Information Society Technologies

PROGRAMME

SIXTH FRAMEWORK

SATNEX

Satellite Communications Network of Excellence

Fourth SatNEx International Summer School
Pisa (Italy), July 28th - August 1st, 2008

PROGRAM

ORGANIZER: Dr. Erina Ferro
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ISTITUTO DI SCIENZA E TECNOLOGIE DELL'INFORMAZIONE "A. FAEDO"

Sunday 27/07/2008

18.00 - 20.00 Welcome Party and Registration

Program From Monday 28/07 to Thursday 31/07, 2008

08.30 - 09.00 Welcome by the organizer (Monday 28/07 only)

09.00 - 11.00 Lecture
11.00 - 11.30 COFFEE BREAK
11.30 - 13.00 Lecture
13.00 - 14.00 LUNCH
14.00 - 15.30 Lecture
15.30 - 16.00 COFFEE BREAK
16.00 - 17.00 Collaborative Test
17.00 - 17.30 Test Correction

Monday July 28, 2008

Lecturer: **Prof. Marco Luise**
Affiliation: University of Pisa (Italy)
e-mail: Marco Luise <marco.luise@iet.unipi.it>
Title: **Topics in Signal Processing for Global Satellite Navigation Systems (GNSS)**

Abstract
The blooming and booming of systems and services based on information about the user location is something that everyone is experiencing at the moment. Suffice it to cite car and nautical navigation systems, anti-burglar devices, E-911 (in the States) and E-112 (in Europe) services for emergency and rescue, positioning of wireless terminals for conditional advertising or tourist information (or for optimal network resource allocation such as power and bandwidth), just to stick to the mass market, and not mentioning professional applications[1], such as cartography, agriculture, etc., and military use. The vast majority of such services are at the moment provided with the aid of satellite positioning services, that is to say, through the American Global Positioning System (GPS). The Russian counterpart, GLONASS (GLObal Navigation Satellite Systems) has practically no relevant commercial application. The European Union is catching up with the growing market of satellite positioning through the development of the Galileo system that will basically provide the same services as the GPS does nowadays, but with enhanced accuracy and availability, starting form the year 2012.
As with wireless communications, the DSP contents of a navigation receiver is ever-increasing. The relevant techniques that are being implemented in precision as well as mass-market equipment are borrowed from the classical subjects of estimation theory and signal detection and synchronization. Amidst the many aspects that are treated by the scientific and technical community dealing with GNSS, this tutorial intends to specifically focus on the main aspects related with signal processing. The aim is in particular that of presenting a simple but rigorous framework that helps understanding the actual DSP contents of satellite navigation equipment. Coming to a more detailed description of the various topics, it is known that reliable and accurate positioning is based on TOA (time of arrival) estimation of the satellite spread-spectrum signals and on triangulation techniques. Therefore, a good GNSS receiver has to implement a number of DSP-based techniques for the (coherent) demodulation of the radio signal, such as carrier frequency/phase offset estimation and correction, time delay

1 To this category belong also the so-called augmentation systems such as the America WASS (Wide Area Augmentation System) and the European EGNOS (European Geostationary Navigation Overlay satellite Service).

estimation and/or tracking, compensation of the signal distortion due to multipath radio propagation, just to cite a few. All such techniques have to keep into account the particular signal format, namely, digital spread-spectrum, and has to cope with the low-signal-to-noise ratio environment that is typical of satellite communications. Therefore, a short seminar that introduces and reviews all such techniques is highly desirable. The tutorial will start with a brief review of the fundamental problem of positioning (from TOA estimation to user coordinates) and of the fundamental aspects related to TOA estimation (Gabor bandwidth, the Cramér-Rao bound), will go through a survey of the main signal formats of positioning systems (GPS and GALILEO) to come to more practical issues related to the implementation of navigation receivers (receiver architecture, carrier Doppler and phase estimation/correction, ranging code acquisition and tracking etc.), and will finally touch upon the main sources of accuracy degradation (multipath, ionosphere) and the main relevant countermeasures in terms of DSP functions.

Index of the arguments

1. The problem of positioning: from TOA estimation to user coordinates:
- TOA and range estimation - 2D and 3D positioning
- Time uncertainty and the positioning equations
- Dilution of Precision

2. Signal design for best TOA estimation:
- Spread-spectrum signals and ranging codes
- The Cramér-Rao bound for TOA estimation
- Relation to the Gabor bandwidth of a signal
- Optimized signals for best positioning accuracy

3. GPS and GALILEO signals:
- Satellite constellations
- Spread-spectrum and CDMA
- GPS L1 (C/A) and L2 (P) signals
- GALILEO E1 and E5 signals
- Binary Offset Carrier (BOC) signaling

4. Signal detection and synchronization:
- General architecture of a positioning receiver
- Satellite Doppler shift and the carrier loop
- Maximum-likelihood estimation of the ranging code delay
- The Delay-Lock Loop (DLL)
- S-curve of the DLL

5. Accuracy Degradation sources and relevant countermeasures:
- The multipath radio channel
- S-curve bias and the multipath error envelope
- Reducing the MPE through channel estimation and/or beamforming

6. Test

Lecturer's Short Bio

Marco LUISE is a Full Professor of Telecommunications at the University of Pisa, Italy. He was born in Livorno, Italy, in 1960 and received his MSc (cum Laude) and PhD degrees in Electronic Engineering from the University of Pisa, Italy. In the past, he was a Research Fellow of the European Space Agency (ESA) at the European Space Research and Technology Centre (ESTEC), Noordwijk, The Netherlands, a Researcher of CNR, the Italian National Research Council, at the Centro Studio Metodi Dispositivi Radiotrasmissioni (CSMDR), Pisa, and an Associate Professor at the Dipartimento di Ingegneria dell'Informazione (Department of Information Engineering) of the University of Pisa. He chaired the V, VI, VII, and IX editions of the Tyrrhenian International Workshop on Digital Communications, respectively, and he was the General Chairman of the URSI Symposium ISSSE'98. He's been the Technical Co-Chairman

of the 7th International Workshop on Digital Signal Processing Techniques for Space Communications and of the Conference European Wireless 2002. Recently, Prof. Luise was the General Chairman of EUSIPCO 2006 held in Florence, Italy, in September 2006. He regularly teaches at the University of Pisa and at the Lucca Institute for Advanced Studies IMT. M. Luise is a senior member of the IEEE, was an Editor of the IEEE Transactions on Communications and has served as the co-editor of the '98 Special Issue on *Signal Processing in Telecommunications* of the European Transactions on Telecommunications. He's also been co-editor of the IEEE Journal of Selected Areas in Communication special issue on *Signal Synchronization in Digital Transmission Systems* and Editor for Communication Theory of the European Transactions on Telecommunications, and has co-edited a Special Issue of the Proceedings of the IEEE on *Turbo techniques: algorithms and applications*. He is the co-Editor-in-Chief of the recently founded International Journal of Navigation and Observation, and acts as General Secretary of the Italian Association GTTI, Gruppo Telecomunicazioni Teoria dell'Informazione. He is also member of the Italian Committee of URSI and of the International Committee on Global Navigation Satellite Systems (ICG) of the UNO. His main research interests lie in the broad area of communication theory, with particular emphasis on wireless communications, and mobile and satellite communication and positioning systems.
A full list of Prof. Luise's scientific publications is available on his home page or directly at the link http://www2.ing.unipi.it/~d7384/HTML/PubFrm.html

Tuesday July 29, 2008

Lecturer: **Dr. Maria Angeles Vazquez Castro**
Affiliation: Universitat Autònoma de Barcelona (Spain)
e-mail: M. Ángeles Vázquez Castro < angeles.vazquez@uab.es>
Title: **Game Theory applied to Satellite Systems Design**

Abstract
Satellite systems and networks are continuously increasing their complexity both in the space and in the terrestrial segment. Moreover, architectures are also evolving towards different hybridizations with terrestrial wireless netwkors. The latest advances related to adaptive physical layer have resulted in dynamic interactions among different layers and subsystems. It is therefore becoming difficult to analyze and predict performance, hampering the development of optimal satellite systems. Therefore, new design tools are necessary to tackle such new challenges and Game Theory is a good candidate.

Game Theory has already been successfully applied during to wired and wireless terrestrial systems. In particular, it has been applied for analysis and design of adaptive resource management, MAC strategies or forwarding policies for ad-hoc networks. Throughout the lecture, the main concepts of Game Theory will be introduced by using illustrative examples. The concepts will be then applied to the design of adaptive Satellite Systems for which two instructive examples have been carefully chosen.

Index of the arguments

1. Introduction to Game Theory
- What is Game Theory? History
- Why is Game Theory relevant to Satellite Systems Design?
- Decision making and utility theory
- Examples

2. Non-Cooperative Games and application to Satellite System Design
- Strategic form game
- Nash equilibrium
- Equilibria in repeated games
- Stackelberg and Cournout games
- Application to Satellite System Design

3. Cooperative Games and application to Satellite System Design
- Definition of cooperative game
- Marginal contribution
- The Core

- The Shapley value
- Application to Satellite System Design

4. Test

Lecturer's Short Bio

Dr. María Angeles Vázquez Castro received the Telecommunication Engineer degree (1994) and Ph.D. (cum laude, 1998) both from the Polytechnic University of Vigo (Spain). She is currently Associate Professor at the Universitat Autònoma de Barcelona (Spain). She has been a Research Fellow at the European Space Agency (2002-2004) and a visiting researcher at the University of Southern California (2000). She leads a research group on wireless communications that belongs to the European Network of Excellence on Satellite Communications (SatNEx). She has lead and participated in several national and international research projects and has co-authorised a number of chapter books, journal papers and peer reviewed conference papers, 2 of them were awarded as Best Papers. She holds one patent of a cross-layer packet scheduler and actively contributes to standardization bodies such as ITU, DVB and ETSI. Her current areas of interest are related to wireless system design for multimedia communications, with particular interest in satellite communications. Specifically, her current research topics are cross-layer design for packet-level coding, adaptive resource allocation with delay constraints and collaborative communications using Game Theory.

Wednesday July 30, 2008

Lecturer: Dr. Petia Todorova
Affiliation: Fraunhofer Institute for Open Communication Systems (FhG-FOKUS), Belin (DE)
e-mail: Petia Todorova <Petia.Todorova@fokus.fraunhofer.de>
Title: Call Admission and Handoff Management Schemes for Multimedia LEO Satellite Networks

Abstract: The lecture is devoted to Low Earth Orbit **(**LEO) satellite multimedia networks.
LEO satellites are expected to support real-time multimedia traffic and to fulfil certain pre-negotiated Quality of Service (QoS) requirements. However, the limited bandwidth of the satellite channel, satellite rotation around the Earth and mobility of end-users make QoS provisioning and resource management a challenging problem.
Due to a large number of handoffs experienced during a lifetime of a connection Call Admission Control (CAC) and handoff management are very important tasks if the system is to provide fair bandwidth sharing and QoS guarantees.
In the lecture we describe LEO satellite systems, define the objectives of Radio Resource Management (RRM) for this type of systems and focus on CAC and handoff management problems.
In particular we investigate CAC strategies, handoff management schemes and the relationship between CAC, handoff management and bandwidth allocation. Examples of recent algorithms for CAC and handoff management are illustrated, too.

Index of the arguments

1. Low Earth Orbit (LEO) Satellite Networks
- Introduction to LEO satellites
- LEO versus GEO and MEO satellites
- General architecture of the LEO satellite system
- ATM-based LEO satellite networks
- LEO satellite system challenges

2. Radio Resource Management in Multimedia LEO Satellite Networks
- Bandwidth management
- Buffer capacity in the on-board switch
- RRM and QoS

3. Call Admission Control

- CAC functions
- CAC strategies
- User classes

4. Handoff Management
- Intra-satellite handoff
- Inter-satellite handoff
- Handoff management schemes
- CAC criterion
- Priority classes
- Bandwidth allocation/de-allocation

5. Algorithms for CAC and Handoff Management
- The LEO satellite scenario
- Mobility model(s)
- Traffic parameters
- Performance matrix

6. Overview of some CAC and Handoff Management algorithms

7. Test

Lecturer's Short Bio

Dr. Petia Todorova received the M.S. degree in electrical engineering and the PhD degree in computer networks from the Technical University of Sofia. Upon graduation, she joined the Research Institute of Telecommunications, Sofia. From 1987 to 1988 she was Visiting Scientist with the University of West Berlin. Since 1988 she has been with GMD-FOKUS, now Fraunhofer Institute for Open Communication Systems (FhG-FOKUS) as a Senior Scientist working in the area of advanced networks technologies and protocols. From 1989 to 1997 she participated in the ETSI and ITU-T standardization efforts as a DEUTSCHE TELEKOM Expert Member. She was also an active participant in a large number of international projects within the EURESCOM, ACTS and IST Program. Dr. Todorova has been appointed as Adjunct Associate Professor of Computer Science - Old Dominion University, Norfolk, VA, USA for the period 2002 - 2006. Here recent research interests include resource allocation and handoff management in IP/ATM-based satellite networks, QoS in mobile and wireless network, resource and topology control in sensor networks. She published as author or co-author over 100 papers in International Journals, book chapters and Conference Proceedings. She was co-author of the book titled "Resource Management in Satellite Networks - Optimization and Cross-Layer design", Springer 2007. She was member of Technical Committee of several International Conferences and is member of the Satellite Society Committee (SSC).

Thursday July 31, 2008

Lecturer: **Dr. Stefano Chessa**
Affiliation: University of Pisa, Department of Computer Science, Italy
e-mail: Stefano Chessa <stefano.chessa@isti.cnr.it>
Title: Sensor Networks and their Interconnection with the wireless world

Abstract: Recent advances in Microelectro-mechanical Systems, tiny microprocessors and low power radio technologies have created low-cost, low-power, multi-functional miniature sensor devices, which can observe and react to changes in physical phenomena of their surrounding environments. When networked together over a wireless medium, these devices can provide an overall result of their sensing functionality.
Wireless sensors are battery powered and are equipped with a radio transceiver and a set of transducers through which they acquire information about the surrounding environment. When deployed in large quantities in a sensor field, these sensors can automatically organize themselves to form an ad hoc multihop network to communicate with each other and with one or more sink nodes. A remote user can inject commands into the sensor network via the sink in order to assign data

collection, processing, and transfer tasks to the sensors, and it can later receive the data sensed by the network through the sink. To this purpose the sink may be connected to the internet or to satellite links.
The effective development of scalable wireless sensor networks presents a number of research challenges related to the design of energy efficient protocols implementing channel access, routing, data collection and management, and the interconnection with remote users.
This tutorial first describes the available technologies and standard for sensor network, then it provides a detailed view of the state of the art on sensor network protocols and architectures, giving special emphasis to the issues related to the interconnection with satellite links.

Index of the arguments

1. Introduction
- Applications
- Energy efficiency

2. Sensor network platforms
- Hardware platforms
- Software platforms

3. Sensor networks protocols
- MAC layer
- Network layer
- Transport layer
- Application layer

4. Remote sensing with hybrid architectures (sensors and satellite links)
- Applications
- Hybrid architectures
- Interconnection with satellite links
- Open issues

5. Test

Lecturer's Short Bio

Dr. Stefano Chessa received his MS and PhD degrees in Computer Science from the University of Pisa, Italy, in 1994 and 1999, respectively. Currently he is also Research Associate at the ISTI/CNR Institute (Information Science and Technology Institute). His research interests are in the areas of wireless ad hoc networks, and wireless sensor networks, and he has been involved in many national and European projects. In particular he is participating to the EU FP6 Network of Excellence in Satellite Networks (Satnex), to the FP6 Network of Excellence "Interactive Media with Personal Networked Devices" (InterMedia), the FP6 Strep project "Secure Middleware for Embedded Peer-to-Peer Systems" (SMEPP), and to the FP6 Integrated Project "PERceptive Spaces prOmoting iNdependent Aging" (Persona). He has co-authored about 50 papers published on international journals and conference proceedings and he is reviewer for several international journals and congresses. He has been member of the program committee of the IEEE DSN conference in 2003 and of IEEE CAMPS '06, MHNET '06, DIWANS '06, and SMC '07, and he had been co-organized of the 2nd RSPSI workshop in 2007.

Program of Friday August 1st, 2008

THE PhD students "Innovative Ideas" Day

09.00 - 11.00 4 PhD Student Presentations (1/2 hour each)

11.00 - 11.30 COFFEE BREAK

11.30 – 13.00 3 PhD Student Presentations (1/2 hour each)

13.00 – 14.00 LUNCH

14.00 – 16.00 4 PhD Student Presentations (1/2 hour each)

16.00 – 16.30 COFFEE BREAK

16.30 – 17.00 Best "Innovative Idea" Award & Closure of the school

Aim of the Tests

At the end of each lecture day, the lecturer will propose a test to the attendees. These tests will allow PhD students to grant 1 ECTS point for their PhD courses.