2010-11 academic year

Traffic Engineering (21727)

Degree/study: Bachelor's Degree in Telematics Engineering
Year: 2nd
Term: 3rd
Number of ECTS credits: 4 credits
Hours of studi dedication: 100 hours
Teaching language or languages: Catalan / Spanish / English
Teaching Staff: Boris Bellalta and Cristina Cano

1. Presentation of the subject

This course presents the concepts and mathematical tools which are necessary to analyse and to dimension links and communication networks and gives an overview of the different aspects related to data link level. At the end of the course, students must know and understand data link level functions and to analyse them as well as their impact in the whole communication system both quantitatively and qualitatively. In order to provide the students with applied examples of the contents of this course, some of the functions used in current technologies.

Traffic Engineering is a compulsory subject for the students of the degree on Telematics Engineering. Since it is taught on the third term of the second year of studies, students already have a deep knowledge on the higher protocol layers (application - network) and the lower ones (physical level) as well. All in all, this course is strongly related to previous courses and the knowledge that the students acquired in them.

2. Prerequisites to follow the subject

The previous knowledge that students are supposed to have are the following (concept / subject or subjects where they are mastered):
- Basic concepts on probability.
- Channel models, modulation and codification.
- Application, transports and network functions (Networks and Services 1 and 2).

The basic abilities that students are expected to have are:
- Abstraction capacity in order to understand the set of mathematical tools to be used.
- Abstraction capacity in order to visualise and understand how communication networks work.
- Capacity to learn new concepts on communication networks without the teacher's help.
- Abstraction capacity in order to understand how communication systems work.
- Capacity to plan and solve problems in an analytical way.

3. Competences to be acquired in this subject

General competences	Specific competences
Instrumental 1. Capacity to analyse and summarize. 2. Problem solving. 3. Information managing (look for information in different sources and	1. Knowing what traffic is and which are the types of communication networks. 2. Knowing and understanding the basic tools and principles to analyze and dimension communication links. 3. Knowing and understanding the concepts of traffic offered,

analyze it). 4. Capacity to organise and plan. Interpersonal 5. Critical reasoning. Systemic 6. Investigation abilities. 7. Learining abilities. 8. Capacity to have new ideas (creativity). 9. Ability to work autonomously. 10. Motivation for quality.	traffic carried and traffic lost. Knowing the concepts related to communication links (delay, loss, occupation, ...) 4. Being able to analyze communication systems both at the parcel and the flow/call level. 5. Understanding the functions implemented by the link level in a communication system. 6. Understanding the need to frame information before its transmission. 7. Understanding how the mechanisms used to control errors (such as CRCs) work. 4. Understanding and knowing how to value retransmission control systems (ARQ) always taking into account the failure probability function in frames during their transmission through a channel. 8. Understanding the need to manage the access to shared channel frameworks and which mechanisms make this possible. 9. Understanding, evaluating and implementing centralized and distributed access control mechanisms. 10. Indentifying the link level functions implemented in the current communication systems. 11. Understanding the interaction between the link and the physical level (channel encoding, modulation, bandwidth, as well as with the higher levels of the TCP/IP architecture.

4. Contents

- Block 1. Introduction: The Internet as a queue network (2h)

- Block 2. Random processes (2h)
  - 2.1. Statistic moments
  - 2.2. Discrete Markov processes
  - 2.3. Continuous Markov processes
  - 2.4. Markov chains

- Block 3. Queuing theory (8h)
  - 3.1. Kendall notation
  - 3.2. M/M/1/K, M/M/1, M/G/1, M/G/1 with vacations
  - 3.3. Priority queues (QoS)
  - 3.4. Queue networks

- Block 4. Transmitting of link packets with errors (4h)
  - 4.1. Characterization of the physical level
  - 4.2. ARQ protocols
  - 4.3. Modelling through queuing theory

- Block 5. Shared channel (4h)
  - 5.1. Medium access protocols
  - 5.2. Modelling through queuing theory

- Block 6. Planning cellular networks (4h)
  - 6.1. Call / flow models
  - 6.2. New calls / handover
  - 6.3. Modelling through queuing theory

- Practical exercises: Simulating an M/M/1/K in C queue

- Seminars
  - 10 1-hour seminar sessions

5. Assessment

General assessed criteria
Students are assessed individually according to their performance in the different activities of this subject. There are two grading procedures: one for the June session and one for the September session.

A) June Session
- Final exam: 60 % of the final grade for the subject
  - It takes place during the third quarter examination session (end June).
  - It lasts for 2 hours.
  - It consists of short theory questions and problems that need to be solved in a analytical way.
  - It weights 60% of the final grade for the subject. If the grade for the final exam is greater than that of the mid-term exam, it will weight 85% of the final mark.
  - In order for the students to pass the subject, the mark for the final exam needs to be greater than 4.

- Mid-term exam: 25 % of the final grade for the subject
  - It is an in-class exam (done during theory sessions).
  - It lasts for 1 hour.
  - It weights 25% of the final grade for the subject. If the grade for the final exam is greater than that of the mid-term exam, the later one will be not taken into account.
  - It consists of short theory questions and problems that need to be solved in a analytical way.

- Practical sessions exercises: 5 % of the final grade for the subject
  - They are done in groups of 4 people except for a test that will be individual.

- Seminar sessions exercises: 10% of the final grade for the subject
  - Set of activities and exercises to be done throughout the course.

B) September Session
The final grade for the September session is calculated only with regards to an exam which weights 100% of the final grade. Considerations for this exam remain the same as for the June session exam.
It is important to bear in mind that one of the previous grades will be kept for the September session.

Grading summary:
A) EF >= EP Final Grade = 0.85·EF + 0.1·AC + 0.05·PR
B) EF < EP Final Grade= 0.60·EF + 0.25·EP + 0.1·AC + 0.05·PR

EF: Final Exam. EP: Mid-term exam. AC: Continuous Evaluation (in-class activities, problems to be handed in throughout the course). PR: Practical exercises.

6. Bibliography and teaching resources

6.1 Didactic resources. Basic readings (paper and electronic)

- L. Kleinrock; "Queueing Systems", John Wiley and Sons, 1975.
- Leon-Garcia, Widjaja; "Communication Networks" Fundamental Concepts and Key Architectures. McGraw-Hill International Editions. All editions.
- Andrew S. Tanenbaum; "Computer Networks". All editions.
- D. Bertsekas, R. Gallager; "Data Networks", Prentice Hall, 1992 (Second Edition).

6.2 Didactic resources. Further readings (paper and electronic)

- Practical Queuing Theory in Java (formulae + applets)
http://irh.inf.unideb.hu/user/jsztrik/education/09/english/index.html

6.3. Learning materials. Further information (paper and electronic)

Students will find links to the recommended resources for each theory block.

6.4. Didactic resources. Teaching material for the course

- Notes for the subject.
- PowerPoint presentations for the subject.
- Set of problems (with the corresponding solution).
- Set of problems (without the corresponding solution).

6.5. Didactic resources. Additional materials.

Students will find links to the recommended resources for each theory block. However, students are strongly advised to use the following Java queue simulator.
Java Modelling Tools: http://jmt.sourceforge.net/

7. Metodology

Subject's methodology
The in-class component of the subject is divided into 2 different parts: 35 hours

- Theory sessions: Common sessions for the whole group of students where the main concepts of the subject are presented and analysed.
- Practice and seminar sessions: These sessions are held in small groups and give the students the chance to work on the concepts introduced during the lectures and to put them into practice. Teachers may help students whenever doubts arise.

After the in-class sessions, students have to work individually in order to:

- Understand the key concepts and acquire the competences needed to take part in the subject.
- Solve the activities in exercises given to strengthen the said competences and knowledge.