Notices:

- **Class-related material** including sketches to problem solutions and incremental grades will be usually posted [below](#) under password protection.
- Students in ECE/CSC 776 are expected to check this web site and/or their e-mail for class related updates at least twice a week.
- **IMPORTANT**: Read office hour and meeting policies

Past Assignments, Lectures & Notices:

- **First day of lectures is Thursday January 10, 2008, in 1230 EB 2.**
- **Deadline of February 16** to declare groups of 2 (groups are not mandatory for distance education students) and topic for essay/simulation/presentation project (from end-to-end service delivery, service oriented architectures, traffic and workload modeling, peer-to-peer networks, wireless networks, triple play, VoIP, next generation networks and other similar topics.)
- **Reading Assignment #1** (before you come to class for the first time):
  - Read carefully the syllabus and administrative procedures.
  - Review your background material (basics of high-speed networks, stochastic modeling, queuing).
  - Read Chapter 1 from the book by C. Courcoubetis (on reserve).
- **Reading Assignment #2** (weeks 1-2):
  - Read Chapter 1 from the textbook, Ch. 2 from the book by C. Courcoubetis.
  - Browse through the material related to network services and their pricing at [http://www.aueb.gr/Users/courcou/](http://www.aueb.gr/Users/courcou/)

Syllabus and Policies:

**Instructor:**
Professor [Michael Devetsikiotis](mailto:Michael.Devetsikiotis@ncsu.edu)
Office: 3060 EB II
Telephone: 515-5253
[Personal home page](mailto:Michael.Devetsikiotis@ncsu.edu)

**Teaching Assistant:**
- Name: [Ioannis Papapanagiotou](mailto:Ioannis.Papapanagiotou@ncsu.edu)
- Office hours:

**Lectures:**
Twice a week, Tue and Thu, 15:50 - 17:05, in **1230 EB 2**.

**Course description:**
Introduction to the design and performance evaluation of network services. Topics include
top-down network design based on requirements, end-to-end services and network system architecture, service level agreements, quantitative performance evaluation techniques. Provides quantitative skills on network service traffic and workload modeling, as well as, service applications such as triple play, IPTV, P2P, VoIP, storage, network management, and access services.

**Course Objectives:**

Under the guidance of the instructor and in an interactive and participatory manner, students will

- Apply the basic principles of top-down design of networks based on requirements
- Describe end-to-end services and network system architectures
- Utilize network traffic and application workload modeling for real workload characterization
- Critically evaluate the performance of multiplexed/scheduled network resources.
- Categorize admission and access control methods
- Incorporate end-to-end quality of service, service level agreements and service envelopes into the design of networks
- Use quantitative/mathematical performance evaluation techniques including simulation methods

There will also be special topics, including closed-loop congestion control, pricing/charging, more advanced mathematical techniques and optimization.

Students will be introduced to the fundamental concepts of performance of network services and the design of network infrastructure to deliver such services. Furthermore, they will receive an introduction to the design of network systems for selected applications and services such as triple and quadruple play, voice-over-IP, IPTV and peer-to-peer systems. At the end of the course, students should be able to handle advanced tools such as analysis and simulation for the design of network services and systems. Students will also obtain some practical experience, through real-life case-studies and projects

**Prerequisites:**
ECE 570 or equivalent and ECE 579 or equivalent.

**Office Hours (in 3060 EB II):**

- Tue 11:00 - 12:00
- Thu 11:00 - 12:00
- Outside the hours above, email to set up an appointment.

**Laboratory:**

Effort is being made to develop more demo exercises in OPNET and/or ns2. Depending on the status of the labs in EB II and the installation of OPNET and ns2 on the the EOS/Unity network, laboratories may be assigned for grade later in the term.

**Textbook:** No mandatory textbook. The "main sources" below are part of the course required reading.

**Main Sources (reserved at the library):**

Additional References:

Simulation Project

OPNET and ns2 are installed on EOS and, at least, on some of the ECE/CSC departmental networks. However, you can still use the software of your choice (or any language such as C/C++) for the course simulation project(s). Additional references:

31. My old simulation course page in Canada
33. The "project" appendices in Chapters 6 and 7 of the book by H. Perros (on the simulation of an ATM switch).
34. The book on simulation by Paul Fishwick in University if Florida.
35. The NS simulator (*NOT*available yet on the public EOS system) and its tutorial

Lecture Outline by Week:

1. Course arrangements and administration. Recap and discussion of high-speed network technologies and background

2. Network services: Introduction and motivation - discussion of pertinent text sections

3. End to end services – introduction to network service systems – examples and cases

4. Overview of quantitative performance modeling: analysis and simulation

5. Network architecture and components

6. Stream versus elastic services

7. Network traffic and workload characterization

8. Open loop solutions: Connection admission control and Effective bandwidths


10. Midterm exam.

11. Service routing and scheduling

12. End to end solutions

13. Closed loop systems: TCP

14. Pricing and management of services

15. Student presentations on selected topics (e.g., simulation techniques, multiple access, fluid approximations, large deviations and rare event analysis, long range dependence and self-similar models).

16. Discussion of simulation project; catch-up and final review

Attendance Policy:
In accordance with university policy, regular attendance at classes, laboratory period and
examinations is expected of all students

**Exams:**
The first, 75 minute mid-term exam will be held *in class* on Tuesday March 11, 2008. The final exam will be held on Thursday May 1, 13:00 – 15:00, in class.

*You will be allowed to bring to each exam any related material that you believe will assist you* ("open book"). A calculator (or two, for reliability) will be useful.

**Grading:**
- Project: 35%
- Midterm: 30%
- Final: 35%

**Audit Requirements:**
Completion of all assignments and exams with a total of at least 60% (normalized if needed, and if done for the rest of the class).

**Drop date:**
Last day to withdraw or switch to audit is Wednesday March 19, 2008.

**Assignments:**
Assignments will include simulation project(s) (at least one), research papers (essays) (at least one), and possibly conventional homework problem sets.

**Policies and Procedures:**
- Reading assignments are assumed as *actual assignments*, in other words, the instructor will assume each time during the lecture that the reading assignment material has been studied by the students *before* the class.
- Due date will be shown on each writing assignment and posted on the web. Late assignments will *NOT* be accepted.
- New assignments and deadlines will be announced in class. Hard copies of handouts, assignments etc. will usually *not* be distributed. Updates and copies of assignments will be available only from the web and/or e-mail. It is your responsibility to check whether anything new has been issued if you miss a class.
- Collaboration is allowed and, in fact, encouraged, on assignments other than exams. However, each student must turn in his/her own report and be responsible for understanding all the material involved.
- The purpose of assignments is to help you learn the material and prepare for examinations. It is essential that you fully understand all the assignments. If you perform badly on some questions, ensure that you find out afterwards what you should have done.
- If you are unable to turn in an assignment or take a test due to illness or similar reason, you are expected to inform the instructor *before* the due date or exam time, or by the *end of that day* at the latest (by phone or e-mail).
- Objections to grading of assignments or exams have to be submitted in writing at most one week after the date they are handed out. Any question or objection has to be taken up with the TA first, and only after that, if the issue is not resolved, with the instructor.
- Please do not expect the instructor to return phone calls, unless it is a true emergency. Outside office hours, e-mail is strongly preferred.
- A passing grade in both the combination of Assignments and Lab, and a passing grade in the Final Exam is required to pass this course.
- Incremental grades will be posted frequently, please check them. Requests for correction of errors must be received before final exam.
Students with disabilities
Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. Also see http://www.ncsu.edu/provost/offices/affirm_action/dss/
For more information on NC State’s policy on working with students with disabilities, please see http://www.ncsu.edu/provost/hat/current/appendix/appen_k.html

Academic integrity
All the provisions of the code of academic integrity apply to this course. In addition, it is my understanding and expectation that your signature on any test or assignment means that you neither gave nor received unauthorized aid.

Slides/Lecture Material:

1. Lectures 1-2 on background, motivation and network services.
2. An Introduction to Communication Networks and Services (C. Courcoubetis).
3. Alternative slides on Ch. 1 of Pricing book (R. Battiti, University of Trento)
4. Lecture 3 on network services classification and contracts.
5. Lecture 4 on examples of quantitative methods applied to network system design.
6. Lecture 5 on technologies, current practice, controls and business models.
7. Lectures on traffic modeling.
8. Slides on OPNET - overview.
9. Slides on NS2 - overview.
17. Intro to Simulation - I
18. Selection of Simulators (from the European Project "TEQUILA")
19. Intro to Simulation - II
22. Slides on multifractal traffic
26. OPNET introductory material
27. Fractal Simulation Traffic Models for Internet Simulation, B. Ryu and S. Lowen.
31. Material on Large Deviations EB and Zero Buffer approximation (Kesidis).
35. Rare Event Simulation Tutorial.
36. Prof. Do Young Eun's slides on network calculus and asymptotics.