270016 - XC - Computer Networks

Coordinating unit: 270 - FIB - Barcelona School of Informatics  
Teaching unit: 701 - AC - Department of Computer Architecture  
Academic year: 2018  
Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Optional)  
ECTS credits: 6  
Teaching languages: Catalan, Spanish

Teaching staff

Coordinator:  
- Llorenç Cerdà Alabern (lloren@ac.upc.edu)  
Others:  
- David Carrera Pérez (dcarrera@ac.upc.edu)  
- Davide Careglio (careglio@ac.upc.edu)  
- German Santos Boada (german@ac.upc.edu)  
- Jaime M. Delgado Merce (jaime@ac.upc.edu)  
- Jordi Domingo Pascual (jordi.domingo@ac.upc.edu)  
- Jorge García Vidal (jorge@ac.upc.edu)  
- Jose Maria Barceló Ordinas (joseb@ac.upc.edu)  
- Leandro Navarro Moldes (leandro@ac.upc.edu)  
- Luc Etienne Jaulmes (luc.jaulmes@ac.upc.edu)  
- Luis Domingo Velasco Esteban (lvelasco@ac.upc.edu)  
- Manel Medina Llinàs (medina@ac.upc.edu)  
- Marc Riera Villanueva (mriera@ac.upc.edu)  
- Marc Ruiz Ramírez (muniz@ac.upc.edu)  
- Pere Barlet Ros (pbarlet@ac.upc.edu)

Prior skills

Students are expected to have acquired a level of technical English that enables them to follow documentation, manuals and standards, as well as a basic understanding of computer structure: main computer components, input/output devices, bus, direct memory access, interrupts. They are also expected to be familiar with operating systems and have a user-level knowledge of UNIX, OS organisation, drivers, processes, communication between processes and data structures.

Requirements

- Pre-Corequisite SO

Degree competences to which the subject contributes

Specific:

CT2.3. To design, develop, select and evaluate computer applications, systems and services and, at the same time, ensure its reliability, security and quality in function of ethical principles and the current legislation and normative.
CT2.4. To demonstrate knowledge and capacity to apply the needed tools for storage, processing and access to the information system, even if they are web-based systems.
CT3.6. To demonstrate knowledge about the ethical dimension of the company: in general, the social and corporative responsibility and, concretely, the civil and professional responsibilities of the informatics engineer.
CT6.1. To demonstrate knowledge and capacity to manage and maintain computer systems, services and applications.
CT6.2. To demonstrate knowledge, comprehension and capacity to evaluate the structure and architecture of computers, and the basic components that compound them.
CT6.4. To demonstrate knowledge and capacity to apply the characteristics, functionalities and structure of the
Distributed Systems and Computer and Internet Networks guaranteeing its use and management, as well as the design and implementation of application based on them.

CT7.1. To demonstrate knowledge about metrics of quality and be able to use them.

CT7.2. To evaluate hardware/software systems in function of a determined criteria of quality.

CT7.3. To determine the factors that affect negatively the security and reliability of a hardware/software system, and minimize its effects.

CT8.1. To identify current and emerging technologies and evaluate if they are applicable, to satisfy the users needs.

CT8.4. To elaborate the list of technical conditions for a computers installation fulfilling all the current standards and normative.

**Generical:**

G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

**Teaching methodology**

The subject is composed of theory and laboratory classes. Concepts will be explained in the theory classes, and related exercises will be completed. Students will be assigned problems to be completed in class.

Laboratory work represents an important part of the course. Students should obtain, at the beginning of course, a laboratory notebook providing a brief explanation of the theory and guidelines for each practical. The face-to-face laboratory sessions will be scheduled once the corresponding concepts have been covered in theory classes. Students will prepare for these sessions by reviewing the relevant theoretical concepts. Each face-to-face session will conclude with a mini-test.

**Learning objectives of the subject**

1. Identify the main functions associated with physical level protocols, links, networks, transport and networked applications and identify the level to which a protocol belongs.
2. Identify applications using a client-server paradigm and distinguish between temporary and well-known ports.
3. Predict protocol functioning and interpret the content of messages that use web, FTP, e-mail and DNS applications.
4. Interpret electronically represented documents (HTML and XML).
5. Interpret IP header fields, IP datagram fragmentation and messages generated by the ARP and ICMP protocols.
6. Interpret and deduce routing table content, predict RIP routing protocol behaviour and messages, design IP network address allocation, distinguish between public and private addresses and use NAT.
7. Design the basic configuration of a firewall (NAT, access lists and tunnels).
8. Differentiate between the services and functions for TCP and UDP and interpret header content for TCP segments and UDP datagrams.
9. Create time diagrams to model protocol behaviour in ARQ and particularly in TCP.
10. Predict TCP flow and congestion control behaviour, specifically the functioning of pop-up windows, segment transmission mechanisms, congestion windows and slow-start and congestion-avoidance algorithms.
11. Estimate the effective traffic rate for a TCP connection in different conditions (lags, link transmission speeds, segment losses, etc.).
12. Represent time diagrams representing MAC protocols for the local area networks studied.
13. Determine the active flow control mechanisms used for a local area network, traffic distribution according to station and device topology (hubs, switches and routers), distinguish between collision and broadcast domains, configure VLANs/trunks and determine the network topology for the configured VLAN.
14. Identify bottlenecks in a local area network and calculate the effective flow rate for different traffic conditions.
## Study load

<table>
<thead>
<tr>
<th></th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>15h</td>
<td></td>
<td>10.00%</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>15h</td>
<td></td>
<td>10.00%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>6h</td>
<td></td>
<td>4.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>84h</td>
<td></td>
<td>56.00%</td>
</tr>
</tbody>
</table>

**Total learning time:** 150h
### Content

**Introduction**

**Degree competences to which the content contributes:**

**Description:**
Introduction to the Internet, packet networks, standardisation bodies and the ISO OSI reference model.

---

**IP Networks**

**Degree competences to which the content contributes:**

**Description:**
Knowing the format of an IP datagram. IP addressing, numbering, Public and Private IP addresses, subnetting. IP supporting protocols (ICMP, ARP, DHCP, DNS). IP routing, routing table and concepts of IGP and EGP routing algorithms. NAT and security in IP networks: Concept of firewall and virtual private networks.

---

**TCP protocol**

**Degree competences to which the content contributes:**

**Description:**
The transport layer and its most important functions. Automatic error retrieval protocols such as ARQ. TCP/IP network transport layers, UDP and TCP protocols and particularly TCP flow control and congestion control mechanisms. Application interfaces and the transport layer (sockets).

---

**Local Area Networks**

**Degree competences to which the content contributes:**

**Description:**
Transmission media and structured wiring. Principles of access protocols for a shared environment on a local area network, Ethernet protocol, switches, VLANs and trunking. Basic wireless networks and protocol 802.11 (WiFi).

---

**Network applications**

**Degree competences to which the content contributes:**

**Description:**
The client-server paradigm for TCP/IP network applications. Applications (web, e-mail, DNS) and the protocols they use (HTTP, SMTP). Main formats for representing application documents (HTML, XML).
## Planning of activities

<table>
<thead>
<tr>
<th>Topic development: Introduction</th>
<th>Hours: 3h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topic development: Network applications</th>
<th>Hours: 18h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 6h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network applications laboratory</th>
<th>Hours: 2h 42m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 1h 42m</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>

**Description:**
Understand the HTTP, SMTP, POP3 and DNS protocols. Use system tools to monitor system activity and study system format and features.

**Specific objectives:**
3

<table>
<thead>
<tr>
<th>Laboratory mini-test on network applications</th>
<th>Hours: 0h 18m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h 18m</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

**Specific objectives:**
1, 2, 3

<table>
<thead>
<tr>
<th>Content language representation practical</th>
<th>Hours: 6h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>
**Description:**
Explore the use of HTML and XML languages for representing content.

**Specific objectives:**
4

---

<table>
<thead>
<tr>
<th>Sockets practical</th>
<th>Hours: 5h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

**Description:**
Develop a client/server application that uses the C-API socket for communication purposes. Develop TCP and UDP codes.

**Specific objectives:**
2, 8

---

<table>
<thead>
<tr>
<th>Topic development: IP networks</th>
<th>Hours: 25h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 4h 30m</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 12h</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Laboratory on basic commands for IP level configuration with UNIX</th>
<th>Hours: 2h 42m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 1h 42m</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>

**Description:**
Interface configuration, adding entries to the routing table, `/etc/hosts` files and basic commands (ping, traceroute, tcpdump). Face-to-face laboratory session.

**Specific objectives:**
5
| Laboratory mini-test on basic commands for configuring the IP level with UNIX | Hours: 0h 18m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 0h 18m  
Guided activities: 0h  
Self study: 0h |
| --- | --- |
| **Specific objectives:**  
1, 2, 3, 5, 6 |  |

| CISCO routers laboratory and IOS | Hours: 2h 42m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 1h 42m  
Guided activities: 0h  
Self study: 1h |
| --- | --- |
| **Description:**  
Router structure, IOS configuration modes, interface configuration, entries in the routing table and the show running-config command.  
**Specific objectives:**  
5, 6 |  |

| Laboratory mini-test on CISCO routers and IOS | Hours: 0h 18m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 0h 18m  
Guided activities: 0h  
Self study: 0h |
| --- | --- |
| **Specific objectives:**  
1, 2, 3, 5, 6 |  |

| Dynamic routing laboratory: RIPv1 and RIPv2 | Hours: 2h 42m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 1h 42m  
Guided activities: 0h  
Self study: 1h |
| --- | --- |
| **Description:**  
Configuring RIP in a Cisco router. Record update messages and build routing tables.  
**Specific objectives:**  
6 |  |
### Laboratory mini-test on dynamic routing: RIPv1 and RIPv2

**Specific objectives:**
1, 2, 3, 5, 6

**Hours:** 0h 18m  
- Theory classes: 0h  
- Practical classes: 0h  
- Laboratory classes: 0h  
- Guided activities: 0h  
- Self study: 0h

### ACLs and NAT with IOS laboratory

**Description:**  
Configuring standard and extended ACLs in IOS. NAT configuration.

**Specific objectives:**
7

**Hours:** 2h 42m  
- Theory classes: 0h  
- Practical classes: 0h  
- Laboratory classes: 1h 42m  
- Guided activities: 0h  
- Self study: 1h

### Laboratory mini-test on ACLs and NAT with IOS

**Specific objectives:**
1, 2, 3, 5, 6, 7

**Hours:** 0h 18m  
- Theory classes: 0h  
- Practical classes: 0h  
- Laboratory classes: 0h  
- Guided activities: 0h  
- Self study: 0h

### Topic development: TCP

**Hours:** 23h 30m  
- Theory classes: 7h  
- Practical classes: 4h 30m  
- Laboratory classes: 0h  
- Guided activities: 0h  
- Self study: 12h
### TCP and tcpdump practical

**Specific objectives:**
8, 9, 10, 11

**Hours:** 2h 42m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 1h 42m  
Guided activities: 0h  
Self study: 1h

### Laboratory mini-test on TCP and tcpdump

**Specific objectives:**
1, 2, 3, 5, 6, 8, 10, 11

**Hours:** 0h 18m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 0h 18m  
Guided activities: 0h  
Self study: 0h

### Topic development: Local area networks

**Hours:** 20h  
Theory classes: 6h  
Practical classes: 4h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 10h

### Switches laboratory

**Description:**  
Configuring VLANs and trunk links between Cisco switches and routers.

**Hours:** 2h 42m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 1h 42m  
Guided activities: 0h  
Self study: 1h

### Laboratory mini-test on switches

**Hours:** 0h 18m  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 0h 18m  
Guided activities: 0h  
Self study: 0h
## Specific objectives:
1, 2, 3, 5, 6, 11, 13, 14

<table>
<thead>
<tr>
<th>Final laboratory exam</th>
<th>Hours: 6h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 4h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory mini-test on networked applications</th>
<th>Hours: 0h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: 15-minute test issued at the end of the laboratory session.</td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory mini-test on basic commands for IP level configuration with UNIX</th>
<th>Hours: 0h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: 15-minute test issued at the end of the laboratory session.</td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory mini-test on CISCO routers and IOS</th>
<th>Hours: 0h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: 15-minute test issued at the end of the laboratory session.</td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C: Control 1</th>
<th>Hours: 5h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Evaluation of the units Introduction and IP Networks.</td>
<td></td>
</tr>
<tr>
<td>Specific objectives: 1, 2, 5, 6, 7</td>
<td>Guided activities: 1h 30m</td>
</tr>
<tr>
<td></td>
<td>Self study: 4h</td>
</tr>
</tbody>
</table>
### Laboratory mini-test on dynamic routing: RIPv1 and RIPv2

**Description:**
15-minute test issued at the end of the laboratory session.

**Hours:** 0h
- Guided activities: 0h
- Self study: 0h

### Laboratory mini-test on ACLs and NAT with IOS

**Description:**
15-minute test issued at the end of the laboratory session.

**Hours:** 0h
- Guided activities: 0h
- Self study: 0h

### C: Control 2

**Description:**
Evaluation of the unit TCP.

**Specific objectives:**
8, 9, 10, 11

**Hours:** 5h 18m
- Guided activities: 1h 18m
- Self study: 4h

### Laboratory mini-test on TCP and tcpdump

**Description:**
15-minute test issued at the end of the laboratory session.

**Hours:** 0h
- Guided activities: 0h
- Self study: 0h

### Laboratory mini-test on switches

**Description:**
15-minute test issued at the end of the laboratory session.

**Hours:** 0h
- Guided activities: 0h
- Self study: 0h

### EL: Final laboratory exam

**Hours:** 0h
- Guided activities: 0h
- Self study: 0h
**Description:**
This exam will be issued in the last week of face-to-face classes as a directed activity (AD) (i.e. separate from the face-to-face laboratory sessions).

**Specific objectives:**
1, 2, 3, 4, 5, 6, 7, 8, 11, 13

<table>
<thead>
<tr>
<th>EF: Final theory exam</th>
<th>Hours: 8h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guided activities: 3h</td>
</tr>
<tr>
<td></td>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

**Specific objectives:**
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14

<table>
<thead>
<tr>
<th>C: Control 3</th>
<th>Hours: 5h 18m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Guided activities: 1h 18m</td>
</tr>
<tr>
<td></td>
<td>Self study: 4h</td>
</tr>
</tbody>
</table>

**Description:**
Evaluation of the units: LANs and Applications

**Specific objectives:**
3, 4, 13, 14
The subject is assessed as follows: theory (75%) and laboratory (25%).

\[ NF = 0.25 \times NL + 0.75 \times NT \]

where:
- NF = final grade.
- NL = laboratory grade.
- NT = theory grade.

The laboratory grade will be calculated from the mean obtained from labs (25%) and final exam grade laboratory (75%). The presental lab sessions will be assessed by a minicontrol held at the end of each session. The non presental labs will be assessed with an exam at the end of the course. To make minicontrols in every session, it is required submitting a report at the beginning of the session. Otherwise, the minicontrol can not be done, and the grade of it is 0.

The theory grade (NT) can be obtained by continuous evaluation (NC) or by a final exam (EF), and will be computed as \[ NT = \text{max}(NC, EF) \]. The continous evaluation consists of 3 controls with weights 40% (C1), 40% (C2) and 20% (C3). That is:

\[ NC = 0.4 \times C1 + 0.4 \times C2 + 0.2 \times C3. \]

If NC and NF are greater or equal than 5, it is possible to do the final exam to obtain a higher grade. The student must communicate that to the coordinator.

Incentive to study. The final mark (NF) will be increased 1 point to students who meet the following conditions:
1) Deliver on time the tracking problems that will be proposed during the course.
2) Approve at least 1 of the Controls.
3) Have a theory grade (NT) and lab (NL) greater or equal to 5.

The mark of the transversal competence is computed as the average of the final exam marks of the presental and non presental labs.
270016 - XC - Computer Networks

Bibliography

Basic:


Complementary:


Others resources:

Hyperlink

http://www.ietf.org/

http://www.w3.org/ Consortium


http://www.isoc.org/