

Chapter 2

MULTI-POS: Multi-Technology Positioning Professionals Training Network

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2.1 How Everything Has Started

During Fall 2011, when a group of senior researchers and professors at Tampere University of Technology started to think about putting together an EU training network in the field of localization, the wireless localization landscape had recently undergone a major paradigm shift, from GNSS global localization solutions to emerging non-GNSS indoor mass-market localization solutions. Indeed, several big players in the indoor localization market had already shown their interest into providing global indoor navigation solutions. For example, HERE started acquiring floor maps and site maps of several indoor locations in 2011, Apple was already using on its mobile devices the Skyhook solutions, and Google was already starting to map the indoor locations. Also, new companies focusing on indoor localization or RTLS were born, such as Meridian Apps or Sonic Notify Inc. It was clear that the wireless positioning was becoming an increasingly important part of future mobile devices.

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The European Commission (EC) statistics at that time showed that the global navigation market was expected to grow to around €244 billion EUR (incl. sales of GNSS-enabled products) in the next decade, with significant growth being driven by cellular mobiles and LBS.

The wireless positioning research world at that point was split into two large and distinct research communities: the technical community (focused on location technologies and techniques) and the business community (focused on understanding users and markets needs and on finding new LBS in order to enhance the social well-being). Moreover, the existing graduate schools in EU in 2011 related to wireless location focused heavily on GNSS (e.g., ESA International summer school on GNSS or the EU Initial Training Network TRANSMIT). Therefore, there was still a missing link between these two communities, the technical and business community, and the need for creating a graduate school to create expert workforce with good background in all the layers involved in a wireless positioning system was becoming urgent. Thus the idea of creating an international network bringing together experts from various fields of wireless localization was born. Indeed, experts from fields such as mathematics, statistics, signal processing, telecommunications, computer systems, machine learning, aerospace, economics and business administration were contacted and a global network has been created in order to address the gaps of the wireless positioning-related training at EU level. The created network, baptized Multi-technology Positioning Professionals, or MULTI-POS in brief, received the funding from the EU FP7 Marie Curie Initial Training Network (ITN) program (grant nr. 316528) and officially started in October 2012 with a kick-off in Belgium. The network fellows were recruited during the late 2012 and early 2013 and we have had a total of 12 Early Stage Researchers and 3 Experienced Researchers recruited from all over the world in our network. We were lucky to be able to recruit also four female fellows (27%), as vast majority of the competent resources available in the research fields consists of male researchers.

The ten partners of MULTI-POS include six universities and four companies (including two SME). In addition, there are ten associate partners, of which six are companies (five SME and one large enterprise), three research institutes, and a university (see Table 2.1).

2.2 MULTI-POS Aims and Structure

The MULTI-POS network has been built as a fully integrated research training program with a strong contribution of private sector partners, focusing on training Early Stage Researchers through doctoral programs and on offering complementary academic-industrial skills to all the recruited fellows. The network started to exist during Fall 2012, the fellows' recruitment took place mainly around the mid of 2013 and the network officially ended at the end of September 2016. The goals of MULTI-POS network have been:

Table 2.1 MULTI-POS network

Abbreviation	Organization name	Country	Organization type
<i>Full partners</i>			
TUT	Tampere University of Technology, Coordinator	FI	University
CUT	Chalmers University of Technology	SE	University
ENAC	Ecole Nationale de l'Aviation Civile	FR	University
GMV	GMV Aerospace and Defense	ES	Large Enterprise
HON	Honeywell International	CZ	Large Enterprise
PCG	Ptolemus	BE	SME
PLD	Pildo Labs Consulting	ES	SME
UAB	Universitat Autònoma de Barcelona	ES	University
UNOTT	University of Nottingham	UK	University
VU-VUMC	Stichting VU (Vrije Universiteit Amsterdam)	NL	University
<i>Associated partners</i>			
AVEA	AVEA İletişim Hizmetleri	TR	Large Enterprise
DLR	German Aerospace Center	DE	Research Center
FGI	Finnish Geospatial Research Institute	FI	Research Center
FPNT	Focal Point Positioning	UK	SME
GEO	Geodan	NL	SME
ITMO	National Research University of Information Technologies Mechanics and Optics	RU	University
SP	SP Technical Research Institute of Sweden	SE	Research Center
SSF	Space Systems Finland	FI	SME
T6ECO	T6 Ecosystems	IT	SME
WPS	Wirepas	FI	SME

- To bridge the gap between the lower technology layer and the upper application layer involved in wireless mobile positioning and navigation.
- To offer high-quality comprehensive training to young researchers in the broad field of the wireless localization and will promote the exchange of fellows in mixed academic-industrial R and D trajectories and in multiple European cultures, thus strengthening also the academic-industrial collaborations and the European collaboration.
- To ensure a superior scientific and engineering design expertise, combined with agile development of new kinds of applications in the area of wireless navigation.
- To create novel methods, technologies and business models for the future location-enabled wireless devices.
- To enhance EU competitiveness in multiple localization-related sectors, as its technology is clearly transferable to such multiple industry sectors.
- To initiate an educational and research framework that unifies the currently fragmented research activities on technological and applications aspects of wireless.

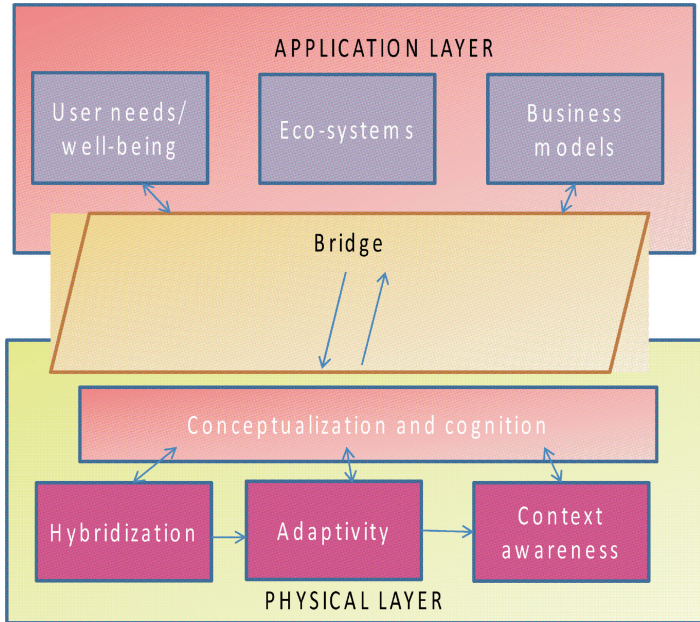


Fig. 2.1 MULTI-POS research overview at various layers involved in wireless positioning

- To create a community of researchers capable of exploiting synergies and complementarities between various fields involved in location and navigation, such as engineering, social sciences, and business world.
- To enhance the career prospects of young researchers by training them to use the tools from various research fields and to tackle the problems in a holistic manner.

The methodology to achieve these goals has been based on exposing the fellows to both technical and economic aspects, to both academic and industrial environments, and offering them first-hand experience and understanding of positioning needs through own mobility between several countries. The logic of the scientific research themes is illustrated in Fig. 2.1.

In MULTI-POS, there have been three main research themes, and several sub-themes per each research theme, as enumerated below:

1. **Location-Based Applications and Business Models:** focusing on investigating novel business models for companies involved in wireless localization, on creating novel LBS with special focus on enhanced social well-being and crisis management, and on developing the cognitive bridge between the application layer and physical layer. The sub-themes addressed here have been:

- Location techniques, ecosystem, and business model for 2020 urban mobility
- Deriving knowledge and social benefits from mass mobile network user data
- Developing markets for LBS

- Location integration in crisis management life cycle
 - Advanced assistance services of high performance in harsh environments
2. ***Cognitive Long-Term Location Approaches***: focusing on developing advanced technologies and algorithms for flexible, context-aware, and dynamically adaptive positioning, and on feeding into the location-based applications and business models theme the cognitive information needed to fill the gap between the application and physical layers. The sub-themes addressed here have been:
 - Building a cognitive prototyping platform
 - Developing cognitive methods for positioning and communications
 - Deriving innovative interference mitigation techniques for dynamically changing environments
 - Context-aware semantic processing
 - Adaptive flexible sensor integration for indoor location
 3. ***Hybrid Positioning Technologies***: dealing with novel hybridization solutions that take into account also the trustworthiness of the offered solutions, and with the definition of the technology gaps that can be filled by the cognitive positioning long-term approaches and to feed them into the location-based applications and business models. The sub-themes addressed here have been:
 - Large scale data analytics systems for GNSS data
 - Signals of Opportunity
 - Signals for combined positioning and communication systems
 - GNSS integrity monitoring in urban environment
 - Multi-GNSS positioning

2.3 Main Results and a Look Ahead

MULTI-POS covered a wide and varied range of research topics, as also demonstrated by this book. Regular training and networking events have been organized within the network, with an average of an event at each 4 months, as seen in Table 2.2.

The cross-sector training has been strongly emphasized in MULTI-POS, as all but one among the long-time recruited fellows have got two-sector experience. The MULTI-POS fellows have been exposed to complementary industrial and academic training, with at least 5 months of secondment in a sector different from the sector of their host unit. Also, fellows have been involved in international mobility. A map of the international mobility of the network is shown in Fig. 2.2. The arrows point out to the secondment country. The red circles indicate the locations of the partners of the network.

MULTI-POS greatly helped the fellows getting access to top researchers and sharing ideas and thoughts with them. Some fellows experienced “personal paradigm shifts” when tackling jointly certain research problems, by getting inspiration from the other network members and their collaborators.

Table 2.2 MULTI-POS events

Network event	Location	Date
Kick-off meeting	Brussels, Belgium	Sep 2013
First workshop	Tampere, Finland	Sep 2013
Special session in DASIP 2013 conference	Cagliari, Italy	Oct 2013
Second workshop Prague	Prague, Czech Republic	Dec 2013
Winter school	Ruka, Finland	Feb 2014
Summer school	St. Petersburg, Russia	Jun 2014
Special session in ICL-GNSS 2014 conference	Helsinki, Finland	Jun 2014
Midterm review	Amsterdam, Netherlands	Jul 2014
Special session in ISWCS 2014 conference	Barcelona, Spain	Aug 2014
Third workshop	Barcelona, Spain	Nov 2014
Spring school	Toulouse, France	Apr 2015
Special session in ICL-GNSS 2015	Gothenburg, Sweden	Jun 2015
Fourth workshop	Gothenburg, Sweden	Jun 2015
Spring school and fifth workshop	Nottingham, UK	Apr 2016
Special session in ICL-GNSS 2016	Barcelona, Spain	Jun 2016



Fig. 2.2 MULTI-POS international mobility of fellows

Among the main research results generated within this network, we mention:

- new algorithms and receiver designs for GNSS, such as Vector Delay Frequency Lock Loop (VDPLL)-based dual constellation GNSS receiver design and developments of a computationally efficient algorithm which is capable to perform a binary detection whether GNSS signal is present or not,
- novel jamming detection schemes for GNSS receivers,
- integration of data driven methodologies for ionospheric models generation and development of a methodology for ionospheric threat assessment for low latitudes equatorial data,
- multi-GNSS performance investigation based on full constellation simulated data,
- proposing an NLOS measurement rejection technique prior to the navigation module through the use of a 180° Field-of-View Fisheye camera mounted on the vehicle rooftop,
- extensive comparative analysis in terms of tracking robustness and positioning performance for the automotive usage in case of multipath and signal outages of the conventional GNSS scalar tracking receiver and the vectorized tracking and navigation module,
- evaluation of hybrid cooperative positioning in low signal-to-noise ratio environments, explicitly accounting for scenarios where receivers can receive signals but cannot decode navigation messages,
- development of a new channel prediction framework for mobile multi-agent networks which incorporates the agents' location uncertainty,
- new architectures and frameworks for semantic analysis of location-related parameters,
- proposing a new software component, called the Context Engine, that is responsible for dealing with user context in mobile devices,
- working on information inference, i.e., the prediction of relevant (unknown) user information based on available information and making available two information inference experiments,
- new methods for navigation sensor integration and detection and hybridization of Signals of Opportunity,
- studies about end-user preferences in current GNSS applications and market opportunities for future developments,
- detailed surveys on LBS in environmental protection, safety applications and drones, and commercial Galileo services,
- studies about the possibilities for applying geographic information systems and remote sensing for environmental purposes.

Several of the reports and deliverables within MULTI-POS are available in public access from the project webpage www.multi-pos.eu. The MULTI-POS list of publications is also available at the above-mentioned project webpage.

Multi-Technology Positioning

Nurmi, J.; Lohan, E.-S.; Wymeersch, H.; Seco-Granados, G.; Nykänen, O. (Eds.)

2017, X, 348 p. 127 illus., 111 illus. in color., Hardcover

ISBN: 978-3-319-50426-1