University of Pisa

and

Scuola Superiore Sant'Anna

Master Degree Program in Computer Science and Networking

Minor (subsidiary) Courses

academic year 2013-14

SYLLABUS

Algoritmi paralleli e distribuiti (6 CFU)

Parallel and Distributed Algorithms

The goal of the course is to introduce the main algorithmic techniques in the framework of parallel and distributed models of computing; to define the most significant complexity parameters and the computational limits of parallelism and concurrency. Finally computational tools to design and analyze parallel and distributed algorithms are given.

Syllabus

1) Models of computation
a. The PRAM model
b. Bounded degree networks. BSP.
c. The distributed model.

2) Design and analysis of parallel algorithms
a. Prefix sums, List Ranking, Euler tour.
b. Standard techniques and inner sequential problems.

3) Design and analysis of distributed algorithms
a. Communication complexity.
b. Control algorithms.
c. Fault tolerant algorithms .
d. Distributed data manipulation.
e. Classical examples: Broadcast and Spanning tree; Computation on trees: Saturation, functions evaluation; Election on Ring and other networks; Routing.
f. Distributed coordination and control of autonomous mobile robots.

Exam consists of a written test including both the design of algorithms and theoretical questions, and of a seminar on a research topic chosen by the student.

Ambienti virtuali su rete (6 CFU)

Networked Virtual Environments

This course will provide a general introduction to Virtual Environments, including an analysis of the common forms of network communication used in real-life applications. The course will also expose the practical aspects of Virtual Environments development, and practical lab sessions will provide the opportunity to conduct tests on some simple test applications.

Syllabus

1) Virtual Environments theory
    a. General concepts
    b. Introduction to Virtual Environments
    c. Real-Time computer graphics for VEs
    d. OpenGL fixed pipeline & Shaders
    e. Real-time physics
    f. Motion Tracking
    g. User Interaction
    h. Haptic feedback
    i. Communication architectures in Networked VEs
    j. Data traffic, payloads, latencies
    k. Events arbitration
    l. Gemetric data compression

2) Development & exercises
    a. Virtual Environments software architectures
    b. Introduction to a VE Integrated Development Environment
    c. Authoring 3D content
    d. VR equipment for Immersive visualisation, motion tracking and force feedback
    e. System Integration, profiling and debugging
    f. Testing network communication in collaborative VEs

Exam consists in a colloquium concerning course concepts and discussion of a simple project assigned to the student.

Amplificazione ottica e sensoristica (9 CFU)

Optical Amplification and Sensing

This course, which is composed of two parts, after providing the necessary fundamentals on optical components, will overview the most commonly used optical amplification and optical fiber sensor technologies. The course will also provide a hands-on laboratory module, where students will learn how to work and carry out experiments with optical amplifiers and components
Optical amplification has been one of the most important enabling technologies in communications during last years, which has allowed for the extraordinary increase in capacity and transmission distance underlying the present worldwide development of Internet and network-based services.
In the last few years a new sector is emerging, which is related to fiber-optic sensors, where optical and fiber-optic components are used for sensing of several physical, chemical and environmental parameters, finding manifold applications over a wide range of domains, from electric, electronic and nuclear engineering, to civil engineering and to energy-related sectors.

Syllabus

Optical amplification and fiber-optics sensing
- Fundamentals on light sources for optical communications: rate equations in semiconductors and the light emitting diode, LED, optical feedback, the LASER, multi-mode and single-mode lasers
- Photodiodes: pin and avalanche photodiodes
- Passive components: optic al fiber, coupler/splitter, Mach-Zehnder interferometer, optical filter technologies, tuneable filters, multiplexer/ de-multiplexer
- Non-reciprocal devices: isolator and the circulator
- Optical amplifier basics: stimulated emission and optical amplification, basic amplifier features, gain, noise figure, saturation power
- Overview of distributed and discrete amplifiers: Raman and Erbium-doped fiber amplifiers, semiconductor optical amplifier (SOA), parametric processes and parametric amplification
- Optical fiber sensors: introduction to fiber-optics sensing, distributed Raman and Brillouin sensors, fiber-Bragg grating sensors

Laboratory of photonic amplification and components
- Using a power meter, using a pin photodiode and an avalanche photodiode
- Measurements of wavelength-independent parameters in optical passive components
- Using the optical spectrum analyser in optical component measurements
- Characterising a laser
- Measurements of amplifier gain and saturation
- The amplifier optical noise figure: measurement basics
- Characterizing an EDFA
- Component linewidth characterisation: optical homodyne and heterodyne measurements
- Dynamic measurement with an oscilloscope and electric spectrum measurements

The final exam will be a written exam.

Architetture, componenti e servizi di rete (9 CFU)

Networking Architectures, Components and Services

The aim of the course is to present the architecture and protocols of modern packet-switching networks, focusing on the underlying problems and the different solutions proposed to solve them. In particular, issues related to IPv6, user mobility, multicast communications, Quality of Service requirements and peer-to-peer networks will be analysed. The theoretical part of the course will be followed by a lab module, devoted to the simulation of IP networks, the study of TCP (Linux TCP) and the implementation of rules for packet filtering and NATting in the Linux OS.

Syllabus

1) IPv6 and MIP
    a. General features of IPv6 and header format
    b. ICNPv6 and procedures of Neighbour Discovery
    c. Transition IPv4-IPv6
    d. Host mobility: MIPv4 e MIPv6
2) Multicast
    a. Multicast addresses
    b. IGMP
    c. Multicast Routing Protocols (DVMRP, PIM-SM, PIM-DM)
3) Transport Layer
    a. Overview on transport layer protocols (UDP, TCP, DCCP)
    b. Flow and Congestion Control mechanisms in TCP and DCCP
    c. RTT estimations
    d. Congestion Avoidance techniques (DECbit, RED, CHOKe, TCP Vegas)
4) Quality of Service
    a. Queueing and scheduling disciplines (FIFO, priority queueing, GPS, WFQ, WF2Q)
    b. Token bucket traffic characterization
    c. Intserv architecture
    d. DiffServ architecture
5) P2P
    a. General features
    b. Classification of P2P architectures and examples

6) Lab
    a. Simulation of IP networks
    b. Simulation analysis of TCP connections
    c. TCP linux in Linux OS
    d. IPtables: packet filtering and NATting

The exam will consist of an oral examination about the theoretical part as well as the lab activities.

Architetture di commutazione ed elaborazione dati a pacchetto (6 CFU)

Packet Switching and Processing Architectures

The course presents the main network switching architectures, with particular focus on packet switching architectures. After a brief introduction to the notions of circuit and packet switching, the course will focus on the main schemes of packet switching together with their performance and possible issues. Then, the course will deal with packet lookup and classification by presenting main algorithms currently in use. Finally, the course addresses the topic of traffic measurements and monitoring by introducing the main probabilistic techniques (mainly Bloom filters and their variations) to improve performance on high-speed links.

Syllabus

1) Basics on switching paradigms (circuit/packet switching)
2) Switching fabrics
    a. Basic properties of Interconnection Networks
    b. Multistage Networks
    c. Clos Networks
        i. Strictly and Rearrangeably non blocking networks
        ii. Recursive construction of Clos networks
    d. Self-routing (Banyan) Networks
3) Packet switching architectures
    a. Output Queued Switches (OQ)
        i. Average delay and maximum throughput
    b. Input Queued Switches (IQ)
        i. Head Of the Line blocking (HOL)
        ii. Virtual Output Queueing
        iii. Scheduling (MWM, MSM, etc.)
    c. Combined Input-Output queueing (CIOQ) and OQ emulation
4) Packet Lookup and Classification
    a. Exact/Prefix match lookup algorithms
        i. Unibit and MultibitTrie
        ii. Lulea-Compressed Tries
        iii. Tree bitmap
    b. Mono/Multi dimensional packet classification
5) •Traffic Measurements/Monitoring
    a. Packet capturing
    b. On-the-wire packet processing
    c. Probabilistic techniques for high performance monitoring applications

Exam consists of an oral colloquium including the discussion on a simple project that will be assigned during class time.

Aspetti prestazionali e di progetto delle reti wireless (6 CFU)

Performance and Design Issues of Wireless Networks

The objectives of the course are the presentation of the cellular network evolution, of the most popular technologies for Wireless LAN and MAN, and of the different solutions available for the Wireless Mesh Networks (WMN). Furthermore, the course aims at providing the tools necessary for the design of these networks and at highlighting their performance problems.

Syllabus

1) Cellular Networks
   a. General structure of a cellular network
   b. GSM network Architetture
   c. UMTS network Architetture
   d. Mobility and session management in cellular networks
2) Wireless LAN
   a. The standard IEEE 802.11
   b. Operative modes of IEEE 802.11 networks
   c. Distributed Coordination Function and Point Coordination Function
   d. IEEE 802.11 systems evolution
   e. Security threats and solutions in IEEE 802.11 networks
3) WiMAX Networks
   a. WiMAX network architecture
   b. The standard IEEE 802.16
4) Wireless Mesh Networks (WMN)
   a. MAC protocols
   b. Capacity
   c. Routing protocols
   d. Transport protocols
   e. Fairness issues
   f. QoS, Security and Management issues
   g. The working group IEEE 802.11s
5) Lab activity
   a. Design issues of cellular networks
   b. Performance and design issues of IEEE 802.11 networks
   c. Performance and design issues of WiMAX networks
   d. Techniques for improving performance of WMN

Exam consists in a colloquia concerning course matter plus a discussion on a simple project

Laboratorio di protocolli a architetture di routing (6 CFU)

Laboratory of Routing Protocols and Architectures

Required skills
Basic courses on Telecommunications Networks, basic configuration of Juniper routers

Aims
The course is aimed to provide the fundamental knowledge to understand the key concepts and the functional components necessary to design and implement inter-domain routing. Basic concepts concerning the configuration, management and monitoring of Juniper Networks router are recalled. Moreover, the course deals with theoretical and practical topics, such as the design and deployment of networks with EGP (BGP) routing protocols or the implementation of advanced services and functionalities (Stateful firewall, NAT/PAT, IPSec VPNs, QoS). Traditional lectures are coupled with laboratory experiments which provides students with the possibility to work with Juniper Networks routers.
The course includes the topics for the Juniper Networks Certified Internet Specialist (JNCIS-ER) exam.

Contents
JUNOS Policy. Policy language and policy evaluation process overview. Routing policy. Firewall policy.
(L:4)

BGP routing protocol. BGP overview. IBGP implementation. EBGP implementation. BGP-IGP interaction.
(L:4)

Enterprise routing policies. Design and deployment of BGP in an enterprise network. Case Study: primary/secondary routing policy.
(L:4; Lab:8)

Transitioning between IGP routing protocols. Transition methodologies overview. Overlay transition. Route redistribution transition. Integrated transition.
(L:2; Lab:2)

JUNOS services. Introduction to JUNOS services. Layer 2 services configuration. Layer 3 services configuration. Stateful firewall and NAT. applications. Configuring stateful firewall rules. Configuring NAT rules. Implementing and monitoring stateful firewall and NAT. IPSec VPN overview. IPSec VPN configuration, implementation and monitoring.
(L:4; Lab:8)

Quality of Service in IP networks. Class of Service overview. Design of a network with QoS support at IP level. Differentiated Services architecture overview. DSCP marker. Traffic classification. Traffic queuing. Traffic scheduling. Troubleshooting.
(L:4; Lab:4)

Examinations. Form of assessment:
Oral Examination with lab test.

Calcolo scientifico ad alte prestazione (6 CFU)

High Performance Scientific Computing

Aims:

- formulate parallel numerical methods,
- introduce selected advanced numerical methods and applications.

Outline:

1. Introduction: review of basic concepts and simple examples.
2. Numerical linear algebra: LU factorization, sparse matrices, iterative methods.
3. High performance linear algebra:scalability of LU factorization, computational aspects of iterative solvers, parallel preconditioners, ordering strategies, block algorithms.
4. Introduction to Boundary Value Problems: one dimensional model BVP, two dimensional model BVP, parallel FFT methods.

Exam: oral test.

Commutazione fotonica (9 CFU)

Photonic Switching

The course introduces the fundamentals of photonic technologies by considering the photonic devices on a structural, functional and manufacturing point of view. Moreover it will be given the basis of the photonic switching techniques by means of nonlinear photonic devices based on semiconductor and fibres. The curse includes practical in the laboratory.

Syllabus

1) Semiconductors for Photonics
a. Optical Proprieties of Semiconductors.
b. LEDs.
c. Optical guiding and cavities, losses and threshold condition.
d. DBR lasers, DFB lasers, VCSELs, quantum-cascaded lasers, microcavity lasers.
e. Key design parameters and degradation mechanisms in semiconductor lasers.
f. Semiconductor optical amplifiers.
g. PIN and avalanche receivers.
2) Photonic Passive and Functional Integrated Devices
a. Integrated guided optics.
b. Passive integrated devices.
c. Functional integrated devices.
d. Nonlinear devices.
3) Deposition and Compound Semiconductors Growth Techniques
a. Oxidation, sputtering, evaporation.
b. “Plasma enhanced” and “low-pressure” CVD.
c. Liquid-phase (LPE/) and vapour-phase (VPE/MOCVD) epitaxy.
d. Molecular beam epitaxy (MBE).
4) Processing/Manufacturing Devices
a. Lithography (electron-beam lithography, laser-beam lithography, optical lithography) and metallization.
b. "wet“ e “dry” etching techniques.
c. Ion implantation techniques, diffusion, annealing.
d. Device packaging.
5) Material/Device Testing and Characterization
a. Characterization equipment for materials (x-ray diffraction, photo-luminescence, Hall measurements, spectroscopy and microscopy techniques).
b. Characterization equipment for devices, examples of test setup.
6) Photonic Crystals Devices
a. Basic principles.
b. One-, two-, and three-dimensional PCD: typology, fabrication and characterization techniques.
7) Optical Fiber Technologies
a. Step- and graded-index fiber technology.
b. Micro-structured Fibers.
c. Fibre devices.
d. Optical fiber amplifiers.
e. Opical fiber sensors.
f. Fiber-guide coupling.
8) Glass-on-Silicon Technology.
9) Polarisation switching in a highly nonlinear fibre.
10) Signal inversion through XGM in a SOA.
11) Mode locked pulse characterization.
12) NOLM characterization through optical pulses.
13) AND photonic logic gate in a HNLF.
14) RZ packet generation.

Exam consists in a colloquium concerning course concepts and it could include the evaluation of reports on the experimental activities.

Piattaforme abilitanti distribuite (6 CFU)

Distributed Enabling Platforms

This course develops the issues of fundamental course on distributed computing platforms in depth, such as Grids and Clouds. This aim is also achieved through the study of state-of-the-art solutions, the detailed analysis of their technologies and of the best practices regarding last-generation distributed enabling platforms,

Syllabus

1) Introduction to distributed middleware
2) Development of concepts and techniques for Grid computing in depth
3) Grid computing components and solutions
4) Resource virtualization
5) Virtualization technologies
6) Introduction to cloud computing
7) Development of concepts and techniques for Cloud computing in depth
8) Applications tools for grid and cloud Computing

The examination procedure consists in a colloquium on course topics and on a project assigned to the student.

Information retrieval (6 CFU)

Information Retrieval

The goal is to introduce the theoretical foundations and algorithmic-engineering tools for the design, analysis and implementation of IR systems.

We will study several algorithmic techniques which are nowadays deployed to design IR applications, like: algorithms for data streaming, data compression, data indexing, data sketching and data searching. This algorithmic machinery will be used to study the design and analysis of the main components of a modern search engine, and to investigate their computational limitations.

Together with the theoretical study of the previous, the course will consist also of a practical activity (3 CFU) in which the students will practice with the open-source tools nowadays available for the implementation of a search engine and of other IR applications.

Laboratorio di sistemi fotonici (6 CFU)

Laboratory of Photonic Systems

The course, which is devoted mainly to experimental issues, introduces the student to the knowledge and to the use of components and techniques used in photonics. The course also will explain the principles of operation of the analysis and measurement instruments. Objectives of the course are: kearning working principle of devices and equipment used in photonics, learning basic measurements procedures, practicing in the lab.

Syllabus

1) Laser Sources and modulators
    a. DFB Laser and laser diodes
    b. Fabry-Pèrot Lasers
    c. Mode-Locked Lasers
    d. Light Modulation
        i. Direct
        ii. External
2) Devices
    a. Polarizators and polarization controllers.
    b. Optical Isolators, circulators and couplers
    c. Optical Filters
    d. Periodic Optical Filters:
    e. Detectors
    f. OTDR
    g. Optical amplification (summary)
    h. Light coupling between optical fibre, air and devices
3) Instruments
    g. Digital Sampling Oscilloscopes
    h. Real-Time Oscilloscopes
    i. Optical Spectrum Analysers
    j. Polarimeters
    k. Temperature Controller
    l. Remote Instrument control and automated measurements

Exam consists in a colloquium concerning course concepts and a possible project assigned to the student.

Metodi di ottimizzazione delle reti (6 CFU)

Network Optimization Methods

Aim of the course is to present the main modelling techniques and the main algorithmic methodologies for managing communication networks both at a design and at an operational level.

We shall introduce relevant design and operational problems for communication networks, such as QoS routing problems, location problems, resiliency and robustness problems, and equilibrium problems in traffic networks. Then, we shall describe modelling techniques and algorithmic approaches for both basic probelms and NP-Hard problems.

Syllabus

1) Basic network optimization problems: models and algorithms

a. Maximum flow

b. Minimum cost flow

c. Multicommodity flows

2) NP-Hard network optimization problems: models and algorithms

a. Routing models

b. Network design models

c. Main heuristic techniques

d. Exact approaches

3) Applications

a. QoS routing

b. Location problems

c. Resiliency problems

d. Robustness in communication networks

e. Equilibrium in traffic networks

The exam consists of an oral examination.

Metodi formali per la sicurezza (6 CFU)

Formal Methods for Security

Introduction to some notions and problems that concern the security of net applications and presentation of some formalisms and techniques to address them.

Syllabus

- Introduction to security
- Security models
- Cryptographic protocols:
    - formal description
    - security properties
    - static and dynamic analysis techniques
- Language-based security:
    - problems and properties
    - formalisms, methods and techniques
    - history-based security
    - web-services security and service orchestration

Exam consists in an oral test.

Metodi per la specifica e la verifica di processi di business (6 CFU)

Methods for the Specification and Verification of Business Processes

The objective of the course is to explain the main concepts and problematic issues related to the process management, where processes are understood as workflow over some basic activities, and to show some of the languages, conceptual models and tools that can help to handle the main problems in a proper way.
To this aim, the course reconciles abstraction techniques with a modular and structured approach and with operational models typical of computer science. In particular, it will be shown how the properties to be verified can drive the choice of the languages and models to be used in the specification and design phases of business processes.
During the course, the students will become acquainted with the technical terminology of the area, with several rigorous models that can be used to structure and compose processes, with the logical properties that such processes can be required to satisfy and with specific analysis and verification techniques. Moreover they will be given the possibility to experiment with some advanced tools for the design and analysis of business processes.

Syllabus:

Introduction to key issues in business process management
- Terminology (business process, business process management, business process management system, business process model, process orchestration, business process lifecycle, workflow) and classification (orchestration vs choreography, automation, structuring)
- Hints on the evolution of business process architectures

Process modelling
- Conceptual models and levels of abstraction
- Functional decomposition and modularity
- Process orchestration
- Process properties
- Orchestration patterns (sequencing, parallel split, exclusive split, and-join, exclusive join,...) and structured workflow
- Rigorous workflow models: Petri nets and workflow nets

Tool-supported workflow design and analysis
- experimentation with state-of-the-art integrated tools for business process design, analysis and verification: WoPeD (Workflow Petri Net Designer) is open source and available at http://www.woped.org/

The exam will include a final term project and oral discussion.

Metodi per la verifica del software (6 CFU)

Software verification methods

Model checking concerns the use of algorithmic methods for the assurance of software and hardware systems. As our daily lives depend increasingly on digital systems, the reliability of these systems becomes a concern of overwhelming importance, and their reliability can no longer be sufficiently controlled by the traditional approaches of testing and simulation.

Syllabus

- Verification algorithms: linear and branching temporal logics, omega automata, equivalences.
- State explosion: symbolic data structures, automatic abstraction, compositional reasoning.
- Case studies

Exam consists in an oral test and possibly of a small project.

Modelli di Calcolo (9 CFU)

Models of Computation

We introduce the principles of operational semantics, the principles of denotational semantics, and the techniques to relate one to the other for an imperative language and for a higher order functional language. Operational and observational semantics of two process description languages (CCS and pi-calculus) is also presented. Finally, we consider operational nondeterministic models with discrete probabilities, and we present them from the perspective of probabilistic automata.

Syllabus

1) Operational and denotational semantics of a simple imperative language (IMP)
    e. Introduction and proof systems based on inference rules
    f. Syntax and operational semantics of IMP
    g. Induction principles
    h. Complete partial orderings
    i. Minimal fixpoint theorem
    j. Signatures and term algebras
    k. Denotational semantics of IMP
    l. Equivalence between operational and denotational semantics
2) Operational and denotational semantics of a higher order functional language (HOL)
    m. Syntax and lazy operational semantics of HOL
    n. Domains and domain constructions
    o. Lazy denotational semantics of HOL
    p. Relations between operational and denotational semantics of HOL
3) Transition systems and process calculi for mobile, probabilistic communicating systems
    i. Syntax and operational semantics of a process calculus (CCS)
    j. Observational semantics of CCS
    k. Hennessy-Milner logic
    l. Syntax and semantics of a process calculus for mobile systems (pi-calculus)
    m. Operational models with discrete probabilities, Markov processes
    n. Probabilistic automata (PA)
    o. Simulation and bisimulation of PA

The final exam consists in written and oral parts. The written part can be replaced by two written exams taken during the course.

Problemi di sicurezza in applicazioni web (6 CFU)

Security Issues in Web Applications

The course subject is to address the main problems related to a secure usage of web applications, and coutermeasures for fight the possible attacks that attackers may perform.

After a short introduction to the general issues related to security, and to those related to the use of world wide web, the main attacks web users are subject to, like cross site scripting, or phishing, are presented, as well as the software that typically is used in such attacks. Such an example software is taken from real attacks performed in the past, and for which working patches exist and are widespread, but it is similar to that presently used by hackers. Besides, the actions, software tools and web applications that can be used for such attacks are presented. Finally, countermeasures typically adopted to counterfight the above attacks, or to alert about them, are given.

The attacks considered are not only those performed by technically skilled attackers: also attacks based on human weaknesses, like those known as social engineering, are part of the course.

Syllabus

1. Introduction and intelligence gathering
2. cross site scripting
3. cross site request forgery
4. internet application level vulnerabilities
5. blended attacks
6. vulnerabilities of the applications for cloud computing
7. attacks to mobile devices
8. phishing
9. social engineering through the web
10. attacks to the executives
11. case studies

Exam consists in an oral examination.

Propagazione e ottica applicata (6 CFU)

Applied Optics and Propagation

This course, divided into three parts, aims to provide the basic concepts about the nature and use of electromagnetic fields, which are the basis of wired and wireless telecommunications. The part on the fundamentals of applied optics provide the concepts and fundamentals on lightwaves, their nature, their description and their physical characteristics, it will also illustrate the main areas of application engineering, with particular attention to aspects of telecommunications. The part on the fundamentals of electromagnetic fields and propagation provides the student with the first introduction to concepts related specifically to the theory of electromagnetic fields and will therefore be focused on the theory of propagation of dielectric waveguides and optical fibers. The part on wireless communication networks will present and discuss aspects related to radio and mobile phones, dealing with issues that are fundamental physical layer communications over wireless networks.

Syllabus

- The ray optics
- The lens equation and its applications
- Matrix Optics
- Maxwell's Equations
- Plane waves
- Polarization
- Interference and applications
- Diffraction and spatial Fourier transform
- Solution of Maxwell's equations
- Transmission lines
- Propagation and reflection of plane wave
- Rectangular dielectric waveguides
- Cylindrical waveguides: single mode and multimode optical fibers
- Transmission of radio signals
- Antennas
- Radio wave Propagation
- Transmission techniques
- Multiplexing
- Cellular networks
- Quantum optics
- Concept of Photon
- Emission and absorption
- Lasers and their applications

Exam consists in a written test and possibly a colloquium concerning course concepts.

Reti e tecnologie per le telecomunicazioni (9 CFU)

Networks and Technologies for Telecommunications

The course objective is to provide the student with a broad overview of the communication network architectures and protocols and the physical layer technologies for transmitting data. The course is divided in three modules. The first module on *network optimization* introduces instruments for communication network modelling and optimization. The second module covers network management systems and services. The third module covers advanced topics for optical networks.

Syllabus

1) Telecom Network Optimization
    a. Introduction to linear programming
    b. Introduction to graph theory
    c. Introduction to routing and wavelength assignment (RWA)
2) Network Management Systems
    a. Basic foundations of Network Management
    b. IP Network Management
    c. Transport Network Management
    d. Distributed application Management
3) Advanced topics for optical networks
    a. Physical impairments in optical networks
    b. Energy saving in networks
    c. Relability and robustness to faults
    d. Optical interconnection networks

Exam consists in a colloquium concerning course concepts and a possible discussion of a project assigned to the student.

Reti wireless di sistemi embedded (6 CFU)

Wireless Networks of Embedded Systems

Objectives:

The course aims at presenting the fundamental principles of Wireless Sensor Networks, with a specific focus on micro-kernels, IP programming, and Service Oriented Architectures. The approach of the Internet of Things will be followed. Technological add-up's related to real-time programming will be also discussed.

Syllabus:

• Introduction to WSN technology and applications
• Device architectures and components
• Low-level coding and Operating Systems
• Wireless Communication Techniques at PHY and MAC layer
• Characterization of IP-level communication protocols
• Basic programming for embedded systems
• Networking sample applications
• Sensor network abstraction (db-like)
• Case studies: Embedded Vision, Multinode Data Aggregation
• Real-world applications, notably Intelligent Transportation"

Final term: oral exam, plus an optional student project.

Sicurezza delle reti (9 CFU)

Network Security

This courses introduces the main concepts, tools and methodology to analyze a computer network system from a security perspective to increase the security level of the system. A systemic point of view is adopted where security is seen as an inner system property that involves all the system levels from the operating system one.

Syllabus

1. Introduction and Terminology
a. Security Attributes and Relations with other Attributes
i. Confidentiality
ii. Integrity
iii. Availability

b. Vulnerability
c. Threat
d. Attack
i. Elementary Attack
ii. Complex Attack

e. Countermeasure
f. Risk

2. Vulnerability Analysis
3. Threat Analysis
4. Countermeasure Analysis
a. Hardware/firmware countermeasures
b. Operating System countermeasures
c. Application Countermeasures
d. Network Countermeasures
e. Development of Secure Software
f. Intrusion Analysis
i. Firewall
ii. Intrusion Detection System
iii. Network Intrusion Detection System

g. Security Policies

5. Risk Analysis
a. Qualitative Approaches
b. Quantitative Approaches
c. Hybrid Approaches

Sistemi embedded (6 CFU)

Embedded Systems

This course covers the main stages in the development of embedded systems, with emphasis on model-based development and formal methods for the analysis of system properties. We review problems and approaches related to all the stages of development including requirements analysis, system-level design, component oriented modelling, behavioural modelling, verification of properties, architecture selection and design, code generation and testing.

Syllabus

1) Model-based development of embedded Systems
    a. Embedded systems and impact on modern day industrial electronics
    b. Stages in the development flow, model based design.
    c. Computation models for Embedded Systems: finite state machines, hierarchical FSM, timed automata, dataflows.
    d. User requirements analysis, system-level testing, requirements tracking, architecture selection and analysis, component modelling, design of components, implementation of models into concurrent code, semantics preservation issues. Tools, standards and methods for system modelling.
    e. Introduction to verification techniques, functional and timing analysis.
    f. Automatic code generation for abstract models.
    g. Testing techniques, conformance testing, concept of coverage, MC/DC coverage.
2) Embedded Systems Programming: Operating systems and wireless communication
    a. Computer architecture of dsPic microcontrollers. Hardware overview of the Flex board. Programming the Flex board.
    b. The OSEK standard interface. The Erika kernel. Programming control applications under Erika. Using Scilab/Scicos.
    c. Wireless communication. The Zigbee protocol. Real-time MAC protocols. Programming distributed control applications.

Exam consists in a colloquium concerning course concepts and the discussion of the project assigned to the student.

Sistemi peer to peer (6 CFU)

Peer to Peer Systems

Il corso introduce le principali metodologie e tecniche per la progettazione e la realizzazione di sistemi P2P. In particolare verranno introdotte le problematiche relative alla definizione di overlay P2P strutturati e non.

Le tecniche introdotte verranno inoltre esemplificate con riferimento ad un insieme di applicazioni reali. Il corso infine prevede la presentazione di un insieme di strumenti per la simulazione e la realizzazione di sistemi P2P.

Syllabus

1. sistemi P2P: classificazione e caretteristiche generali
2. overlay P2P non strutturati
   a. routing,
   b. analisi di reti non strutturate: Random Graphs, Power Law Graphs,
   c. Small World Networks, Scale Free Networks
   d. reti ibride: elezione di superpeers
   e. *esempi*: Napster, Gnutella, e-Mule, Kazaa, Freenet
3. overaly P2P strutturati: Distributed Hash Tables
   a. indicizzazione distribuita
   b. routing
   c. bilanciamento del Carico
   d. *esempi*: Chord, CAN, Pastry, Symphony, Kademlia
   e. Range Query su DHT: Skip-Graphs
   f. Proximity Aware Overlays: Internet Coordinate Systems
4. Cooperative Content Distribution
   a. strategie di distribuzione dei contenuti
   b. strategie di collaborazione: elementi di teoria dei giochi
   c. compressione delle informazioni: network Coding, Bloom Filters
   d. *esempi*: Bittorrent
5. DHT in applicazioni reali: la rete KAD di e-Mule, Trackerless BitTorrent
6. Voice Over Peer to Peer
   a. Skype
7. Strumenti di simulazione e di supporto per reti P2P :JXTA, Peersim, Overlay Weaver

Written Exam or Project. In both cases, the student must take an oral exam as well.

Sistemi real-time (6 CFU)

Real-time Systems

The course introduces kernel mechanisms and analysis techniques for increasing the predictability of computer controlled systems.

Syllabus

1. Basic concepts on real-time computing

Application domains. Typical system requirements. Limits of traditional approaches. Task models. Typical timing constraints. Task Scheduling. Metrics for performance evaluation.

2. Real-Time scheduling algorithms

Algorithm tassonomy. Scheduling with precedence constraints. Scheduling periodic tasks. Utilization-based analysis. Response-time analysis. Aperiodic task handling. Fixed-priority servers. Dynamic priority servers.

3. Protocols for accessing shared resources

The priority inversion phenomenon. Non-preemptive protocol. Priority Inheritance Protocol. Priority Ceiling Protocol. Stack Resource Policy. Computing blocking times. Schedulability analysis.

4. Overload management

Definition of computational load. Methods for overload handling. Admission Control. Robust Scheduling. Imprecise Computation. Job Skipping. Elastic scheduling. Handling overruns. Resource reservation mechanisms. Resource reclaiming techniques.

5. Implementation issues

Kernel mechanisms for real-time support. Required data structures. Time representation. Taking overhead into account. Basic kernel primitives. Process states and state transitions. Synchronous and asynchronous

Exam consists in a colloquium concerning course concepts.

Strumenti di programmazione per sistemi paralleli e distribuiti (6 CFU)

Programming Tools for Parallel and Distributed Systems

The course deals with design, evaluation and utilization of programming tools and environments for parallel and distributed applications. The programming paradigms, and related cost models, concern high-performance stream- and data-parallel computations, distributed shared memory, adaptive and context-aware programming, high-performance event-based programming, real-time programming, programming of fault-tolerance strategies, and others. For these paradigms, static and dynamic tools are defined and their performances are evaluated through case studies in experimental and laboratory activites.

Syllabus

1. high-performance stream- and data-parallel computations,
2. distributed shared memory,
3. adaptive and context-aware programming,
4. high-performance event-based programming,
5. real-time programming,
6. programming of fault-tolerance strategies,
7. tools and environments
8. run-time supports
9. case studies

Exam consists in a written and an oral part.

Teoria e tecniche della comunicazione ottica (9 CFU)

Optical Communication Theory and Techniques

Prerequisites

Basic training equivalent to the first two or three years of a bachelor's degree in engineering or computer science. Essential prerequisites are knowledge of the Fourier transform and the theory of probability and stochastic processes. Students must also have familiarity with matrix notation, signal theory and linear systems theory.

Learning objectives

- Introduction to the concepts of digital transmission and detection theory.
- Understanding of the basic concepts for the analysis and design of digital communication systems, with particular attention to optical systems.
- Ability to select a suitable communication system, given the constraints imposed by the transmission channel, in relation to the desired performance.

Brief course description

The course will introduce the students to the fundamental principles of communication theory and data transmission, with emphasis on spectral characteristics of signals and performance and complexity of optical systems. The most common transmission impairments that must be taken into account when designing modern high capacity optical systems are reviewed, and the fundamentals of optical modulation and demodulation are presented on an introductory level. The structures of high-performance optical transmitters and receivers and their noise properties are also outlined.

Syllabus

1. Digital transmission theory
   a) Data transmission over Gaussian channels
   b) System design for band-limited channels
   c) Channel and line coding
   d) Adaptive equalization
2. Fundamentals of optical communications
   a) Optical transmitters and modulation formats
   b) Impact of fiber linear and nonlinear transmission impairments
   c) Optical receivers and noise

Bibliography

- S. Benedetto and E. Biglieri, *Principles of Digital Transmission: With Wireless Applications*, Springer, 1999. ISBN 0-306-45753-9.
- J. Proakis, *Digital Communications*, 4th ed., McGraw-Hill, 2001. ISBN 0-07-232111-3.
- G. P. Agrawal, *Nonlinear Fiber Optics*, Academic Press, 2001. ISBN 0-12-045143-3.
- G. P. Agrawal, *Fiber-Optic Communication Systems*, Wiley, 2002. ISBN 0-471-21571-6.

Mode of examination

Written exam for part 1 and oral examination for part 2.