Challenges in Multi-System Multi-Frequency GNSS Receiver Design

A tutorial proposal for

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Abstract

There are several new systems emerging in the Global Navigation Satellite Systems era. The US GPS system is under modernization, the European GALILEO has established ramp-up plans, the Russian GLONASS is going to be restored, and China has its own plans on the global Beidou/Compass navigation system. In addition, there are national satellite systems planned, e.g., in Japan and India, and the established continental geostationary WAAS and EGNOS augmentation systems. These all set new challenges to positioning receiver design, as multiple frequencies, modulations, message protocols, and system parameters have to be coped with. This tutorial gives an overview of the challenges and solutions in the receiver chain: antennas, RF front-end, receiver baseband algorithms, baseband hardware implementation, PVT (position, velocity, time) solution computation software, and also hybridization with sensors producing other than satellite-based location or kinetic information.

Agenda

Introduction: Satellite navigation basic principles, existing and emerging GNSS satellite constellations and augmentation systems (30 minutes): Jari Nurmi, TUT/DCS

Antennas and RF front-ends for multi-frequency GNSS receivers (30minutes): Marco Detratti, Acorde

Advanced receiver algorithms for baseband processing (30 minutes): Simona Lohan, TUT/DCE

Baseband hardware solutions for multi-system, multi-frequency reception (30 minutes): Heikki Hurskainen, TUT/DCS

Issues in PVT solution software for GNSS (20 minutes): Francescantonio Della Rosa, TUT/DCS

Hybridization with other sensor data (30 minutes): Stephan Sand, DLR

Wrap-up and conclusions (10 minutes): Stephan Sand, DLR

Presenter biographies

The presenters are working together in FP7 funded GRAMMAR (Galileo-Ready Advanced Mass-Market Receiver) research project. In the past, the groups have worked together also in FP6 project GREAT (Galileo Receiver for Mass Market). The individual biographies follow.

Jari Nurmi (MSc 1988, Lic.Tech. 1990, Dr.Tech. 1994) is a professor of Computer Systems in Tampere University of Technology (TUT), Finland. In 1987-1994 he worked in various research, teaching and management positions at the university. In 1995-1998 he was the Vice President of VLSI Solution company. Since 1999 he has held the full professor position at TUT. His research activities include embedded processor architectures, DSP and communications circuits, Software-Defined-Radio, and positioning receiver HW/SW implementations. In addition to GREAT and GRAMMAR, his group has participated in several large national projects in positioning and navigation since 1999. He has by year 2009 supervised 12 PhD and 101 MSc theses, evaluated 13 PhD theses in other universities (as opponent/reviewer), published over 200 international papers in journals and conferences, and has edited/co-edited two Springer books. He has been the general chair in 13 international events, has organized several tutorials and workshops (e.g. ISCAS, ESSCIRC, SoC), and he is currently in the steering committee of three international conferences (FPL, SoC, NORCHIP). He was one of the recipients of Nokia Educational Award in 2004, and was given the Tampere Congress Award in 2005.

Marco Detratti (MSc.2000, Post. Dipl. 2005) is the responsible of custom MMIC developments and novel RF systems for emerging telecommunication application at ACORDE Technologies S.A. (ACORDE), Spain. From 2000 to 2004 he was with the Department of Communication Engineering of the University of Cantabria participating in several projects related with the development of MMIC and hybrid circuits for spaceborn applications. Since 2005 he has been with ACORDE working on the development of X, Ku and Ka band products and on several R&D EU funded projects. He is in charge of the GNSS related activity at ACORDE and since 2005 he is working on the development of advanced GNSS receiver Front-Ends. In addition to the participation in FP6 GREAT and FP7 GRAMMAR, ACORDE has been involved in multiple projetcs on Navigation and Location Based Services since 2004.He is currently the Management Committee Member for Spain of the COST Action IC0803 on RF Subsystems for Emerging Wireless Applications.

Elena Simona Lohan received the M.Sc. degree in Electrical Engineering from "Politehnica" University of Bucharest, Romania, in 1997, the Diplome d'Etudes Approfodies (DEA) degree in Econometrics, at Ecole Polytechnique, Paris, France, in 1998, and the Ph.D. degree in Telecommunications from Tampere University of Technology (TUT). In 2007 she was nominated at TUT as a Docent (Adjunct Professor) in the field of "Wireless communication techniques for personal navigation." Since November 2003, she has been working as a Senior Researcher at TUT and she has been acting as a group leader for the mobile and satellite-based positioning activities at the Department of Communications Engineering (http://www.cs.tut.fi/tlt/pos/). Her research interests include satellite positioning techniques, CDMA baseband signal processing, multipath mitigation, and wireless channel modeling and estimation. She has also been involved with the EU FP6 project "GREAT" and is currently involved in the EU FP7 project "GRAMMAR", both related to Galileo mass-market receivers.

Heikki Hurskainen received M.Sc. degree on Electrical Engineering and Doctoral degree on Computing and Electrical Engineering from Tampere University of Technology (TUT) in 2005 and 2009 respectively. His doctoral thesis was titled ''Research Tools and Architectural Considerations for Future GNSS Receivers''. Currently Heikki is working as a senior research scientist at TUT's Department of Computer Systems, where he continues to work in satellite navigation research projects. Heikki Hurskainen has

been as author or co-author in 10 scientific publications, all in the area of satellite navigation. His research interests include, but are not restricted to, evolution of Global Navigation Satellite Systems, GNSS receivers, and implementation and prototyping issues of receiver algorithms.

Francescantonio Della Rosa received his M.Sc. degree in Electrical and Electronic Engineering, with specialization in Mobile Communications, from Aalborg University (AAU), Aalborg, Denmark, in June 2007. Currently, he is a research scientist at Tampere University of Technology (TUT), Department of Computer Systems, working on hybrid data fusion and software development of GNSS receiver prototypes within the EU FP7 project GRAMMAR (Galileo Ready Advanced Mass Market Receiver). In 2006 he has been involved within the EU FP6 project MAGNET *(*My personal Adaptive Global Network) Beyond, and in the COMET (Cooperative Mobile Positioning) project in 2007 at AAU. Since 2007 he has been working as software engineer and consultant in R&D companies in the field of wireless communications and embedded systems. He is author/co-author of several papers about localization techniques, reviewer for international conferences and for Springer, special issue on "Towards Global & Seamless Personal Navigation". In 2007 he was the main instructor for a tutorial with title "Cooperative Mobile Positioning: Empowering Wireless Location by Fostering Cooperation Among Users" at IADIS WAC'07, Lisbon, Portugal. He is member of IEEE and currently he is the chairman of the IEEE Student Branch at Tampere University of Technology. His research interests include, but are not restricted to, Global Navigation Satellite Systems and receiver prototypes, wireless positioning, hybrid and cooperative localization techniques.

Stephan Sand (M.Sc. EE 2001, Dipl.-Ing 2002) has completed his Ph.D. studies at the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland in 2009. He is currently managing and working on multi-sensor navigation research projects at the Institute of Communications and Navigation, German Aerospace Center (DLR), Oberpfaffenhofen, Germany. He was visiting researcher at NTT DoCoMo R&D Yokosuka, Japan in 2004 and at the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland in 2007 working in the area of wireless communications. Stephan has authored and co-authored more than 60 technical and scientific publications in conferences and journals in the areas of wireless communication and multi-sensor navigation. He has been involved in several research projects on mobile radio funded by the European Commission (4MORE, NEWCOM, COST289, PLUTO) and by international industry cooperation. In the GJU/GSA project GREAT and the EU FP7-ICT collaborative project WHERE, he has been leading the work on hybrid location determination. Currently, he is the consortium coordinator of the EU FP7 project GRAMMAR, which aims at developing a Galileo ready advanced mass market navigation receiver prototype.

Contact information (main organizer)

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