School of Electrical Engineering and Telecommunications

Term 2, 2019

Course Outline

TELE4642
Network Performance

COURSE STAFF

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Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with "[TELE4642]" in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will be using the course webpage http://subjects.ee.unsw.edu.au/tele4642/. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

COURSE SUMMARY

Contact Hours

The course consists of 4 hours of lectures for the first 6 weeks, and 3 hours per week for the remaining 4 weeks. There is a 2-hour laboratory session each week.

	Days	Time	Location
Lectures	Monday (w1,3-11)	2pm - 4pm	Ainswth202
	Wednesday (w1-6)	9am - 11am	Ainswth102
	Wednesday (w7-10)	10am - 11am	Ainswth102
Labs	Wednesday (w1-10)	12noon - 2pm	ElecEng108
	Wednesday (w1-10)	2pm - 4pm	ElecEng108
	Wednesday (w1-10)	4pm - 6pm	ElecEng108

Context and Aims

This course aims to develop an understanding of the tools and technologies for understanding and improving the performance of communication networks such as the Internet. It will introduce students to quantitative methods for loss and delay analysis in packet networks, using techniques from stochastic traffic modelling, Markov chains, and queueing theory. It will expose students to frameworks for optimisation and orchestration of network performance, including emerging paradigms such as software defined networking (SDN). The quantitative methods studied in this course will be applied to practical examples from network architecture and design, in domains ranging from data centres and wide-area networks to home networks, mobile networks, and content-delivery networks.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1 (4 hours)	Stochastic Processes, M/M/1 queueing model
Week 2 (4 hours)	M/M/1 variants: finite storage, multiple servers, batch arrivals/departures
Week 3 (4 hours)	Networks of queues; **Quiz 1 (Wed 19 Jun)**
Week 4 (4 hours)	SDN concepts
Week 5 (4 hours)	SDN platforms and control plane
Week 6 (4 hours)	SDN use-cases; **Quiz 2 (Wed 10 Jul)**
Week 7 (3 hours)	Discrete Time Markov Chains (DTMC) concepts
Week 8 (3 hours)	DTMC applications: Google Page Rank, Slotted Aloha
Week 9 (3 hours)	DTMC applications: Randomised Routing; **Quiz 3 (Wed 31 Jul)**
Week 10 (3 hours)	QoS and traffic models; Review; **Project presentations**

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 1-3	Lab 1: Queueing system simulation
Week 4-6	Lab 2: SDN application
Week 7-10	Lab 3: Project

Assessment

Laboratory Practical Experiments	30 %
Quizzes	30 %
Final Exam (2 hours)	40 %

COURSE DETAILS

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term. It includes lectures and laboratories. Supervised labs are held 2 hours per week; however, you will be expected to work on the assignments and projects outside of designated lab hours.

Relationship to Other Courses

This is a 4th year undergraduate elective course in the School of Electrical Engineering and Telecommunications.

Pre-requisites and Assumed Knowledge

The course TELE3118 "Network Technologies" is a pre-requisite for this course. Knowledge of data networking protocol architectures is assumed, since this course develops techniques for the design and performance analysis of such architectures. In addition, it is expected that the student is conversant with basic probability and statistics, and comfortable with programming (preferably in C, Java, or Python).

Following Courses

The course is not a pre-requisite for other courses in the school of faculty.

Learning outcomes

After successful completion of this course, you should be able to:

1. Identify the causes of poor performance (losses and delays) in the Internet
2. Quantify the performance of simple network systems by developing appropriate analytical models
3. Critique emerging technologies used by Internet Service Providers for offering Quality of Service (QoS) to Internet traffic
4. Construct and evaluate practical tools for performance evaluation

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in **Appendix A**. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in **Appendix B**). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in **Appendix C**.

Syllabus

This course aims to develop an understanding of the tools and technologies for understanding and improving the performance of communication networks such as the Internet. It will introduce students to quantitative methods for loss and delay analysis in packet networks, using techniques from stochastic traffic modelling, Markov chains, and queueing theory. It will expose students to frameworks for optimisation and orchestration of network performance, including emerging paradigms such as software defined networking. The quantitative methods studied in this course will be applied to practical examples from network architecture and design, in domains ranging from data centres and wide-area networks to home networks, mobile networks, and content-delivery networks.

TEACHING STRATEGIES

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;

- Tutorials (though not formally scheduled, many of the Wednesday lectures will be run as tutorials), which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement and debugging skills;
- Project, which will use group-work as a means of exploring a research problem in greater depth, and provide you with the opportunity to demonstrate and communicate your approach and solution.
- Quizzes, which will provide feedback on your progress in problem-solving.
- Final examination, which is the final test of competency

Learning in this Course

You are expected to attend all lectures, labs, and quizzes in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW assumes that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Laboratory Program

The laboratory schedule is deliberately designed to provide practical, hands-on exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory from Week 1 to Week 10.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course must take the labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to apply for a catch-up lab during another lab time, as agreed by the laboratory coordinator.

ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Ongoing assessment occurs through the lab checkpoints (see lab manual), lab exams and the mid-term exam.

Laboratory Assessment

- Assignment 1 [10%]: This assignment will involve design and development of simulation software to be demonstrated in lab session by week 3. Grading will be based on correctness, functionality, and novelty of design.
- Assignment 2 [10%]: This assignment will require you to develop a software application for an SDN. You will demonstrate your functioning tool by week 6. Grading will be based on correctness, functionality, and novelty of design.
- Project [10%]: This project will be done in groups of up to 4 students, and is designed to train you in conducting team research into a topic. Groups will choose from a given list of topics (most likely related to the area of Software Defined Networking) or propose their own in consultation with the course convenor. The chosen topic will be briefly presented to the class in week 7. The final presentations will be done in week 11.

Quizzes

This course will have three in-class written quizzes that will evaluate and provide feedback on your understanding of the material in this course. Quiz 1 will be held in week 3 (Wed 19 Jun), quiz 2 in week 6 (Wed 10 Jul), and quiz 3 in week 9 (Wed 31 Jul). Each quiz is worth 10% of the final grade, and each will typically test your problem-solving skills. Re-tests will not be granted in the event that a student misses the test, unless satisfactory written evidence is presented of adverse conditions that prevented the student from taking the test. In such a case, the course convenor may at his sole discretion conduct the re-test orally (instead of or in addition to a written component) individually with the student, within two weeks of the original test date

Final Exam

The exam in this course is a standard closed-book 2 hour written examination. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course*.

COURSE RESOURCES

Textbooks

There is no one prescribed textbook for this course. Material from the following books will be used, and will be augmented with papers supplied via the course web-page:

- Ivo Adan and Jacques Resing, "Queueing Theory", 2001, available on-line at no cost from the web-site http://www.win.tue.nl/~iadan/queueing.pdf
- Piet Van Mieghem, "Performance Analysis of Complex Networks and Systems", Cambridge University Press, 2006. This book is available in the bookshop. Some chapters of this book are available on-line free of charge at http://www.nas.ewi.tudelft.nl/people/Piet/bookPA.html
- Peter G. Harrison and Naresh M. Patel, "Performance Modelling of Communication Networks and Computer Architectures", Addison-Wesley, 1993.
- James F. Kurose and Keith W. Ross, "Computer Networking: A Top-Down Approach", 4th Edition, Addison-Wesley, 2007.
- Leonard Kleinrock, "Queueing Systems. Volume I: Theory", Wiley-Interscience, 1975.
- Papers and other reading material will be posted on the course web-page https://subjects.ee.unsw.edu.au/tele4642/

OTHER MATTERS

Dates to note

Important dates are available at: https://student.unsw.edu.au/dates

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see: https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/guide), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and independent, self-directed study. In periods where you need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the online student survey myExperience. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies: https://www.engineering.unsw.edu.au/electrical-engineering/resources and https://student.unsw.edu.au/guide.

APPENDICES

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing digital and information literacy and lifelong learning skills through assignment work.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	✓
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	✓
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓
	PE2.2 Fluent application of engineering techniques, tools and resources	✓
	PE2.3 Application of systematic engineering synthesis and design processes	
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	✓
	PE3.3 Creative, innovative and pro-active demeanour	✓
	PE3.4 Professional use and management of information	✓
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	✓