepts. The exam will only cover the lecture materials during the first half of the class.

4. Final Presentation (15%) - during the dead or final week

Grading scale will be

A+ = 98 - 100+
A = 94 - 97.99
A- = 90 - 93.99
B+ = 87 - 89.99
B = 83 - 86.99
B- = 80 - 82.99
C+ = 77- 79.99
C = 73 - 76.99
C- = 70 - 72.99
D-, D, D+ = 60 - 69.99
F = Below 60

Note: Automatic two-business day extension will be granted in exchange for 30% reduction in that assignment score. To take this option, you need to send me an e-mail specifying that you will be late within 24 hours **AFTER** the deadline. I will not accept late assignment after the extended period. This precisely means that you will get **NO** credit for your work.

9 Ground Rules

Please note that by staying on the course you are abiding to the rules and regulations described below. These are non negotiable.

1. All work submitted has to be your own work. Cheating of any form (copying from someone (or other groups) allowing someone to copy from you (or your group), presenting someone else's work as your own either partially or fully) will guarantee FAILURE in this course. In addition, your action will be reported to the Dept. Chairman. We **encourage** you to collaborate with your classmates on issues such as clarifying the problem statements, discussing potential solutions, discussing related tools and features needed for the assignments.

2. Project reports are due on a day we have a class up until the end of the lecture. Anything after that is considered late. If you decide to use the mailboxes in the CSE department then we are not liable if they are lost or stolen from the mailbox. It is your responsibility to get your report submitted. If you fail to do so you will receive no credit for it. Unless specified, your work should be submitted through *hand-in*.

3. For project assignments, instructions will be given accordingly.

4. No assignment will be accepted after the two-day extended period.

5. For the purpose of this course, you will have to download and install certain software packages. Help pages will be provided but you are expected to perform the task yourselves.

6. You are expected to be comfortable with the prerequisite material. If you feel you are not, it is your responsibility to revise and prepare accordingly.

10 Special Needs

We will try to accommodate any student with a disability. Please contact the instructor as soon as possible if you need special accommodations.