Course guide
230619 - NET - Network Science

Last modified: 11/04/2025

Unit in charge:	Barcelona School of Telecommunications Engineering
Teaching unit:	744 - ENTEL - Department of Network Engineering.

Degree:	MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject). MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2025   **ECTS Credits:** 5.0   **Languages:** English

LECTURER

Coordinating lecturer: MARCOS POSTIGO BOIX

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to deal with the convergence, interoperability and design of heterogeneous networks with local, access and core networks, as well as with service integration (telephony, data, television and interactive services).
2. Ability to design and dimension transport, broadcast and distribution networks for multimedia signals
3. Ability to develop, direct, coordinate, and technical and financial management of projects in the field of: telecommunication systems, networks, infrastructures and services, including the supervision and coordination of other's subprojects; common telecommunications infrastructures in buildings or residential areas, including digital home projects; telecommunication infrastructures in transport and environment; with corresponding energy supply facilities and assessment of electromagnetic emissions and electromagnetic compatibility.
4. Ability to model, design, implement, manage, operate, administrate and maintain networks, services and contents
5. Ability to plan networks and decision-making about services and applications taking into account: quality of service, operational and direct costs, implementation plan, supervision, security processes, scalability and maintenance. Ability to manage and assure the quality during the development process
6. Ability to understand and to know how to apply the functioning and organization of the Internet, new generation Internet technologies and protocols, component models, middleware and services

Transversal:
7. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

8. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Individual work (distance)
- Exercises
- Exams

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The aim of this course is to understand the role of social networks in our lives. Social networks pervade our social and economic lives. They play a central role in the transmission of information about job opportunities and are critical to the trade of many goods and services. The countless ways in which network structures affect our lives make it critical to understand how social networks structures impact behavior, which network structures are likely to emerge in a society, and why we organize ourselves as we do.

STUDY LOAD

Type	Hours	Percentage
Self study	86,0	68.80
Hours large group	39,0	31.20

Total learning time: 125 h

CONTENTS

0. Course presentation

Description:
- Faculty introduction
- Overview of the contents of the course.
- Description of the grading system and the activities of the course.

Full-or-part-time: 3h
Theory classes: 3h

1. Influence models: Population-Based

Description:
1.1. Introduction.
1.2. Information Cascades.
1.3. Tipping.
1.4. Diffusion.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

2. Influence Models: Topology-Dependent

Description:
2.1. Nodes and links importance.
2.1.1. Graphs and adjacency matrix.
2.1.2. Centrality measures.
2.1.2.1. Degree centrality.
2.1.2.2. Closeness centrality.
2.1.2.3. Betweenness centrality.
2.1.2.4. Eigenvector centrality.
2.1.2.5. Katz centrality.
2.1.2.6. PageRank centrality.
2.1.2.7. Link Betweenness.
2.2. Contagion and Infection.
2.2.1. Contagion.
2.2.2. Infection.
2.2.2.1. SI Model.
2.2.2.2. SIS Model.
2.2.2.3. SIR Model.
2.2.2.4. SI Model Topology-based.

Full-or-part-time: 20h
Theory classes: 6h
Self study : 14h

3. Social Networks Topology

Description:
3.1. Milgram's experiment (6 degrees of separation).
3.2. Small Worlds.
3.2.1. Characteristics.
3.2.2. Structural Small Worlds (average shortest path and clustering coefficient).
3.3. Network Models.
3.3.1. Erdos-Renyi model.
3.3.2. Regular Ring Graph.
3.3.3. Watts-Strogatz Model.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

4. Internet Topology

Description:
4.1. Scale-free networks (power-law characteristic).
4.1.1. Power-law characteristic.
4.1.2. Generative model: Preferential attachment.
4.1.3. The Achilles heel of the Internet?
4.2. The real Internet: self-organized and based on contrained optimization.
4.2.1. Generative model: Constrained optimization.
4.3. Functionality model of the Internet.
4.3.1. Network likelihood.
4.3.2. Network Performance.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

Exam 1

Description:
Exam of the first part of the course (lessons 1-4).

Full-or-part-time: 11h
Theory classes: 3h
Self study : 8h

5. Behavior and networks

Description:
5.1. Introduction.
5.2. Game theoretic-basics.
5.2.1. Definitions and fundamentals.
5.2.2. Qualitative presentation of games. Examples.
5.2.3. Types of games. A typical classification.
5.2.4. Application examples.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

6. Analysis and presentation of games

Description:
6.1. Games in normal form.
6.2. Games with sequential actions (extensive form games).
6.3. Games in equilibrium. Nash equilibrium.
6.4. Dominant strategies.
6.5. Application examples.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

7. Solving matrix two-person games

Description:
7.1. Two-person zero sum game. The basics.
7.2. Constant sum matrix games. Application examples.
7.3. Minimax theorem. Pure and mixed strategies. Saddle point.
7.4. Best response strategies. Dominated strategies.
7.5. Solving 2*2 matrix games graphically.
7.6. Graphical solution of 2*m and n*2 games.
7.7. Application examples.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

8. Alternative solutions to two-person matrix games

Description:
8.1. 2*2 games revisited.
8.2. Invertible matrix games.
8.3. Matrix games and linear programming.
8.4. Application examples.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

9. Two-person nonzero games

Description:
9.1. The basics.
9.2. 2*2 Bi-matrix games.
9.3. Bi-matrix games and nonlinear programming.
9.4. Application examples.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

Exam 2

Description:
Exam of the second part of the course (lessons 5-9).

Full-or-part-time: 11h
Theory classes: 3h
Self study : 8h

GRADING SYSTEM

First part (Lessons 1-4): Exam 40%, Continuous Assessments 10%
Second part (Lessons 5-9): Exam 40%, Continuous Assessments 10%

BIBLIOGRAPHY

Basic:

- Chiang, Mung. Networked life : 20 questions and answers [on line]. Cambridge ; New York: Cambridge University Press, 2012 [Consultation: 08/11/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=1025055. ISBN 1316089975.
- Easley, D.; Kleinberg, J. Networks, crowds, and markets: reasoning about a highly connected world. New York: Cambridge University Press, 2010. ISBN 978-0-521-19533-1.
- Leyton-Brown, Kevin; Shoham, Yoav. Essentials of game theory : a concise, multidisciplinary introduction. [San Rafael]: Morgan & Claypool, cop. 2008. ISBN 9781598295931.
- Osborne, Martin J. An Introduction to game theory. New York [etc.]: Oxford University Press, 2004. ISBN 9780195128956.
- Spaniel, W. Game theory 101: the complete textbook. CreateSpace Independent Publishing Platform, 2020. ISBN 9781492728153.

Complementary:

- Jackson, M.O. Social and economic networks. Princeton University Press, 2011. ISBN 978-0-691-14820-5.
- Barron, E. N. Game theory : an introduction. 2nd ed. Hoboken, N.J.: John Wiley & Sons, cop. 2008. ISBN 9781118216934.
- Newman, M.E.J. Networks. 2nd ed. Oxford: Oxford University Press, 2018. ISBN 9780198805090.