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 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.

Syllabus


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 2010, this course will not cover:

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

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

Programs: TELE9751 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).

TELE9751 is worth 6 Units of Credit (UOC). “The normal workload expectations of a student are approximately 25 hours per Semester for each UOC” [https://my.unsw.edu.au/student/atoz/UnitsOfCredit.html]

Several other UNSW courses relate to TELE9751:

Prerequisites: TELE9751 assumes background from an introductory networking course like UNSW's TELE3118 or COMP3331. For the project, you are expected to be familiar with programming.

Complementary: 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.

Following: TELE9751 is not a prerequisite for any other UNSW course.

Old: TELE9301 Switching Systems Design is the predecessor of TELE9751.
Learning outcomes

By the end of this course, students should:

- **know** the different components of Internet equipment, such as switching fabrics, packet classifiers, buffers, and packet schedulers. They should also know alternative designs for these components, how the components are combined to construct Internet equipment, and the communication protocols used between Internet equipment.
- **understand** the trade-offs (e.g. performance and implementation cost) that affect the design of the above components.
- **be able to** predict how (the components of) Internet equipment will behave when subjected to given stimuli, and so select and design (on paper) (the components of) Internet equipment that is appropriate for a particular context.

This course contributes to the following **UNSW Graduate Attributes**:

- **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, for critically thinking about 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.
Teaching strategies

**Delivery mode**

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

*Face-to-face classes:* The TELE9751 class meets face-to-face on Monday evenings from 6-9pm in room 224 of the Electrical Engineering Building. 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.

*Online learning:* Many TELE9751 resources will be available electronically through the course web page [http://subjects.ee.unsw.edu.au/tele9751/](http://subjects.ee.unsw.edu.au/tele9751/) or through Moodle, including PDF copies of lecture slides, MP3 recordings of slide narratives, and copies of papers that form recommended reading for this course. Where course web pages require a username and password, use the username “tele9751” and password “9751idea”. 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. This course will also use Faculty Moodle for:

- Electronic distribution of this Course Outline
- Discussion forums
- Disseminating marks

Moodle is an open-source software package designed to provide electronic support for teaching. UNSW’s Moodle system can be accessed through [http://129.94.131.42/moodle](http://129.94.131.42/moodle). If you have problems using Moodle, then see [http://moodle.org/](http://moodle.org/) for support. If that fails, then contact the Lecturer.

*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 an assignment in which students will be asked to implement one of the components covered in the course and to test this component in the framework of a complete software-based switch.

**Timing**


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

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

The times and dates for assessment tasks are stated in the Assessment section of this course outline.

**Teaching staff**

The Lecturer for this course is Dr Ashay Dhamdhere.
http://www.ee.unsw.edu.au/staff/ashay/profile.htm

**Communication channels**

*Email:* You can contact the Lecturer about course administration issues through email to ashay@unsw.edu.au if you include the phrase “tele9751” in the subject line. Please do not ask technical questions about the content of this course through email.

*Consultation:* The Lecturer is available for consultation during breaks during class time on Monday nights, and in his office only between 5-6pm Mondays. You are encouraged to ask technical questions about the content of this course during consultation time.

*Notifications to students:* Notifications to students about this course may be:
- made orally during lectures,
- posted on the course web page (which you are expected to check at least once per week),
- emailed to your student email address, e.g. z1234567@student.unsw.edu.au (which you are expected to check at least once per day and to maintain so that messages sent to your student email address do not bounce).

**Course resource list**

The course web page http://subjects.ee.unsw.edu.au/tele9751/ is the primary 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 recommended book for this course is
Note that this book is recommended, and not required/prescribed.

**Assessment**

**Synopsis**

<table>
<thead>
<tr>
<th>Weighting</th>
<th>Task</th>
<th>Submission date</th>
</tr>
</thead>
<tbody>
<tr>
<td>80.00%</td>
<td>Examinations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30% mid-session exam</td>
<td>during week 6 class</td>
</tr>
<tr>
<td></td>
<td>50% final exam</td>
<td>during end-of-semester exam period</td>
</tr>
<tr>
<td>20.00%</td>
<td>Programming project</td>
<td>end of week 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(11:59pm Fri June 4, 2010)</td>
</tr>
<tr>
<td>5%</td>
<td>Bonus for course improvement</td>
<td>before the final exam</td>
</tr>
</tbody>
</table>

**Examinations**

The bulk (80%) 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 50%). These are intended to give you feedback about your individual performance.

*Special consideration:* If you require special consideration for an examination, then follow the procedures described at https://my.unsw.edu.au/student/atoz/SpecialConsideration.html. Pay particular attention to the need to apply within 3 days of the date of the examination for which you seek special consideration, and note that 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.

*The mid-session exam* will last one hour and be held during lecture time in week 6, i.e. on Monday April 12, 2010. Conducting this examination electronically using Moodle will allow students to receive feedback about their progress in the course before the middle of session, while still allowing the exam to be run late enough in session to allow it to cover a meaningful chunk of course material. The exam will consist of multiple choice and "fill-in-the-blanks" questions, and cover material covered in the course up to the end of week 5.

*Final Exam Paper Inspection Session:* A Final Exam Paper Inspection Session will be held in the second week after results are released (the exact date is to be announced when the schedule for releasing results is known). 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 after the release of results.

**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. Your program is to be submitted through Moodle. You can resubmit your program 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 program 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 project (i.e. rather than contributing additively to your overall course mark, your submission may subtract 20% from your overall mark).

**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 5%. Such contributions (be they questions, answers, comments, pointers to useful course material, etc) must be made before the final exam.

**Other matters**

**Academic Honesty and Plagiarism**

Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply: http://www.lc.unsw.edu.au/plagiarism.

**Administrative Matters**

On issues and procedures regarding such matters as special needs, equity and diversity, occupational heath and safety, enrolment, rights, and general expectations of students, please refer to the School policies: http://scoff.ee.unsw.edu.au/

**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 5%) 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 introduction in 2009 of MP3 recordings of slide narratives, which is
intended to enhance effective communication with students as measured in CATEI surveys.
The design of this course has been informed by the following publications:
M. Ulema: “Design and implementation of a network management course for undergraduate information systems students”, Proc. ISECON 2006

UNSW Guidelines on learning
http://www.guidelinesonlearning.unsw.edu.au/overview.cfm

ENGAGING students in learning
1. Effective learning is supported when students are actively engaged in the learning process.
2. Effective learning is supported by a climate of inquiry where students feel appropriately challenged and activities are linked to research and scholarship.
3. Activities that are interesting and challenging, but which also create opportunities for students to have fun, can enhance the learning experience.
4. Structured occasions for reflection allow students to explore their experiences, challenge current beliefs, and develop new practices and understandings.

CONTEXTUALISING students' learning experiences
5. Learning is more effective when students' prior experience and knowledge are recognised and built on.
6. Students become more engaged in the learning process if they can see the relevance of their studies to professional, disciplinary and/or personal contexts.
7. If dialogue is encouraged between students and teachers and among students (in and out of class), thus creating a community of learners, student motivation and engagement can be increased.

INCLUSIVE learning and teaching experience
8. The educational experiences of all students are enhanced when the diversity of their experiences are acknowledged, valued, and drawn on in learning and teaching approaches and activities.
9. Students learn in different ways and their learning can be better supported by the use of multiple teaching methods and modes of instruction (visual, auditory, kinaesthetic, and read/write).

DESIGNING an engaging, contextualised and inclusive curriculum
10. Clearly articulated expectations, goals, learning outcomes, and course requirements increase student motivation and improve learning.
11. When students are encouraged to take responsibility for their own learning, they are more likely
to develop higher-order thinking skills such as analysis, synthesis, and evaluation.

12. Graduate attributes - the qualities and skills the university hopes its students will develop as a result of their university studies — are most effectively acquired in a disciplinary context.

TEACHING an engaging, contextualised and inclusive curriculum

13. Learning can be enhanced and independent learning skills developed through appropriate use of information and communication technologies.

14. Learning cooperatively with peers — rather than in an individualistic or competitive way — may help students to develop interpersonal, professional, and cognitive skills to a higher level.

15. Effective learning is facilitated by assessment practices and other student learning activities that are designed to support the achievement of desired learning outcomes.

16. Meaningful and timely feedback to students improves learning.

Evaluations by students

UNSW evaluation forms can be found at http://learningandteaching.unsw.edu.au/content/LT/evaluation/catei_process.cfm?ss=2

A CATEI evaluation will be conducted during the second half of the course.

Workload

“The Academic Board has determined that the normal workload expectations of a student are approximately 25 hours per semester for each unit of credit.” Since this course is worth 6 Units of Credit, you are expected to expend approximately 150 hours (12.5 hours per week) towards this course. There are 3 contact hours per week for this course, which will mainly involve lectures but will also involve tests.

Special events:
week 0
 tests