Requirements for Ph.D. Students of the Graduate School of Information Engineering:

1. Students are required to take courses from the present catalogue for a minimum of 80 hours (20 credits) during the first year of the Ph.D. program.

2. Students are required to take for credit at least two out of the following three basic courses “Applied Functional Analysis”, “Applied Linear Algebra”, and “Statistical Methods” during the first year of the Ph.D. program. Moreover, the third course is strongly recommended to all students.

3. After the first year, students are strongly encouraged to take courses (possibly outside the present catalogue) for at least 10 credits (or equivalent) according to their research interests.

Students have to enroll in the courses they intend to take at least one month before the class starts. To enroll, it is sufficient to send an e-mail message to the secretariat of the school at the address calore@dei.unipd.it

Students are expected to attend classes regularly. Punctuality is expected both from instructors and students.

Instructors have to report to the Director of Graduate Studies any case of a student missing classes without proper excuse.
Contents

1 Applied Functional Analysis, Prof. G. Pillonetto 5

2 Applied Linear Algebra, Prof. T. Damm and Prof. H. Wimmer 7

3 Bioelectromagnetics, Prof. T. A. Minelli 8

4 Codes, graphical models, distributed algorithms, Prof. F. Fagnani 10

5 Computation of Game and Market Equilibria, Prof. Bruno Codenotti 12

6 Design Patterns in Software Development, Prof. G. Manduchi 14

7 Dose, Effect, Threshold, Prof. A. Trevisan 15

8 Dynamical Models in Systems Biology, Prof. C. Altafini 16

9 Identification techniques, Prof. A. Chiuso 18

10 Introduction to Quantum Optics, Proff. P. Villoresi and C. Bonato 20

11 Nonlinear Feedback Systems, Prof. C. I. Byrnes 21

12 Physical models for the numerical simulation of semiconductor devices, Prof. G. Verzellesi 23

13 Pollution and Prevention, Prof. G. B. Bartolucci 24

14 Positron Emission Tomography (PET), Prof. M.C. Gilardi 25

15 Real-Time Operating Systems, Prof. I. Bertolotti Cibrario 26

16 Statistical Methods, Prof. L. Finesso 28
<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stochastic Modeling of Computer and Communication Systems, Prof. A. Willig</td>
<td>29</td>
</tr>
<tr>
<td>Topics in Quantum Information, Prof. F. Ticozzi</td>
<td>31</td>
</tr>
<tr>
<td>Wireless Sensor Networks, Prof. A. Willig</td>
<td>32</td>
</tr>
</tbody>
</table>
1 Applied Functional Analysis

Instructor: Prof. G. Pillonetto, Dept. Information Engineering, University of Padova, e-mail: giapi@dei.unipd.it

Aim: The course is intended to give a survey of the basic aspects of functional analysis, operator theory in Hilbert spaces, regularization theory and inverse problems.

Topics:


Course requirements:

1. The classical theory of functions of real variable: limits and continuity, differentiation and Riemann integration, infinite series and uniform convergence.

2. The arithmetic of complex numbers and the basic properties of the complex exponential function.

3. Some elementary set theory.


All the necessary material can be found in W. Rudin’s book Principles of Mathematical Analysis (3rd ed., McGraw-Hill, 1976). A summary of the relevant facts will be given in the first lecture.
References:


Examination and grading: Homework assignments and final test.
2  Applied Linear Algebra

Instructors:

Tobias Damm, TU Kaiserslautern, Germany
e-mail: damm@mathematik.uni-kl.de

Harald Wimmer, University of Würzburg, Germany
e-mail: wimmer@mathematik.uni-wuerzburg.de

Aim: We study concepts and techniques of linear algebra, which are important for applications and computational issues. A wide range of exercises and problems will be presented such that a practical knowledge of tools and methods of linear algebra can be acquired.

Topics:

• Matrix equations and inequalities
• Kronecker products and structured matrices
• Least squares problems and singular value decomposition
• Computational methods
• Perturbation theory

References:


Course requirements: A good working knowledge of basic notions of linear algebra, as e.g. presented in [1].

Time table: Course of 16 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 4:30 – 6:30 P.M. First lecture on Tuesday, March 17, 2009. Classroom Oe (Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Grading is based on homeworcking or a written examination or both.
3 Bioelectromagnetics

Instructor: Prof. Tullio A. Minelli, CIRMANMEC University of Padova, e-mail: minelli@pd.infn.it.


Topics:

1. Basics of bioelectromagnetics.
2. Neuroelectrical phenomena.
3. Chaos, fractals, solitons and neuroelectrical signals.
4. Mobile phone radiation and neuroelectrical phenomena.
6. Mathematical models of cell membrane dynamics.

References:


**Time table:** Course of 12 hours plus a visit to an electro-physiology laboratory. Lectures (2 hours) on Friday 11:00 – 13:00. First lecture on Friday, January 9, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** None.

**Examination and grading:** Production of simple pedagogical circuits or measures and simulations of biophysical interest.
4 Codes, graphical models, distributed algorithms

Instructor: Fabio Fagnani, e-mail: fabio.fagnani@polito.it

Aim: The goal of this course is twofold. We will first give a quick introduction to channel coding theory with a special emphasis on low density parity check codes and iterative decoding techniques which have been developed in the last 15 years and have allowed to concretely achieve the fundamental Shannon limit. Iterative decoding is an instance of the so-called Belief Propagation (BP) algorithm whose range of possible applications is much wider than just coding. In short, BP is a low-complexity algorithm which allows to compute (in an approximative way) the marginals of a stochastic process defined on a graph. BP can be applied to solve a variety of problems in artificial intelligence, statistical inference, estimation, combinatorics. In the second part of the course we will consider such more general instances of BP algorithm, we will establish some theoretical results and we will investigate some connections with statistical mechanics.

Topics:

1. [6h] Codes for reliable transmission over noisy digital channels. Maximum-a-posteriori (MAP) decoding. Shannon theorem. Some important channels: the binary symmetric channel (BSC), the binary erasure channel (BEC), the Gaussian channel. Complexity of a coding scheme. Linear binary codes, syndromes, minimum distances, weight enumerators, spectra, theoretical bounds. Examples of specific codes and ensembles of codes.


References:


**Time table:** Course of 20 hours. Lectures (2 hours) on Tuesday and Thursday 4:30 – 6:30 P.M.. First lecture on Tuesday, April 21, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Basic courses on calculus, linear algebra, probability.

**Examination and grading:** 5 weekly homeworks.
5 Computation of Game and Market Equilibria

Instructor: Dr. Bruno Codenotti, Research Director, Istituto di Informatica e Telematica, CNR Pisa, Italy. e-mail: bruno.codenotti@iit.cnr.it

Aim: The widespread use of Internet has promoted tighter interactions between Computer Science and Game Theory. Game Theory techniques are being increasingly used to analyze scenarios featuring users with potentially conflicting interests. In such environments, a fundamental notion is the one of equilibrium. The main purpose of this course is to analyze different notions of equilibrium under suitable models (non-cooperative games, cooperative games, and markets). Specifically, we will discuss the computation of such equilibria and their applications to relevant case studies (e.g., routing, resource sharing, pricing of shared resources, etc.).

Topics:

1. Non-cooperative games in normal form
   - Two-player constant-sum games
   - Two-player variable-sum games
   - Multi-player games
   - Existence of Nash equilibria

2. Cooperative Games
   - Cooperative three-player games
   - Bargaining
   - Cooperative multi-player games
   - Coalitions
   - Equilibria in a cooperative environment (core, kernel, nucleolus, Shapley value)

3. Markets
   - Simple market models
   - Arrow-Debreu model
   - Walras equilibrium (definition, existence results)
   - Markets and games: comparison and reductions

4. Classical Algorithms
   - Preliminaries: Sperner’s lemma
   - Scarf’s algorithm
   - Lemke-Howson’s algorithm
   - Variations and extensions

5. Recent Algorithms and Applications
   - Selection of recent algorithms (chosen based on the students’ interests and inclinations)
• Selfish routing: Nash equilibria vs optimal solution
• Resource sharing: fairness criteria
• Mechanism design and Internet protocols

References: The material for the class will be covered by excerpts from the following reference books.


Course requirements: Basic background in algorithms and mathematics.

Examination and grading: Each student is expected to give a presentation in the class on a topic previously agreed with the teacher. The presentation will be followed by a discussion with the teacher and the other students. The final grade will be based on the presentation and on the participation to class activities.
6 Design Patterns in Software Development

Instructor: Gabriele Manduchi, Istituto Gas Ionizzati del CNR
e-mail: gabriele.manduchi@igi.cnr.it

Aim: Introduction of Design Patterns in software development. The course is centered around a case study in software development in "e-Science". A graphical front-end for browsing and visualizing scientific data is progressively refactored using important design patterns for object-oriented software. The use of design patterns is presented in the context of the Unified Process. An introduction to UML and the Unified Process is presented at the beginning of the course.

Topics:

1. Advanced Java Programming: the case study refers to a graphical waveform browser for networked scientific data.

2. Design Patterns definition: design patterns are introduced step by step during the refactoring stages. Finally an overview of the most useful design patterns which have not been encountered in the case study is provided.

3. UML Modelling: a subset of UML will be used thorough the course to represent class organization and component relationships.

4. Unified Process: The steps in the case study are presented in the more general framework of the Unified Process, by first analyzing Use Cases and then introducing the basic architecture.

References:

1. E. Gamma, R. Helm, R. Jonson, J. Vlissides: Design Patterns: Elements of Reusable Object Oriented Software, Addison Wesley 1995


Course requirements: Basic Java programming, Object-Oriented terminology and methods.

Examination and grading: A project will be assigned to students, and will represent the base of the final discussion
7 Dose, effect, threshold

Instructor: Prof. Andrea Trevisan, Dipartimento di Medicina Ambientale e Sanità Pubblica, Univ. di Padova, e-mail: andrea.trevisan@unipd.it

Aim: understanding of biological mechanisms that are the basis of the effect of chemical, physical and biological agents in humans. To supply a critical evaluation of the reference data on biological effects of electromagnetic fields.


References: Handouts provided by the instructor.


Course requirements: None.

Examination and grading: Oral exam.
8 Dynamical Models in Systems Biology

Instructor: Claudio Altafini, SISSA (Int. School for Advanced Studies), Trieste.
e-mail: altafini@sissa.it

Aim: The course aims at providing an overview of some of the mathematical tools used in the
modeling of biological phenomena. The emphasis is on nonlinear models and system analysis, and
the examples are mostly from signaling and metabolic pathways.

Topics:

1. Qualitative analysis of ODE models
   - single and two-species dynamics
   - linear and nonlinear systems, equilibria and (multi)stability, monotonicity
   - oscillations

2. Examples of specific “biological mechanisms”
   - predator-prey models
   - epidemic models (HIV dynamics, kinetic of prion replication)
   - precision (kinetic proofreading)
   - adaptation (bacterial chemotaxis)
   - autoinduction (quorum sensing)

3. Whole network dynamical theories:
   - Stoichiometric network analysis
   - Metabolic control analysis
   - Chemical reaction network theory

References:

- E. Sontag, “Lecture Notes in Mathematical Biology”, available at the URL:
  http://www.math.rutgers.edu/~sontag/613.html
**Time table:** Course of 16 hours. Lectures (two hours) on Monday and Wednesday 2:30 – 4:30 P.M. First lecture on Monday, February 2, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Basic courses of linear algebra and ODEs.

**Examination and grading:** Final project and student seminar.
9    Identification techniques

Instructor: Professor Alessandro Chiuso, Dept. Tecnica e Gestione dei Sistemi Industriali, University of Padova, e-mail: chiuso@dei.unipd.it

Aim: This course is intended to provide a deep comprehension of modern methods for identification of multivariable (MIMO) systems.

Topics:

1. BACKGROUND OF STATISTICS AND PARAMETER ESTIMATION (Brief Overview)
   Parametric estimation theory, properties of estimators: bias, consistency, variance.
   Parametric Estimators for Linear-Gaussian models. Model selection and validation.

2. LINEAR STOCHASTIC MODELS AND STOCHASTIC PROCESSES

3. REVIEW OF PARAMETRIC IDENTIFICATION FOR ARX, ARMAX MODELS AND STATE SPACE MODELS (Brief Overview)
   ML (Maximum Likelihood) and PEM (Prediction error methods) for multivariable ARX, ARMAX and SS models. Iterative Algorithms for the minimization of the mean quadratic error in general ARMAX models. Quasi-Newton method. Main complications: identifiability in multivariable models. Canonical forms, local minima, over-parameterization and ill-conditioning.
   State space models: Data Driven Local Coordinates and EM Based Approaches.

4. SUBSPACE IDENTIFICATION FOR MULTIVARIABLE STATE SPACE MODELS

5. ASYMPTOTIC STATISTICAL PROPERTIES OF SUBSPACE ESTIMATORS

6. NON-PARAMETRIC METHODS FOR SYSTEM IDENTIFICATION

7. COMPUTER SIMULATIONS AND CASE STUDIES
**References:** For the first part of the course references are:

2. L. Ljung *System Identification, Theory for the user* (2nd ed).

For the second part of the course the instructor will provide specific material (journal and conference papers, etc.).

**Time table:** Course of 20 hours (two two-hours lectures per week): Classes on Monday and Wednesday from 4:30 to 6:30 P.M., first lecture on Monday, April 20, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Knowledge of probability theory, linear systems theory, stochastic systems, system identification and MATLAB/SIMULINK will be assumed.

**Examination and grading:** Homework assignments and final test on identification and validation of a model with data provided by instructor.
10  Introduction to Quantum Optics

Instructors: Paolo Villoresi and Cristian Bonato,  
e-mail: paolo.villoresi@unipd.it, bonatocr@dei.unipd.it

Aim: The Course is intended to provide the basic concepts of current Quantum Communications in the optical domain. The initial part will review the underlying physical concepts, while in the second part the topics of entanglement, quantum interference, teleportation, quantum computation and quantum key distribution will be addressed. The experimental implementations of these topics will be discussed.

Topics:

1. Review of Quantum Mechanics;
2. quantization of EM field;
3. statistics of radiation;
4. entanglement;
5. quantum interferometry.
6. Applications: teleportation, quantum computation and quantum key distribution.

References: Gerry C, Knight P, Introductory Quantum Optics (Cambridge 2005)


Course requirements: Basic concept of Quantum Physics.

Examination and grading: Homework and final exam.
11 Nonlinear Feedback Systems

Instructor: Prof. Christopher I. Byrnes, Department of Electrical and Systems Engineering, Washington University in St. Louis. e-mail: chrisbyrnes@wustl.edu

Aim: Nonlinear feedback systems are pervasive in biology, control and communications. This course will teach methods for analyzing and designing nonlinear feedback systems. Particular applications will be to stability, stabilization and shaping the steady-state response of nonlinear control systems.

Topics:

1. Basic Nonlinear Analysis
   • The inverse function theorem, the implicit function theorem, the contraction mapping principle
   • One-dimensional nonlinear dynamical systems
   • Population dynamics with constant harvesting
   • The set-point control problem for nonlinear control systems

2. Basic Nonlinear Dynamics
   • Properties of solutions of nonlinear ordinary differential equations
   • The voltage controlled oscillator
   • The Poincaré map
   • Poincaré Bendixson Theorem

3. Stability of equilibria, periodic orbits and attractors
   • Limit sets for initial conditions and initial sets
   • Liapunov theory for invariant sets
   • The set-point control problem for a nonlinear AC motor
   • The existence and stability of periodic orbits
   • The steady-state behavior of nonlinear systems
4. Stability of control systems

- Input-to-state systems
- The small gain theorem for nonlinear systems
- Zero dynamics and minimum phase systems
- Dissipative periodic processes

5. Shaping the response of a nonlinear control system

- The steady-state response of a nonlinear control system
- Output regulation
- Analysis and design of the steady-state behavior of nonlinear feedback systems

References: The course will be based on lecture notes and power point presentations that will be available on the course website. Other reference material would include:

H. Khalil, Nonlinear Systems, Prentice-Hall (for nonlinear dynamics)

A. Isidori, Nonlinear Control Systems, II, Springer-Verlag (for stability of control systems)


Course requirements: It is expected that students have taken courses in classical automatic control and linear systems. We will present basic material from nonlinear analysis and nonlinear dynamical systems, along with examples.

Examination and grading: The grade for the class will be based on homework.
12 Physical models for the numerical simulation of semiconductor devices

**Instructor:** Prof. Giovanni Verzellesi, Department of Information Engineering, University of Modena and Reggio Emilia e-mail: giovanni.verzellesi@unimore.it, http://www.dii.unimo.it/wiki/index.php/User:Verzellesi

**Aim:** This course is intended to provide an introductory coverage on charge transport in semiconductors and on the physical models underlying the semiconductor device simulators, which are nowadays routinely adopted for the design and optimization of device fabrication processes (Technology Computer Aided Design or TCAD).

**Topics:** The course will cover the following topics:


d) Physical models: band-gap narrowing, incomplete ionization, carrier mobility, generation-recombination effects, deep levels.

**References:**


**Time table:** Course of 20 hours. Lectures (two hours) on Thursday 2:30 – 4:30 P.M., and Friday, 10:30 – 12:30. First lecture on Thursday, October 29, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Background at a graduate level on semiconductor devices.

**Examination and grading:** Final test.
13 Pollution and Prevention

Instructor: Prof. Giovanni Battista Bartolucci, Department of Environmental Medicine and Public Health, Occupational Medicine - University of Padova. e-mail: giovannibattista.bartolucci@unipd.it

Aim: Knowledge of legislation and prevention measures in the field of life and work environment; understanding of procedures for exposure and risk evaluation.


References: Handouts provided by the instructor.

Time table: Course of 12 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday from 4:30 to 6:30 P.M.; first lecture on Tuesday January 27-th, 2009. Room DEI/G (3-rd floor, Department of Information Engineering, via Gradenigo Building).

Course requirements: None.

Examination and grading: Homework assignment and final examination.
14 Positron Emission Tomography (PET)

Instructor: Prof. Maria Carla Gilardi, University of Milano Bicocca, e-mail: mariacarla.gilardi@hsr.it

Aim: The aim of the course is to provide a survey of technological issues and applications in Positron Emission Tomography (PET)

Topics:
1. State of the art PET systems.
2. Quantification issues in PET.
3. 4D PET and radiotherapy.

References:


Course requirements: None.

Examination and grading: Grading will be based on a written examination
15 Real-Time Operating Systems

Instructor: Ivan Bertolotti Cibrario  
e-mail: ivan.cibrario@polito.it

Aim: The course, first of all, summarizes the internal architecture of a real-time operating system. Then, after recalling the main issues concerning real-time concurrent programming, it describes in detail the main models, algorithms and techniques being used for both real-time scheduling and scheduling analysis. Furthermore, the course discusses how the synchronization and communication problems among real-time processes are dealt with, both by classical lock-based techniques, and by lock and wait-free synchronization.

Topics:

1. Introduction to Real–Time Operating Systems  
   Definition, characteristics, classification and examples of real-time systems. Architecture of a real-time operating system: monolithic and layered systems, microkernel-based systems, virtual machines. System call and interrupt handling mechanisms. Memory and I/O device management.

2. Concurrent Programming and Real-Time  
   Notion of process and thread. Concurrent execution and its issues: race conditions, deadlock, starvation. Classical IPC problems and their pitfalls revisited from the real-time point of view.

3. Real-Time Scheduling Models and Algorithms  
   Scheduling models: cyclic executive, Rate Monotonic (RM), Deadline Monotonic (DM), and Earliest Deadline First (EDF) schedulers and their implementation techniques. Preemptive versus non-preemptive schemes. Scheduling of sporadic and aperiodic tasks (outline).

4. Scheduling Analysis  
   Utilization-based schedulability tests for RMS and EDF (Liu and Layland). Response time analysis for fixed priority schedulers (full) and EDF (outline). Handling of sporadic and aperiodic processes (outline).

5. Real-Time Scheduling and IPC  

6. Lock and Wait-Free Synchronization  
   Introduction to lock and wait-free synchronization techniques. Comparison between these techniques and the classic, semaphore-based synchronization techniques. Suitability and advantages of lock and wait-free synchronization for real-time execution. Implementation with and without hardware assistance.

7. Execution Environment and Real-Time  
   Further extensions to the the scheduling model to consider non-negligible context switch times, interrupt handling, and the real-time clock handler. Effects of the CPU and system architectures on execution determinism and worst-case execution time analysis.
References:


**Time table**: Course of 16 hours. Lectures (two hours) on Wednesday from 2:30 to 4:30 P.M. and Thursday from 10:30 to 12:30. First lecture on Wednesday, April 22, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements**: General notions about computer architecture, theory and structure of general-purpose operating systems;

**Examination and grading**: Homework and/or Oral exam
16 Statistical Methods

Instructor: Lorenzo Finesso, Istituto di Ingegneria Biomedica, ISIB-CNR, Padova
e-mail: lorenzo.finesso@isib.cnr.it

Aim: The course will present a survey of statistical techniques which are important in applications. The unifying power of the information theoretic point of view will be stressed.

Topics:

Background material. The noiseless source coding theorem will be quickly reviewed in order to introduce the basic notions of entropy and informational divergence (Kullback-Leibler distance) of probability measures. The analytical and geometrical properties of the divergence will be presented.

Divergence minimization problems. Three basic minimization problems will be posed and, on simple examples, it will be shown that they produce the main methods of statistical inference: hypothesis testing, maximum likelihood, maximum entropy.

Multivariate analysis methods. Study of the probabilistic and statistical aspects of the three main methods: Principal Component Analysis (PCA), Canonical Correlations (CC) and Factor Analysis (FA). In the spirit of the course these methods will be derived also via divergence minimization. Time permitting there will be a short introduction to the Nonnegative Matrix Factorization method as an alternative to PCA to deal with problems with positivity constraints.

EM methods. The Expectation-Maximization method was introduced as an algorithm for the computation of Maximum Likelihood (ML) estimator with partial observations (incomplete data). We will present the EM method as an alternating divergence minimization algorithm (à la Csiszar Tusnady) and show its application to the ML estimation of Hidden Markov Models.

The MDL method. The Minimum Description Length method of Rissanen will be presented as a general tool for model complexity estimation.

References: A set of lecture notes and a list of references will be posted on the web site of the course.

Time table: Course of 24 hours (2 two-hours lectures per week): Classes on Monday and Wednesday, 2:30 – 4:30 P.M. First lecture on Monday, November 9, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basics of Probability Theory and Linear Algebra.

Examination and grading: homework assignments and take-home exam.
17 Stochastic Modeling of Computer and Communication Systems

Instructor: Andreas Willig
e-mail: awillig@tkn.tu-berlin.de

Aim: This course aims to provide some of the mathematical techniques that are important for probabilistic performance analysis studies in computer- and communication systems. The focus is on Markov chains and queueing systems and their application in the performance analysis of communication protocols. The mathematical parts of the course aim to achieve a reasonable (for engineers) level of mathematical rigor.

Topics:

1. Probability theory refresher
2. Discrete-time Markov chains
   - Definition and basic properties;
   - Classification of states.
   - Hitting Times, Stopping Times and Strong Markov
   - Long-term behaviour of Markov chains, Steady-state solutions
   - Protocol analysis examples
3. Continuous-time Markov Chains
   - Matrix exponentials and Q-matrices
   - Definition of CTMCs
   - Classification of states, Hitting Probabilities
   - Long-term behaviour, Steady-state
   - Birth-Death and Pure-Birth processes
   - Examples
4. Renewal and Poisson processes
   - Definition of renewal processes
   - Hidden and exposed terminal problems, solution considerations
   - Residual Lifetimes
   - Definition and equivalent characterizations of Poisson processes
5. Queueing Theory
   - Introduction, Notation, Little’s Law
   - Markovian Systems
   - M/G/1 systems
   - Polling and priority systems

References:

Lecture Notes provided by the instructor:
Andreas Willig, *Stochastic Performance Evaluation of Computer and Communication Systems* -
Time table: Course of 20 hours. Lectures (two hours) on Tuesday and Thursday 2:30 – 4:30 P.M. First lecture on Tuesday, March 17, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basics on Probability theory, Stochastic processes;

Examination and grading: Homework and Oral exam
18 Topics in Quantum Information

Instructor: Francesco Ticozzi. e-mail: ticozzi@dei.unipd.it

Aim: The Course aims to serve as an introduction to a selection of topics of interest in quantum information theory, with a focus on the role of uncertainty and noise. A mathematically consistent approach will be developed, in order to tackle problems of information encoding, communication and error-correction for finite-dimensional systems.

Topics:


2. Quantum Information Distances, Uncertainty and Distinguishability; Entropy, relative entropy, trace norm, their interpretation and basic properties. Fidelity and related quantities.


4. Encoding Information in Quantum Systems; The logical qubit. Encoding qubits in physical systems, operational requirements and ”good codes”. Quick overview of the network model.

5. Classical and Quantum Information over Quantum Channels; No-cloning theorem. Schumacher’s quantum noiseless coding theorem. The Holevo-Schumacher-Westmoreland theorem.


References: The main reference is M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum information (Cambridge, 2000). Other relevant references, on-line notes and research papers will be provided during the course.


Course requirements: Standard linear algebra and probability theory.

Examination and grading: Homeworks and final project.
19 Wireless Sensor Networks

Instructor: Andreas Willig
e-mail: awillig@tkn.tu-berlin.de

Aim: This course provides a first introduction to the field of wireless sensor networks, focusing mostly on protocol aspects.

Topics:

1. Node and network architectures
   Node components and their energy consumption
   Energy management strategies

2. Physical layer aspects
   Wireless channels: frequency allocation, wave propagation, error characteristics;
   Some example transceivers.

3. Link-layer aspects
   Error-control schemes
   Framing aspects
   Addressing considerations

4. Medium access control
   Fundamental classes of wireless MAC protocols (TDMA vs. CSMA vs. ...)
   Hidden and exposed terminal problems, solution considerations
   Low duty cycle schemes
   Schedule-based schemes
   Contention-based schemes

5. Routing and topology control
   Flat topology control (power control)
   Clustering
   Backbone construction
   Routing protocols

6. Transport / Reliable delivery in WSNs
   Single-Packet Delivery
   Block-Delivery
   Stream-Delivery

7. Data-centric networking
   Naming and addressing aspects
   Directed diffusion
   Aggregation

8. IEEE 802.15.4 and ZigBee
References:


**Time table:** Course of 20 hours. Lectures (two hours) on Tuesday and Thursday 2:30 – 4:30 P.M. First lecture on Tuesday, April 28, 2009. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Basics on telecommunication systems;

**Examination and grading:** Oral exam
<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>10:30 Ticozzi</td>
<td>10:30 Byrnes</td>
<td>10:30 Ticozzi</td>
<td>10:30 Trevisan</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>16:30 Bartolucci</td>
<td>14:30 Gilardi</td>
<td>14:30 Byrnes</td>
<td>14:30 Byrnes</td>
<td>16:30 Bartolucci</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>10:30 Ticozzi</td>
<td>10:30 Byrnes</td>
<td>14:30 Altafini</td>
<td>16:30 Gilardi</td>
<td>16:30 Bartolucci</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>10:30 Ticozzi</td>
<td>14:30 Gilardi</td>
<td>14:30 Byrnes</td>
<td>14:30 Byrnes</td>
<td>16:30 Bartolucci</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>14:30 Altafini</td>
<td>16:30 Gilardi</td>
<td>14:30 Byrnes</td>
<td>14:30 Byrnes</td>
<td>16:30 Bartolucci</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>10:30 Ticozzi</td>
<td>14:30 Altafini</td>
<td>16:30 Gilardi</td>
<td>14:30 Altafini</td>
<td>16:30 Bartolucci</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10:30 Byrnes</td>
<td>16:30 Bartolucci</td>
<td>10:30 Ticozzi</td>
<td>14:30 Altafini</td>
<td>16:30 Gilardi</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>10:30 Ticozzi</td>
<td>14:30 Altafini</td>
<td>14:30 Byrnes</td>
<td>14:30 Byrnes</td>
<td>16:30 Bartolucci</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>11:00 Minelli</td>
<td>16:30 Bartolucci</td>
<td>10:30 Trevisan</td>
<td>16:30 Bartolucci</td>
<td>11:00 Minelli</td>
<td>1</td>
</tr>
</tbody>
</table>

February 2009
Ph.D. Courses: Room DEI/G

Monday

Tuesday

Wednesday

Thursday

Friday

Saturday

Sunday
<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14:30 Altafini</td>
<td>14:30 Villoresi</td>
<td>14:30 Villoresi</td>
<td>10:30 Villoresi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:30 Codenotti</td>
<td></td>
<td>10:30 Villoresi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10:30 Codenotti</td>
<td>14:30 Villoresi</td>
<td></td>
<td>10:30 Villoresi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Codenotti</td>
<td>14:30 Willig-1</td>
<td>14:30 Willig-1</td>
<td>10:30 Villoresi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Codenotti</td>
<td>14:30 Willig-1</td>
<td>16:30 ROOM Oe: Damm – Wimmer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Villoresi</td>
<td></td>
<td>14:30 Willig-1</td>
<td>16:30 ROOM Oe: Damm – Wimmer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Willig-1</td>
<td>16:30 ROOM Oe: Damm – Wimmer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Villoresi</td>
<td></td>
<td>14:30 Willig-1</td>
<td>16:30 ROOM Oe: Damm – Wimmer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:30 Codenotti</td>
<td></td>
<td>10:30 Villoresi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:30 Codenotti</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:30 Villoresi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14:30 Willig-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16:30 ROOM Oe: Damm – Wimmer</td>
<td>14:30 Villoresi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
April 2009

Ph.D. Courses: Room DEI/G

Monday

30
- 14:30 Codenotti
- 10:30 Codenotti
- 14:30 Willig-1
- 16:30 ROOM Oe: Damm – Wimmer

Tuesday

1
- 14:30 Willig-1
- 16:30 ROOM Oe: Damm – Wimmer

Wednesday

1
- 14:30 Villoresi

Thursday

2
- 10:30 Villoresi

Friday

3
- 10:30 Villoresi

Saturday

4

Sunday

5

6
- 14:30 Codenotti
- 10:30 Codenotti
- 14:30 Willig-1
- 16:30 ROOM Oe: Damm – Wimmer

7

8
- 14:30 Willig-1
- 16:30 ROOM Oe: Damm – Wimmer

9

10

11

12

13
- 14:30 Willig-1

14

15
- 14:30 Willig-1

16

17

18

19

20
- 16:30 Chiuso
- 16:30 Fagnani

21
- 14:30 Cibrario

22
- 10:30 Cibrario
- 16:30 Chiuso
- 16:30 Fagnani

23

24
- Holiday

25

26

27
- 16:30 Chiuso
- 14:30 Willig-2
- 16:30 Fagnani

28
- 14:30 Cibrario

29
- 10:30 Cibrario
- 14:30 Willig-2
- 16:30 Fagnani

30
- Holiday
<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>16:30 Chiuso</td>
<td>14:30 Willig-2</td>
<td>14:30 Cibrario</td>
<td>10:30 Chiuso</td>
<td>14:30 Willig-2</td>
<td>Holiday</td>
</tr>
<tr>
<td>28</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Chiuso</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>14:30 Cibrario</td>
<td>16:30 Chiuso</td>
<td>10:30 Cibrario</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
</tr>
<tr>
<td>31</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
</tr>
<tr>
<td>1</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
</tr>
<tr>
<td>2</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
</tr>
<tr>
<td>3</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
<td>14:30 Willig-2</td>
<td>16:30 Fagnani</td>
</tr>
<tr>
<td>Monday</td>
<td>Tuesday</td>
<td>Wednesday</td>
<td>Thursday</td>
<td>Friday</td>
<td>Saturday</td>
<td>Sunday</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>-----------</td>
<td>----------</td>
<td>--------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>29</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>Tuesday</td>
<td>Wednesday</td>
<td>Thursday</td>
<td>Friday</td>
<td>Saturday</td>
<td>Sunday</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>-----------</td>
<td>----------</td>
<td>--------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>28</td>
<td>29</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
</tr>
<tr>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Verzellesi</td>
<td>Holiday</td>
</tr>
<tr>
<td>Monday</td>
<td>Tuesday</td>
<td>Wednesday</td>
<td>Thursday</td>
<td>Friday</td>
<td>Saturday</td>
<td>Sunday</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>-----------</td>
<td>----------</td>
<td>--------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Pillonetto</td>
<td>10:30 Verzellesi</td>
<td>10:30 Verzellesi</td>
<td>Holiday</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td>14:30 Verzellesi</td>
<td>14:30 Verzellesi</td>
<td>10:30 Verzellesi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td>14:30 Verzellesi</td>
<td>14:30 Verzellesi</td>
<td>10:30 Verzellesi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td>14:30 Verzellesi</td>
<td>14:30 Verzellesi</td>
<td>10:30 Verzellesi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>29</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td>14:30 Verzellesi</td>
<td>14:30 Verzellesi</td>
<td>10:30 Verzellesi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>30</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
</tr>
</tbody>
</table>
## December 2009

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>08:30 Manduchi</td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Holiday</td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td>08:30 Manduchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:30 Finesso</td>
<td>14:30 Finesso</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>