MULTI-POS: Marie Curie Network in Multi-technology Positioning

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Abstract — **The global navigation market (products and services) is expected to exceed 160 billion EUR revenue in 2015 with significant growth being driven by mobile terminals. Future wireless society needs trustworthiness of the wireless positioning device and eco-friendliness of the transmission-reception process. These are triggered by the user requirements, preferences and targeted applications, and by the type of the environment where navigation takes place. A link has been missing between these user needs/environment awareness (or application layer) and the physical layer where the wireless device is actually designed. The missing link can be created by cognitive approaches, borrowed on one hand from cognitive human behavior, and on the other hand from cognitive computing. Building a cognition stage between the application and physical layers creates a myriad of new possibilities for flexible location-based services and positioning-based applications. MULTI-POS training network is bridging the gap between the lower technology layer and upper application layer involved in wireless mobile location. In addition, MULTI-POS offers comprehensive training to young fellows in the broad field of wireless location, creates novel technologies and business models for the future location-enabled wireless devices, promotes the exchange of fellows in mixed academic-industrial R&D trajectories and in multiple European cultures, and will initiate an educational and research framework that unifies the currently fragmented research activities on technological and applications aspects of wireless navigation. There is strong involvement of industrial partners in the network to accomplish all this.**

Keywords — positioning, navigation, GNSS, Location Based Services, localization, wireless positioning, Marie Curie, ITN

I. INTRODUCTION

The wireless positioning research world has so far been split into two large distinct research communities: the technical community and the business community. It is now widely acknowledged that seamless outdoor-indoor location can be achieved only through hybridization of several technologies and systems and therefore the local research and training programmes dedicated to positioning in various universities worldwide are starting to include also the hybrid location technologies in their curricula. So far, all the existing formal training in EU has been focused on only one of these two layers, but it does not address both in an integrated way. This shows a missing link between these two communities and expert workforce with good background in all the layers involved in a wireless positioning system are in demand.

MULTI-POS (Multi-technology Positioning Professionals) [1] is a Marie Curie Initial Training Network funded by the 7th Framework Programme of the European Union [2]. One of the MULTI-POS objectives is to build such a link that would create a lot of new possibilities for flexible Location-Based Services (LBS) and positioning-based applications, and a new approach to wireless location research expertise and training.

The research in MULTI-POS network is carried out by 15 research fellows recruited at the network partners. Twelve of the fellows are Early Stage Researchers (ESRs) pursuing their PhD degree as part of the training, and three fellows are (a bit more) Experienced Researches (ERs) employed in the network for carrying out post-doc research. The fellows are trained to the multi-technology positioning, applications and services on-site and in network-wide training events organized jointly. A major role is played also by cross-border and cross-sector secondments, researcher exchange between the academia and industry.

The ten partners of MULTI-POS include six universities and four companies (including two SMEs). In addition, there are nine associate partners, of which six are companies (five SMEs), two research institutes, and a university. The partners and associate partners are shown in Table I.

The rest of the paper is organized as follows: Section II will introduce the research topics, Section III will provide an overview of the training activities, and Section IV will describe the secondments. In Section V the management issues are discussed, Section VI introduces the lessons learned, and in Section VII we will draw some conclusions.

II. RESEARCH THEMES IN MULTI-POS

Our methodology is based on a vertical approach, where we involve different layers from business issues, location-based services and applications down to specific algorithms and hardware/software implementation of positioning. By integrating the fellows in this kind of multi-disciplinary research they are bound towards achieving a global image of wireless localization world, being exposed to both technical and economic aspects, to both academic and industrial environments, and by 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. 1.
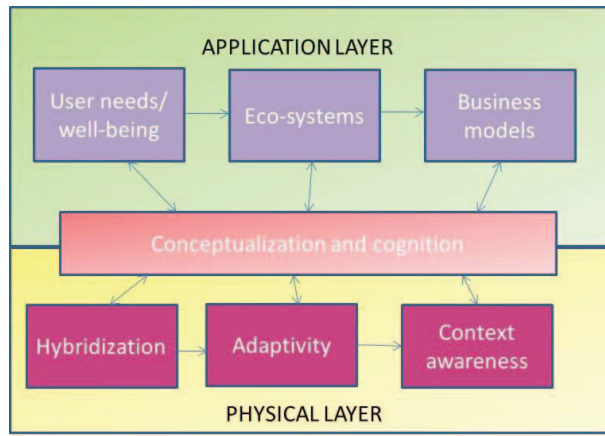
Fig. 1.   MULTI-POS Research Overview [3].

There are three research themes in MULTI-POS, each grouping together five individual research topics for the recruited fellows. We will present the themes briefly in the following subsections.

TABLE I. MULTI-POS CONSORTIUM

Abbr.	Full Partners		
	Organization name	Country	Org. Type [1]
TUT	TUT Foundation (Tampere University of Technology) - Coordinator	FI	UNI
CUT	Chalmers University of Technology	SE	UNI
ENAC	Ecole Nationale de l'Aviation Civile	FR	UNI
GMV	GMV Aerospace and Defense	ES	COM
HON	Honeywell International	CZ	COM
PCG	Ptolemus	BE	SME
PLD	Pildo Consulting	ES	SME
UAB	Universitat Autonoma de Barcelona	ES	UNI
UNOTT	University of Nottingham	UK	UNI
VU-VUMC	Stichting VU-VUMC (Vrije Universiteit Amsterdam)	NL	UNI
	Associated Partners		
	Organization name	Country	Org.Type
AVEA	AVEA Iletişim Hizmetleri	TR	COM
DLR	German Aerospace Center	DE	RES
FPPNT	Focal Point Positioning	UK	SME
GEO	Geodan	NL	SME
ITMO	National Research University of Information Technologies Mechanics and Optics	RU	UNI
SP	SP Technical Research Institute of Sweden	SE	RES
SSF	Space Systems Finland	FI	SME
T6ECO	T6 Ecosystems	IT	SME
WPS	Wirepas	FI	SME

[1] UNIversity, (large) COMpany, SME, RESearch institute

A. Location-based Applications and Business Models

The objectives of the theme are to investigate novel business models for companies involved in wireless localization, to create and investigate novel Location Based Services with special focus on enhanced social well-being and crisis management, and to create the cognitive bridge between the application layer and physical layer.

The individual research topics in the theme include:

- Location techniques, ecosystem and business model for 2020 urban mobility
- Deriving knowledge and social benefits from mass mobile network user data
- Developing markets for Location Based Services LBS
- Location integration in crisis management lifecycle
- Advanced assistance services of high performance in harsh environments

B. Cognitive Long-term Location Approaches

The objectives of the theme are to develop advanced technologies and algorithms for flexible, context-aware and dynamically adaptive positioning, and to feed into the location-based applications and business models theme the cognitive information needed to fill the gap between the application and physical layers.

The individual research topics in the theme include:

- Cognitive prototyping platform
- Cognitive methods for positioning and communications
- Innovative interference mitigation techniques for dynamically changing environments
- Context-aware semantic processing
- Adaptive flexible sensor integration for indoor location

C. Hybrid Positioning Technologies

The objectives of the theme are to offer novel hybridization solutions that take into account also the trustworthiness of the offered solutions, and to define 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 individual research topics in the theme include:

- 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

III.   TECHNICAL AND COMPLEMENTARY SKILLS TRAINING

Our integrated research and training programme consists of several dimensions including a personal career development plan, local and partner-specific training, complementary

training through secondments, joint training through MULTI-POS network events, training through research, training through team work, and training through interaction with research community, standardization community and general public.

Training, research and innovation are inter-linked within our programme. The following research fields and disciplines are involved in our training program: aerospace, business administration, business planning, modelling and forecasting, crisis management, computer and information systems, data management, economics, estimation theory, geo-informatics, information delivery, logistics, machine learning, mathematics, navigation, positioning, signal processing, statistics, strategic analysis, telecommunications. Moreover, MULTI-POS is also offering training in soft skills such as scientific paper writing, communication/public presentations, negotiation skills, management of academic and industrial projects, research ethics, IPR knowledge, innovation and technology transfer, and entrepreneurial skills. Furthermore, skills like adaptability, the capacity to deal with complex problems and the experience of working in international environments, will be developed through our secondment plan. On-site partner-specific training is offered to the hosted and seconded fellows.

There are a number of network-wide training events organized jointly by the network partners. The list of events and their timing are shown in Table II. There are thematic seasonal schools, workshops with a mixture of research progress presentations and training, and special sessions for presenting results and learning from the other researchers in the field. We consider also the review meetings as training for the fellows, as it is very educational for them to learn about the interaction with project reviewers and the review process.

The MULTI-POS fellows have been highly encouraged in their second year of study to pair with other fellows from different research themes in order to write together high-quality publications, covering aspects from all the research themes involved, to better promote cooperation and networking between the researchers, and to ensure a better vertical integration between the research domains. Good examples of multi-site and multi-WP publications include the papers [4], [5] and [9] by several TUT and UNOTT fellows, and [6] by UAB, TUT, GMV, PLD and two universities external to the network. A multi-site fellow team also participated in the European Satellite Navigation Competition (ESNC) 2015 [7], and one of the fellows got a "hole-in-one" by winning the ICL-GNSS 2014 best paper award with his first publication [8]. Another fellow won the best speaker award at ACM SIGSPATIAL 2015 [9].

Each fellow has also been trained through individual research projects and through interaction with other research projects. One or several local supervisors, as well as one or several remote supervisors (e.g., from the secondment places), are following the fellow's progress and offering expert feedback on the addressed research challenges. This training through research is complemented, in case of the 12 Early Stage Researchers, by also being enrolled as PhD students in a university.

TABLE II.   NETWORK TRAINING EVENTS

Event	Location	(Planned) Date
Kick-off workshop	Tampere, Finland	Sept. 2013
Special session in DASIP 2013	Cagliari, Italy	Oct. 2013
2nd workshop	Prague, Czech Republic	Dec. 2013
Winter school	Ruka, Finland	Feb. 2014
Summer school	St. Petersburg, Russia	June 2014
Special session in ICL-GNSS 2014	Helsinki, Finland	June 2014
Midterm review	Amsterdam, NL	July 2014
Special session in ISWCS 2014	Barcelona, Spain	Aug. 2014
3rd workshop	Barcelona, Spain	Nov. 2014
Spring school	Toulouse, France	Apr. 2015
Special session in ICL-GNSS 2015	Gothenburg, Sweden	June 2015
4th workshop	Gothenburg, Sweden	June 2015
Spring school	Nottingham, UK	(April 2016)
5th workshop	Nottingham, UK	(April 2016)
Special session in ICL-GNSS 2016	Barcelona, Spain	(June 2016)
Final review	t.b.d.	(autumn 2016)

Towards the project's end, based on the results within the project, each fellow is contributing to writing (tutorial style) book chapters in order to compile a comprehensive wireless positioning book that is understandable to the technically-oriented general public, on the various aspects studied in MULTI-POS that are dealing with top challenges in wireless location world [10]. That will conclude the research training of the fellows.

IV.   SECONDMENTS

The industrial partners are actively involved in the research activity. The fellows hosted or doing secondments in industrial sector will have the opportunity to work with state-of-the-art equipment and software and have exposure on the real-world engineering and business issues. The associate partners have a big role in hosting the secondments, in addition to the full project partners. They bring in complementary expertise and reduce the load of the full partners by supervising the fellows in exchange.

There is a strong emphasis on the cross-sector (academia – industry) secondments in MULTI-POS. Every fellow will undergo six to ten months of exchange during their employment in the network. As the total contract length for the Early Stage Researchers is 36 months and for the post-docs 22-24 months, the proportion of mobility is considerable. In the first place, the fellows have been all recruited cross-border to an organization which was not in their country of permanent residence.

Table III illustrates the mobility by stating the country of origin, country of employment, and country of the

secondment(s) for each fellow in the network. It is evident that the fellows have a strong training not only in technical and complementary skills but also on different European cultures and working practices.

V. NETWORK MANAGEMENT

The project is coordinated by Tampere University of Technology. In addition to the Coordinator (Prof. Jari Nurmi) there is a project manager taking care of everyday management activities. Major decisions are taken by a Supervisory Board, having representation from all the full and associate partners, one fellow representative elected by the fellows among themselves, and an Equality Officer (elected by the project partners) who happens to be the same person as the Scientific Coordinator of the network, Prof. Simona Lohan.

The board had its kick-off meeting already in November 2012 in Brussels, and it initiated the recruitment activities. The recruitment of the fellows was carried out as a network-wide activity. The 15 fellows were hand-picked from the total of over 250 applicants. We were lucky to be able to recruit also four female fellows (27%), as vast majority of the competent resources available in the field consist of male researchers. Maintaining a reasonable gender balance is important for the European Union and for the consortium and individual organizations, too. The preliminary selections sorted out by the supervisors were approved by the Supervisory Board.

TABLE III.   FELLOW MOBILITY

Nationality / Country of origin	Host Country	Type[2]	Sec. Country	Type	Sec. Country 2[3]	Type
LT	BE	COM	NL	UNI	ES	UNI
SA/IT	BE	COM	FI	UNI		
IR/IE	UK	UNI	TR	COM		
ES	NL	UNI	NL	COM	FI	UNI
PL	ES	COM	ES	UNI	FI	UNI
CZ	FI	UNI	FI	COM	SE	UNI
AT	SE	UNI	DE	RES	SE [4]	RES
FI	CZ	COM	FI	UNI		
ES	FI	UNI	IT	COM		
FI	UK	UNI	UK	COM		
CO	ES	COM	FR	UNI	ES	UNI
PT	FI	UNI	FI	COM	UK	UNI
IR	ES	UNI	ES	COM	SE	UNI
AL	FR	UNI	ES	COM		
IT	FI	UNI	ES	COM	SE	UNI

[2] University, company, research institute
[3] Many fellows have two secondments planned
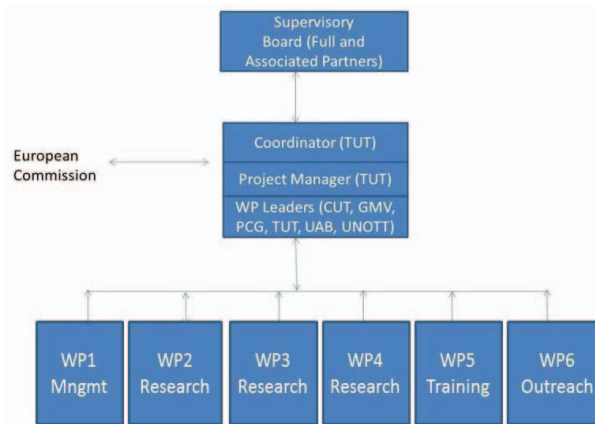[4] A third secondment to a company in CZ, too.

Fig. 2.   MULTI-POS Management Structure [3].

The research themes described above each form a Work Package (WP) in the project, with a responsible leader among the partner organizations. There are also dedicated WPs for management, joint training activities, and dissemination/ outreach activities. The management structure is shown in Fig. 2.

The major management challenges have included the organization of the recruitment, contractual and practical arrangements related to the numerous secondments, coordinating joint actions, and decisions and paperwork related to partner and associate partner changes. The midterm review in July 2014 in Amsterdam, and financial reporting after month 24 (September 2014) were a piece of cake compared to the routine business.

VI. LESSONS LEARNED

MULTI-POS covers a wide and varied range of research topics. This meant that during the workshops, some fellows had difficulties to follow the research issues presented by other fellows working in a distinct area. We noticed that the best way to address this challenge has been to allocate the fellows into smaller groups of 4-5 people (e.g. by work package) and to let them present their work to a reduced audience. This proved to encourage networking, brainstorming and being proactive. For instance, we developed this kind of thinking in the workshop in Gothenburg. One of the outputs of that workshop was a common paper submission in October 2015.

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. However, the full potential of the network was not used since the technical skills of each one were used solely towards their own work and not a common goal.

The first administrative lesson to learn was that although the timing of the project seems very relaxed, as the Early Stage Researchers have three-year contracts in a four-year project, it is very easy to introduce recruitment delays that will at worst

case cut the length of the fellow position. The contracts will not be reimbursed beyond the end of the project that has no flexibility. In our case such delays were caused by:

a) partner withdrawal, causing a chain of a management decision on the withdrawal, search of a partner to take over the position, another decision on moving the position and related funding, restart of the recruitment process, and finally agreeing on the starting date with the selected fellow.

b) difficulties in obtaining a visa and work permit for a fellow recruited from outside Europe.

c) resignment of a recruited fellow, leading to management decisions, restart of the recruitment, and matching the starting date to the incoming fellow's situation.

d) delay in obtaining MSc or PhD diplomas by some selected fellows.

Another lesson related to the length of the fellow contracts was that in most of the countries the PhD studies take more than three years. In this kind of a training network project the timing is even more challenging, as the fellow will spend a long time in secondment which will practically spread the focus a bit and cause a new learning curve to be taken by the fellow. Additionally, the training in MULTI-POS is more extensive than in most of the PhD programmes in individual universities. So much to do, so little time. As a consequence, most of the universities in MULTI-POS will have to find additional funding to support the fellows' PhD completion.

One of the very pleasant lessons was to find out, in a multi-cultural workshop organized as part of one of the training events, that the fellows and supervisors are representing a broad variety of personalities. That depends on the nationality, but also on individual properties. With this take-away from the workshop we have been able to understand and interpret each other much better, and the team of fellows fits very well together at work and in leisure. There have been very few personal adaptability issues even with "extreme personalities".

The difference between a regular EU research project and a Marie Curie network requires some learning curve for some less experienced partners. Here, the funding follows the fellow, and in case there is a need to make a decision to transfer the fellow from one employer to another, there is not such a thing as budget dedicated to the company – it is dedicated to the individual fellow. Unfortunately we had to learn to do a couple of such transfers in the network, to ensure that the planned training will take place. Based on our experience, the standard consortium agreements introduce too time-consuming procedures to deal with acute situations where the fellow needs to be "rescued" to enable the training to continue. The management of regular EU projects do not face similar situations as in the fellow-centric Marie Curie networks.

Some learning was needed also at the financial and/or HR departments of the companies and universities. The requirements to use all the living and mobility allowances to the salary of the fellow and related compulsory employer cost, as well as the freely usable lump sum training and overhead allowances were at first interpreted in different ways and have required some advising every now and then. A financial learning was also that the interim payments have been severely delayed due to a number of clarifications needed from one of the partners.

From above it starts to be obvious that a dedicated project manager is essential in Marie Curie projects. As we also had to make several changes in the secondment plan, and have thus needed to attract new associate partners to host some secondments, there has been a lot of effort to follow all the changes in the secondment and associate partner contracts. It proved to be very difficult also to get new associate partners to join the network afterwards, mostly related to IPR constraints. By default, the IPRs are owned by the employer unless they are explicitly transferred or licensed to the secondment host.

What we also learned that the selective process of recruiting the fellows yielded in excellent fellows. There has been a great team spirit, and the network has increased also the cooperation between the supervisors and their organizations substantially. The pairing and grouping efforts have also triggered more interaction and collaboration between the fellows.

VII. Conclusions

Due to a very good mix of companies and academia, the MULTI-POS network project has gained a good visibility and is expected to make a long-lasting impact in wireless positioning community. Regarding the future employability of the fellows, industry and academy alike look for professionals who are capable of working in an interdisciplinary and international context, beyond the scope of their immediate technical expertise. The MULTI-POS fellows receive hands-on experience in real research projects, as well as a deep insight into underlying analytical models/phenomena involved in the addressed field, thus achieving a comprehensive training in wireless localization. The fellows participate in a frontier research project driven by world-class scientists. The training of the fellows is inter-sectoral and they will all have open career paths in both academic and industrial fields. They also gain a good contact network during their training in MULTI-POS.

The lessons learned include the importance of an efficient recruitment process, understanding the specialty of Marie Curie projects, having a good contractual framework in place, and having a project manager to take care of the daily management routines. Getting the fellows to network intensively in the training events and by guided grouping has paid off. In general, now we know many DOs and DONTs for the next training network setup and operation. We definitely want to try it again now when we have learned all the lessons.

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