TOWARDS MOBILE SEMANTIC GRID FOR INFOMOBILITY

Mario BINETTI[1], Paola AMORUSO[1], Eugenio DI SCIASCIO[2],
Michele RUTA[2], Agnese PINTO[2]

Abstract. Flexible and effective information services in transport call for novel and emerging telematics technologies. Such services require integration and processing of data coming from different information sources together with simple interfaces to make them available via static and mobile devices. A significant development for transport information services can be achieved exploiting networks featuring mobile nodes –with different characteristics and properties- represented by vehicles moving on road network. A semantic-based approach applied to such networks, allows building a high level infrastructure - mobile semantic grid - able to meet requirements of mobile grid with the interaction between connected devices and generic users provided with a simple interface, e.g. a handheld device. In this context the city of Bari, the test site for Pitagora project, represents the first step towards the development of a mobile semantic grid at a real scale. In this grid buses represent nodes as elements of intermodal transport system.

1. Introduction

In the last years a rapid development of telematic technologies has allowed the migration for wireless sensors from static first generation ones characterised by low data rate, towards dynamic second generation sensors with high data rate. This boosts new possible applications within Intelligent Transport Systems. Nowadays most of vehicles are equipped with diagnosis sensors; hence they can easily represent nodes in a network of mobile sensors. Also the widespread use of static and mobile terminals enables travellers to represent as well a mobile node within the network. He can hence be capable to get information in order to plan his trip and receive assistance during his trip. Moreover the

[1] Highways and Transportation Department (D.V.T.) –Technical University of Bari. via E.Orabona,4 70125 Bari – Italy, binetti@poliba.it, paolaamoruso@alice.it
[2] Electrical & Electronics Engineering Department (D.E.E.) Technical University of Bari. via E.Orabona,4 70125 Bari – Italy, {disciascio, m.ruta, agnese.pinto@poliba.it}

application of telematics technologies plays an important role in the management of an integrated transport system. With particular reference to a multimodal transport systems, it allows an improvement in the level of service provided as well as an effect on modal split, increasing public transport in respect to private transport.

2. PITAGORA

The key words for Pitagora project are multimodal trips and multimodal traveller information. The city of Bari, with 300,000 inhabitants, is the test site of the project. The project aims to develop a pre-trip and on-trip information system useful to all stakeholders, particularly multimodal travellers. Travellers shall be able to get real time information about different modes and routes from the origin to their destination on multimodal network via static devices (Internet points, bus stop displays, kiosks,..) as well as mobile devices (mobile phones, PDAs,..). Also user profiles will be set up, in order to provide travellers with bespoke information about delays and disruptions that affect their planned travel times, costs and routes. Automatic Vehicle Detection device will enable bus operators to manage their fleet more effectively through real time monitoring of vehicles running late or ahead of schedule. In this context, communications between on board vehicle (bus equipped with location and communication devices), static devices (bus stops displays, kiosks, etc..) and control room as well as communications between traveller and a generic device used to acquire information can build two scenarios: the first is based on static sensors of the telematic grid; communication channels adopted are GSM, GPRS, MMS, etc..; the second one is based on a wireless communication system, with dynamic sensors that define a mobile grid. Physical extension of this grid on the land depends on the position of the buses (dynamic sensors).

3. Proposed Mobile Semantic Grid Infrastructure

Recent technological advances permit to evolve basic wireless networks in new ones where also sensors are involved and data rates are appreciably higher. Mobile Ad-hoc NETwork (MANET) infrastructures allow more and more powerful application as modern handheld devices integrate a good computational equipment making possible a strong decentralization of the network knowledge and a really ubiquitous computing. From this point of view, an emerging paradigm is the mobile grid one [2]. Although significant work has been done towards mobile grids, it has been basically aimed at extending wired paradigms and approaches to wireless infrastructures. But due to the deeply different nature of two contexts, real potentialities of mobile grids are still hidden and not exploited. Although grid computing offers significant enhancements to user capabilities for computation, information processing and collaboration, only a high level approach in data dissemination and resource discovery within the grid could allow to fully exploit these features [6]. We aim at building and experimenting a **Mobile Semantic Grid** infrastructure where Semantic Web techniques and technologies are seamlessly used in order to characterize grid nodes and actors, as well as to annotate information they manage in an infomobility scenario. Semantic Grids are an extension of the current Grids. There, resources and services become machine understandable, better enabling computers and people to work in cooperation [2]. Here grid nodes are buses moving within a specified urban area, handheld devices of users as well as – considering stable nodes – survey centrals, data collectors and reasoning centres. Hence, by taking into account data received from various wireless sensors within the grid (traffic entity, environmental parameters, location values) as well as semantic annotations of grid resources, a generic user – external to the grid – could retrieve advanced information to this complex "black box" interacting with front end nodes. In particular the grid will combine data managed by different mobile nodes (conceived either as semantically annotated descriptions or as contextual parameters) in order to compute best matching resources w.r.t. user requests. We will use at lower layers communication protocols which allow the correct management of grid information, slightly modifying its application layer in order to enable the use of semantics. Data interchange among wireless sensors and survey centrals or data repositories within the grid will take place by means of ZigBee protocol standard, whereas grid hotspots (mobile vehicular information systems as well as networked service providers) are directly exposed towards external users by means of a Bluetooth interface. ZigBee is a high level protocol suite based on the IEEE 802.15.4 standard. Over the IEEE 802.15.4, the ZigBee Alliance has defined further layers of the protocol stack. Generally the allowed POS (Personal Operating Space) is up to one hundred metres circa, but more nodes can be combined to build a complex bridged infrastructure able to dynamically cover larger areas. ZigBee wireless networks are usually labelled as LR-WPAN (Low Rate WPAN). They are mobile networks simple and low cost permitting application oriented wireless connections with not too much high throughputs. Basically ZigBee allows to build general purpose auto-configuring wireless networks which integrate a variable number of different devices ranging from few ten to some thousand unities. Hence the basic protocol structure offers a good support for application requiring a high environmental covering level. It allows to monitor a heterogeneous and complex context as well as to interact with devices within the environment. For our purpose the high flexibility offered by the protocol will be used as basic network infrastructure in our Mobile Semantic Grid implementation. As previously hinted, together with ZigBee, in the proposed approach we will use Bluetooth to grant the interaction of grid front end nodes with the user. This is mostly due to a couple of reasons. First of all Bluetooth support is widespread in commercial handheld devices. Furthermore, granting a higher data rate, Bluetooth appears more effective in terms of interaction with the user. On the other hand the integration between Bluetooth and ZigBee involves only respective application layer (Service Discovery Protocols) and so it is easier to be implemented. Bluetooth is a short range, low power technology [4], which grants peer to peer interaction between hosts. In such a mobile infrastructure there is one or more devices providing and using services. Service Discovery (SD) protocol in original Bluetooth standard is based on a syntactic matching, which is largely inefficient in ad-hoc environments where there is not a common service interface. A more advanced usage of service discovery protocol is desirable, associating semantic descriptions to the services rather than simple numeric identifiers. For such purpose knowledge representation techniques shall be exploited and adapted to the ubiquitous environment [5], extending the SD protocol without troubling the basic one.

4. Research goal and application framework

By adopting the protocols briefly sketched above we will implement the communication infrastructure for our mobile semantic grid. A fundamental role in this approach is played by an adequate paradigm for data dissemination within the grid. In the proposed framework results and techniques practised for MANETs [3] will be adapted and extended. Basically, we aim to provide a general and common semantic layer over the application one, able to allow the usage of semantic based services also granting a backward compatibility with original standard functionalities. An effective resource discovery approach must take into account the limited bandwidth of mobile ad-hoc networks and their extremely volatile topology. Hence a hybrid solution appears more straightforward w.r.t. a completely decentralized one. Information about grid resources and services will be disseminated within the grid in a totally decentralized fashion allowing the rapid and simple identification of a node, whereas the resource or the services themselves will be mainly provided **on-demand** to the requester. The idea is that *Knowledge* is completely distributed within the grid, but thanks to a capillary data dissemination involving short information about it, the framework is able to easily retrieve semantically annotated services/resources so allowing the direct download from the provider. Notice that technologies designed for Semantic Web have to be adapted and integrated for an effective use in ubiquitous ad-hoc scenarios. In particular the resource discovery paradigm for MANETs has to be shaped taking into account peculiarities of such a system. We exploit an approach which uses a two step discovery. The first step concerns the advertisement of node resources within the grid and the second one allows to select the one best matching user requirements (according to semantic similarity criteria). Basically, the service advertisement is the necessary support to the subsequent semantic enabled discovery and selection procedure. We hence aim at adapting an existing data dissemination protocol [3] to mobile semantic grid applications with a twofold objective:

1. to build an adequate infrastructure for the application layer of the protocol in order to support advertisement and discovery of complex services/resources
2. to perform the tuning of the system for infomobility scenarios.

The first stage basically concerns the adaptation of the ZigBee resource discovery layer in order to implement an efficient system of data dissemination, and successive information retrieval. Obviously the protocol has to be modified to integrate the support for semantically annotated service/resource description. The mobile grid will contain two kind of nodes with different relevance according to their computational capabilities. The first class nodes play a passive role within the grid as they will be interested only in repeating information coming from nearby second class nodes. Those hosts, on the contrary, will also assume a computational function. The combination of ZigBee-Bluetooth protocols is likely to have a good attitude in semantic mobile grid applications although applications layer of both protocols must be modified in order to allow the use of semantics in annotation and discovery of services and resources. Furthermore a middleware for bridging two different application layer has to be implemented in order to allow a complete integration between mobile devices supporting either Bluetooth or ZigBee and a hybrid use of nodes within the grid. Both Zigbee and Bluetooth standards have a good versatility and present fair extension capabilities. We will exploit these features in order to overlap the traditional resource discovery of protocols with a semantic based micro-layer able to support data dissemination as well as a semantic enabled service discovery. With reference to the second stage a fundamental question is the interaction user/grid. The system will have a common front-end interface where borderline nodes will be able to understand user requests also starting the complex discovery phase interfaced to the whole mobile grid. The grid structure must be able to grant reliability and a given Quality of Service (QoS). Hence minimum services have to be ensured, taking into account highly flexible and variable ubiquitous computing application scenario. Furthermore the ad-hoc infomobility context has to be semantically modelled. Grid services and resources have to be identified and characterized and sensor parameters (simple or combined among them) will be used as contextual values able to correct the semantic similarity criteria. The last phase is in identification of inference services useful for the application requirements and in implementation of utility functions taking into account the correlation existing between request/reply semantic based matchmaking procedures [1], numerical models involving field sensor data and contextual parameters. The scenario we envisage is one where a passenger, by means of her Bluetooth handheld device, will interact with the Mobile Semantic Grid requiring information about traffic, parking availability, possible lateness in public bus travels also planning her intermodal movements in real time. In addition she will be able to use further advanced services, we illustrate hereafter with an example scenario pictured in fig. 1.

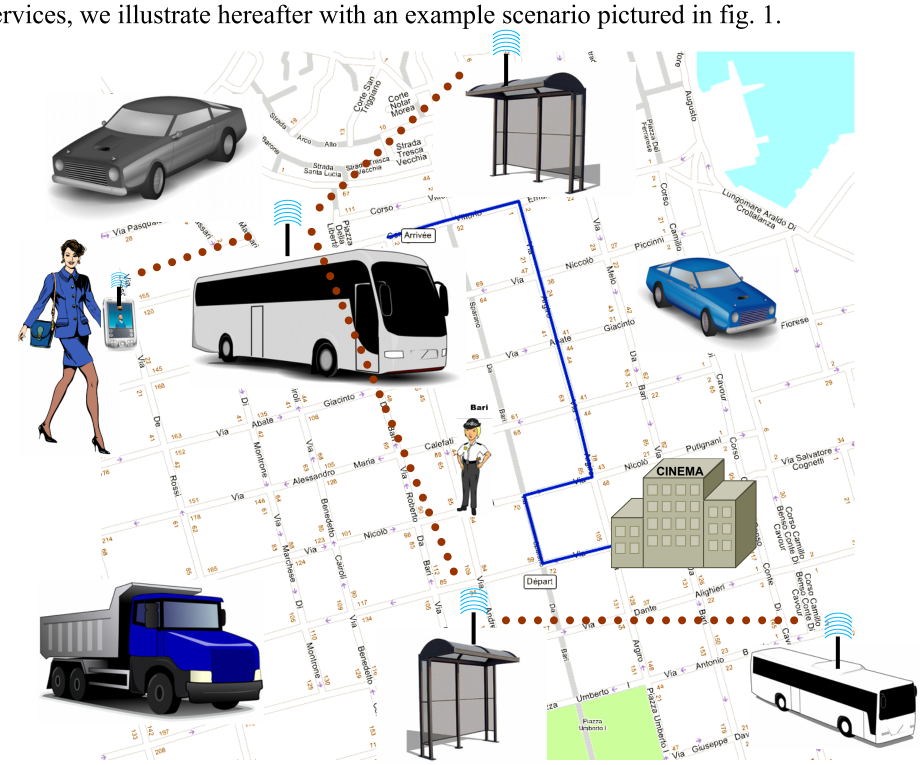

Figure 1: example scenario

Let us suppose a passenger is travelling towards downtown and willing to plan her evening. Via Bluetooth she may contact the micro-information server of the bus (vehicular hotspot) so interacting with the mobile grid. In this manner she can obtain, for example, the theater programming in downtown or verify the opening hours of the downtown shops or finally she can submit to the system a complex request for “a premiere of an american action movie possibly showed in a Dolby surround downtown cinema". The system shall be able to reply to this complex request correctly combining traffic data coming from grid sensor nodes with semantically annotated description of offered services. It will show results best matching the user request also taking into account an estimation of the arrival time (according to bus speed and traffic conditions – given the destination address). Furthermore the system shall also permit e-ticketing operations allowing to purchase a movie ticket on the bus.

5. Conclusions

In this paper we briefly introduced our vision of the Mobile Semantic Grid we plan to develop and implement in the framework of PITAGORA project. The objective is manifold: investigate the integration of protocols and technologies that are emerging to make them usable in practice, study user oriented semantic services and, provide a value-added infrastructure and a test-bed where new technologies and services can be experimented in a real environment.

References

[1] S. Colucci, T. Di Noia, E. Di Sciascio, F. M. Donini and M. Mongiello: Concept Abduction and Contraction for Semantic-based Discovery of Matches and Negotiation Spaces in an E-Marketplace. Electronic Commerce Research and Applications, vol. 4, n. 4 (2005)

[2] D. De Roure, N. R. Jennings and N. R. Shadbolt: The Semantic Grid: Past, Present and Future. In Proc. of the IEEE, vol. 93, n. 3 (2005)

[3] M. Ruta, T. Di Noia, E. Di Sciascio and F. M. Donini: Semantic enabled Resource Discovery, Composition and Substitution in Pervasive Environments. In Proc. of 13th IEEE MELECON 2006 (2006)

[4] M. Ruta, T. Di Noia, E. Di Sciascio and G. Piscitelli: Ontology driven resource discovery in a Bluetooth based m-marketplace. In Proc. of the 3rd IEEE Intl. Workshop on Mobile Commerce and Wireless Services WMCS 2006 (2006)

[5] M. Ruta, T. Di Noia, E. Di Sciascio, F. M. Donini and G. Piscitelli: Semantic Based Collaborative P2P in Ubiquitous Computing. In Proc. of IEEE/WIC/ACM WI-2005 Web Intelligence (2005).

[6] L. Wischhof, A. Ebner and H. Rohling: Information Dissemination in Self-Organizing Intervehicle Networks. IEEE Transaction on Intelligent Transportation Systems, vol. 6, n. 1 (2005)