TELE9751
Internet Design and Equipment Architectures

Course Outline – Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

Course Convener and Lecturer: Dr. Tim Moors, t.moors@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, after lectures during class times (if time permits). Another opportunity to ask questions is during consultation times, from 11am to 12noon on Tuesdays in the Lecturer's office, room 341 of the EE&T building.

Email: You can contact the Lecturer about course administration issues through email to t.moors@unsw.edu.au if you include the phrase “tele9751” in the subject line and your student number in the message body. Please do not ask technical questions about the content of this course through email.

Keeping Informed: Announcements may be made during classes, via email (to your student email address, e.g. z1234567@student.unsw.edu.au) and/or via the course web site. Please check these sources at least once per week. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Resources

Web sites: The course web page http://subjects.ee.unsw.edu.au/tele9751/ is the primary online resource for this course, directly hosting many resources (e.g. lecture slides and schedule) and linking to others. One of the pages that it links to is a set of Recommended Reading. The username and password required for some course web pages will be available through Moodle. This course will also use Moodle for discussion forums and disseminating marks. The Moodle entry page http://moodle.telt.unsw.edu.au gives contact information for UNSW services that can help you access and use Moodle if you have problems. If they fail, then contact the Lecturer.

Textbooks

The recommended book for this course is

G. Varghese: "Network Algorithmics: An Interdisciplinary Approach to Designing Fast Networked Devices", Morgan Kaufmann, 2005

Note that this book is recommended, and not required/prescribed.

Course Summary

Contact Hours

The course consists of 3 hours of lectures each week (except when the mid-session test replaces lectures). Class times and locations are available online https://my.unsw.edu.au/classutil/TELE_S1.html#TELE9751T1 . Class meetings will include traditional live oral lectures, but perhaps more importantly create an opportunity to interact with the Lecturer and other students as they are engaged in the same pursuit of learning. The Lecturer encourages you to participate in these face-to-face meetings by asking and answering questions.

The course web page and wiki provide extra resources, including some pre-recorded lectures in the form of MP3 narrations for lecture slides.

Context and Aims

The aim of TELE9751 is to develop student understanding of the design and architectures of equipment (e.g. switches, routers and caches) that are used to construct switched networks such as the Internet. It focuses on how such equipment works internally, rather than on how to use such equipment through external interfaces. It builds upon basic network technologies courses (e.g. TELE3118) that cover protocols at the link layer (e.g. IEEE 802.3), routing (e.g. OSPF and BGP) and end-to-end protocols (e.g. TCP and HTTP) by focusing on the internal construction of Internet equipment (e.g. switch fabrics and packet classifiers) and on non-routing protocols that are used between such equipment.

Indicative Lecture Schedule

In week 0, students are expected to read this course outline.

Week	Topic
1	Administrivia, switched networks, routers vs switches
2	Traffic characteristics/requirements, switching modes
3	Switch structures and single-stage fabrics
4	Multistage switches
5	Optical switching
6	Mid-session exam
7	Packet classification
8	Buffering, Active Queue Management and Explicit Congestion Notification
9	Traffic Management and Scheduling
10	Bridging
11	ATM, MPLS, intserv, diffserv
12	Caches

Assessment dates and weights

	Weighting	Task	Submission date
Required	70%	Examinations 30% mid-session exam 40% final exam	 during week 6 class during end-of-semester exam period
	10%	Assignment	part A before the end of week 6 part B before the end of week 12
	20%	Programming project	end of week 12
Optional	+≤10%	Bonus for course improvement	before the final exam

If you choose to perform optional assessment tasks, then your mark for those tasks will supplement your mark from required assessment tasks. The "end of" a week is 11:59pm on the Sunday that follows that week of class.

Course Details

In some places, this course is named “TELE9751 Switching Systems Architecture”.

Credits

This is a 6 Units of Credit (UOC) course. “The normal workload expectations of a student are approximately 25 hours per Semester for each UOC” [https://student.unsw.edu.au/uoc] or about 10–12 hours per week throughout the 13 week semester.

Relationship to Other Courses

TELE9751 is a postgraduate course in the School of Electrical Engineering and Telecommunications. It is part of the Telecommunications Specialisation Area of multiple programs (program codes in parenthesis):

- Master of Engineering Science (8538)
- Master of Engineering Science Extension (8539)
- Graduate Diploma of Engineering Science (5338)

It may also be chosen as an elective in other programs, e.g. the Bachelor of Engineering in Telecommunications program (code 3643) and the Doctor of Philosophy program (code 1640).

Complementary courses: TELE9752 covers the operation and control of the devices that this course considers the design and architecture of, and TELE9756 considers advanced aspects of networking. TELE4642 considers network performance in depth. TELE3119 covers network security.

Pre-requisites and Assumed Knowledge

TELE9751 assumes background from an introductory networking course like UNSW's TELE3118 or COMP3331. The course web page will provide links to resources for specific prerequisite topics that you should understand for this course. For the project, you are expected to be familiar with computer programming.

Following Courses

TELE9751 is not a prerequisite for any other UNSW course.

Learning outcomes

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

1. Describe the role of the different components of Internet equipment (such as switching fabrics, packet classifiers, buffers, and packet schedulers), how the components are combined to construct Internet equipment, and the communication protocols used between Internet equipment..
2. Describe alternative technical designs for each component, including the trade-offs (e.g. performance and implementation cost) made by various designs.
3. Predict how (the components of) Internet equipment will behave when subjected to given stimuli
4. Select and design (on paper) (the components of) Internet equipment that is appropriate for a particular context.

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

From the UNSW Course Handbook [http://www.handbook.unsw.edu.au/postgraduate/courses/2015/TELE9751.html]:

> This course provides detailed knowledge of the design of equipment and protocols used to build communication networks such as the Internet. The course has five parts: 1. Switches: The motivations for switched networks, and the fabrics that provide the core switching function inside switches and routers. This includes time- and space-division switches, and all-optical switches. 2. Algorithms and techniques for implementing other functions of switches and routers, such as packet classification, buffering, and traffic management. 3. Protocols used between switches and routers, such as the Spanning Tree Protocol and bridges, signalling protocols, fast packet switching and tag switching. 4. Other internetworking devices, e.g. caches, load balancers, and layer 4/7 switches.

In 2015, this course will *not* cover:

> 5. Design of networks in terms of dimensioning links and nodes (equipment) in order to achieve performance objectives.

Teaching Strategies

Delivery Mode

TELE9751 combines face-to-face classes, online learning and project-based learning.

Online learning: Many TELE9751 resources will be available electronically through the course web page http://subjects.ee.unsw.edu.au/tele9751/, including PDF copies of lecture slides, MP3 recordings of slide narratives, and copies of papers that form recommended

reading for this course. The MP3 recordings constitute a *new mode of teaching*, that complements live oral lectures by giving students control of the timing of the narrative, allowing them to pause, review and play it on demand.

Project: While complete instantiations of Internet equipment take many person-years to develop, and so are infeasible to develop as part of this course, the experience of implementing some component of Internet equipment can be highly instructive in developing deep understanding of that component and in appreciating the effort needed to construct a complete system. Consequently, TELE9751 includes a project in which students will be asked to implement in software one of the components covered in the course and to test this component in the framework of a complete software-based switch. Your group is free to choose the language that you use provided that it supports sockets communication (for interfacing with the rest of the switch) and it is not a simulation language such as Matlab since real devices are not built upon such simulators. C/C++ or Java are often used, and you can get started by reading a classic text (e.g. Kernighan and Ritchie for C) and writing some programs using free compilers/development environments such as GCC or Visual Studio Express.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the session.

Examinations

The bulk (70%) of the assessment will take the form of two closed-book examinations to be held during class time in week 6 (worth 30%), and during the end-of-semester exam period (worth 40%). These are intended to give you feedback about your individual performance. Video surveillance may be used during exams to help secure the exam process.

Mid-Semester Exam

The mid-session exam will last one hour and be held during lecture time in week 6, i.e. on Wednesday April 15, 2015. Questions may be drawn from any course material up to the end of week 5. Marks will be assigned according to the correctness of the responses.

Final Exam

The exam in this course is a standard closed-book 3 hour written examination. 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 covered in weeks 7-12. Marks will be assigned according to the correctness of the responses.

A Final Exam Paper Inspection Session will be held in the second week after results are released (the course web page will provide the exact date by the time that results have been released). If you wish to inspect your Final Exam paper during this Inspection Session, then you must indicate your desire through email to the Lecturer within one week of the release of results.

Other assessed learning activities

During session you will participate in an individual assignment and a group project. For both of these activities:

- You can resubmit your material as many times as you like before the deadline, and you are encouraged to submit early and repeatedly so that you can be confident that you have a successful submission before the deadline, since **late submissions will not be accepted** (receive a mark of 0).
- The material must be your own work, and must not be plagiarised in part or whole. As a disincentive to plagiarism, work that is found to have been plagiarised or not fully written by the student(s) who submitted it may receive a ***negative mark*** with weighting as high as that for the activity (i.e. rather than contributing additively to your overall course mark, a plagiarised project submission may *subtract* 20% from your overall mark).

Assignment

For the assignment you will create wiki pages about topics covered by the course. This will develop your skills in locating and using information about this subject from outside the course, and in finding links between topics covered in this course. Your work on the wiki will be covered by the Creative Commons Attribution Share-Alike 3.0 License [http://creativecommons.org/licenses/by-sa/3.0/]. You must submit your wiki pages to the wiki and they will be marked according to the correctness, and potential usefulness as a learning aid to other students, of the content of the pages.

Programming project

The programming project will allow you to explore in depth one component of a typical packet switch/router by developing software to implement that component which you can then test in in the framework of a complete software-based switch. This assessment task deliberately adds a practical aspect to the course, to complement the more theoretical material covered in lectures. The programming project will be done in groups. One member of each group should email your group's program and report to the Lecturer before the deadline.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes			
Assessment	**1**	**2**	**3**	**4**
Mid-semester exam	✓	✓	✓	✓
Assignment	✓	✓	✓	-
Project	✓	✓	✓	-
Final exam	✓	✓	✓	✓

Bonus for course improvement

Students whose contributions lead to course improvements can receive a bonus mark (that adds to the 100% potential marks from other assessment tasks) of up to 10%. Such contributions (be they questions, answers, comments, pointers to useful course material, etc) must be made before the final exam.

Assessment requirements

Material submitted for assessment must:

- Be submitted before the deadline
- Be original work by the student and not involve plagiarism (defined below)
- Be self-contained in that it can be fully understood independent of course materials (e.g. lecture notes)
- Demonstrate skills and understanding of knowledge that are covered by the course.

Merely memorising course materials and repeating them as answers to exam questions will likely not demonstrate understanding of the materials and such answers will often not be self-contained.

Appeals: Frequently when a course runs, some students are fortunate and receive just enough marks to succeed in their own way (e.g. 50PS or 85HD), and some students are unfortunate and receive slightly fewer marks than they seek (e.g. 49FL or 84DN). Close fails (e.g. 49) are particularly difficult for many TELE9751 students because they are often enrolled in MEngSc degrees in which there is no Pass Conceded mechanism (unlike the EE&T BE degree), and many students incur high costs, e.g. in terms of visas or tuition fees, for failing a course. While the TELE9751 teaching staff are aware that such circumstances exist, we are only able to award marks on the basis of achievement demonstrated in the assessment tasks. If you are dissatisfied with your overall mark and feel that your circumstances warrant special treatment, then you should appeal to the School's Director of Academic Studies (see http://www.eet.unsw.edu.au/info-about/contact-us/school-contacts for contact details) and not to the TELE9751 teaching staff.

Other Matters

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 http://www.lc.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://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve 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 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

UNSW has "special consideration" policies for "when illness or other circumstances interfere with your assessment performance." [https://student.unsw.edu.au/special-consideration] Pay particular attention to the need to **apply though myUNSW within 3 days of the date of the examination** for which you seek special consideration. You should only apply for special consideration for exceptionally severe/grave conditions, since you may not be granted it for moderate/mild conditions. Any alternate assessment given to recipients of special consideration may be conducted orally and will be no easier than the original assessment. Any supplementary final exam will likely be held in week 18 (6 weeks after the last week of session), and you should particularly consider this if you are planning to travel.

Continual Course Improvement

Students are advised that the course is under constant revision in order to improve the learning outcomes of its students. Students are encouraged (in part by the potential for a bonus mark of up to 10%) to forward any feedback (positive or negative) on the course to the Lecturer. You can make anonymous comments through the “Course Improvement” forum under Moodle. An example of the impact of your suggestions for course improvement is the 2013 addition of an assignment to reduce the weighting of the final exam from 50% to 40%, in response to requests in the 2012 CATEI survey.

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:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

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 attributes, as follows:

an in-depth engagement with the relevant disciplinary knowledge in its interdisciplinary context;

TELE9751 focuses on the discipline of designing Internet equipment and treats this in the broader contexts of design of IT systems and general engineering design, as well as the context of communication systems (e.g. end-to-end protocols) that use such Internet equipment.

the capacity for analytical and critical thinking and for creative problem solving;

TELE9751 will engage students in analysing alternative designs for Internet equipment, by critically evaluating the benefits and disadvantages of alternative designs, by considering which designs are most suitable for a particular application, and for creatively solving design problems.

an appreciation of, and a responsiveness to, change

In TELE9751, students will observe how the design of Internet equipment has evolved over the years

a respect for ethical practice and social responsibility.

TELE9751 emphasises the importance of not plagiarising.

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	✓