# MAP-i-UCT - Advanced Computer Networks (5 ECTS)

Doctoral Programme: MAP-i
Proponent Institutions: University of Minho, University of Aveiro, University of Porto
Academic Year: 2009/2010

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## A. Course Programme

### 1. Context and Motivation

In the last decades, the widespread use of the Internet as a general-purpose network and the continuous growth in communications, has motivated an increasing demand for new competencies and skills in the networking area. This demand involves multiple players, including academia, research and development centers, service providers and industry, illustrating a clear trend toward services integration in a single communication platform, where the Internet Protocol is seen as the convergence technology layer. In this scenario, strong efforts have been made to adapt and improve TCP/IP networks with enhanced service models, protocols, control and management facilities, in order to accommodate the integration of applications and services with distinct quality requirements. Achieving seamless and ubiquitous networking solutions is a further intricate issue attending to the plethora of service providers with their own business, management and technological strategies. Despite ongoing advances, achieving scalable and flexible networking solutions requires further study and contributions at multiple levels.

In this context, the course unit on "*Advanced Computer Networks*" aims to provide advanced background on relevant computer networking topics, allowing postgraduate students to acquire and pursue deeper knowledge in the field. The proposed syllabus, integrating current research activities at the University of Minho, University of Aveiro, and University of Porto, covers an encompassing view of recent TCP/IP developments.

Related courses taught at top international universities include:
- Graduate Computer Networks (15744), Prof. Hui Zhang, School of Computer Science, CMU
- Advanced Computer Networks (CS6250), Prof. Constantine Dovrolis, College of Computing, Georgia Tech
- Computer Networking (15441), Prof. Peter Steenkiste and David Eckhartdt, School of Computer Science, CMU
- Networked Systems (GZ01) and Multimedia Systems (GZ05), Prof. Graham Knight and Prof. Mark Handley, Computer Science, UCL

### 2. Objectives

The objective of this course unit is twofold:
(i) to study the problematic of service integration in TCP/IP networks focusing on protocol design, implementation and performance issues;
(ii) to debate the current trends and leading research in the computer networking area.

Promoting a comprehensive and deep knowledge in multiservice networks, this course provides the students with appropriate theoretical and practical skills in the area. In particular, the Internet Protocol (IP) is studied as an internetworking and convergence solution both in fixed and mobile environments, advanced transport issues are debated under the scope of diverse end-to-end delivery requirements, complemented by case studies of current and emerging multiconstrained applications, and related architectures.
The management of multiservice TCP/IP networks, focusing on management models, measurement, monitoring and security issues is a key component to be covered in the course. Self-organizing networks will also be matter of study.

The course aims at fostering students' initiative, innovation and self-criticism in the computer communications field, grounding their ability to carry out fundamental scientific research, on an individual basis. This course also constitutes an important background element for postgraduate students and researchers planning to develop further competence in edge networking topics.

**3. Learning Outcomes**

In general terms, the proposed UCT is envisioned to deliver the following learning outcomes:

i. to identify and discuss the concepts underlying IPv6 protocol, and their main characteristics and functionality;
ii. to understand the principles and functionality of mobile IP, explaining its concretization in IPv6; to understand the needs of optimization of the mobility mechanisms and description of some extensions that aim to reduce handover latency and requirements from terminals;
iii. to recognize the need for service integration and discuss how it can be accomplished;
iv. to explain and exemplify current QoS architectures and mechanisms, and the QoS support challenges in future networks;
v. to understand and explain the design issues in transport services in face of applications and services requirements;
vi. to understand theoretical and practical concepts behind the design of multiconstained applications and services;
vii. to discuss relevant management issues and devise adequate network management solutions;
viii. to identify and assess possible research opportunities and difficulties within the course scope.

**4. Syllabus**

The course includes the following modules:

1) Introduction: Course organization and objectives
Next generation networking: Motivation and Challenges
Discussion and evaluation of positioning papers.
2T+2TP (1 week)

2) IPv6 Internetworking and Mobility
Internetworking with IPv6; IPv6 extensions and functionality.
Routing advances.
Mobile IP networking. Micro and macro mobility.
Discussion and evaluation of positioning papers.
6T+6TP (3 weeks)

3) IP Convergence and QoS
Service integration and Quality of Service (QoS) in IP networks.
Service contracts. Services specification, configuration and management.
Discussion and evaluation of positioning papers.
4T+4TP (2 weeks)

4) Advanced transport issues and signalling
Reliable and unreliable transport services for the support of QoS and real-time.
Signalling for Multiconstrained Services and Applications.
Case studies: Video over IP and VoIP
Discussion and evaluation of positioning papers.
4T+4TP (2 weeks)

5) Service-oriented architectures (SOA)
services in SOA-based networks; technologies for the support and development of services;
technologies and APIs for SOA; WebServices and associated technologies.
Discussion and evaluation of positioning papers.
4T+4TP (2 weeks)

6) Managing TCP/IP networks

Management models and functions. Autonomic management.
Internet measurement and monitoring.
Discussion and evaluation of positioning papers.
4T+4TP (2 weeks)

7) Self-organizing networks
Ad-hoc, sensors and mesh networks; applications; communication support: information dissemination, medium access mechanisms, routing mechanisms, transport protocols, quality of service and security; self-organizing concepts in infrastructure networks.
Discussion and evaluation of positioning papers.
4T+4TP (2 weeks)

**5. Teaching Methodology**

The teaching methodology will consist of four distinct parts. During classes, theoretical subjects will be transmitted to students in slots of aprox. 20-30min (Formal Lecture). These slots will be interleaved with periods of aprox. 10 min, where the full class may discuss the subjects and pose questions to the teacher (Interactive Lecture). Additionally, during the semester the students have to write a research assignment (Individual Research) in order to prepare a presentation to the class for general discussion (Group Discussion). A more detailed description of each one of the methodologies is the following:

1) - Formal lecture
The advantage of this methodology is that it can be structured offering the ability to teach many students in a short (controlled) period of time. This teaching strategy should resort to attractive audio-visual materials in order to motivate the students. Since the students are the passive recipients of information this teaching methodology should be complemented by (interleaved with) other teaching strategies.

2) - Interactive lecture
This methodology aims to foster active learning by the students by inviting their involvement in the teaching activities wherethey can discuss specific issues related with the topics presented by the teacher. This part of the class can also be used to pose questions and doubts to the teacher.

3) - Individual Research (during part of the semester)
The teacher will steer the learner to relevant research topics/articles in the subjects of the discipline. Based on such research, the student (or a small group of students) will prepare a presentation (aprox. 20 min) to the class.

4) - Group Discussion (final classes of the semester)
Based on the individual (or group) presentation, the teacher and the students will discuss the corresponding research topics and raise questions to the class.

**6. Examination Criteria**

The overall grade will be based on intermediate assessments (30%), a final exam (40%), a final presentation (20%), and on class participation (10%).

**7. Bibliography**

The main recommended bibliography includes the following books:


- Silvia Hagen, "IPv6 Essentials", OReilly, 2002.
- H. Soliman, "Mobile IPv6 - Mobility in a wireless Internet", Addison-Wesley, 2004.

- Sanjay Jha, Mahbub Hassan, "Engineering Internet QoS", Artech House Inc., 2002.
- Z. Wang, "Internet QoS: Architectures and Mechanisms for Quality of Service", The Morgan Kaufmann Series in Networking, 2001.

- Michael Welzl, "Network Congestion Control: Managing Internet Traffic", John Wiley & Sons, 2005
- Colin Perkins, "RTP: Audio and Video for the Internet", Addison-Wesley Professional, 2003
- Wes Simpson, "Video Over IP: A Practical Guide to Technology and Applications", Focal Press, 2005

• Olivier Hersent, Jean-Pierre Petit, David Gurle, "IP Telephony: Deploying Voice-over-IP Protocols", John Wiley & Sons, 2005.

• Douglas R Mauro, Kevin J Schmidt, "Essential SNMP", O'Reilly Media, 2 edition, 2005.
• Mark Crovella, Balachander Krishnamurthy, "Internet Measurement: Infrastructure, Traffic and Applications", Wiley, 2006.

Additional bibliography references will be provided to students during the course. These references will be mainly composed by recent and relevant research articles focusing on the lectured topics.

## B. Lecturing Staff

The lecturers involved in this course (from UM, UA, UP) have extensive experience in lecturing at postgraduate level. All of them have significant research publications related to the topics covered in this course programme.

### 1. List of Lecturers

Alexandre Santos, Associate Professor, Department of Informatics, University of Minho
José António Ruela, Associate Professor, Department of Electronic Engineering and Computers, Faculty of Engineering University of Porto.
Paulo Carvalho, Assistant Professor, Department of Informatics, University of Minho (UCT-ACN Coordinator: pmc at di.uminho.pt).
Susana Sargento, Assistant Professor, Department of Electronics, Telecommunications and Informatics, University of Aveiro.

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