MOBILEMAN

IST-2001-38113

Mobile Metropolitan Ad hoc Networks

MOBILEMAN

Exploitation Plan

Deliverable D19

Contractual Report Preparation Date: 30 November, 2005
Actual Date of Delivery: 11 January, 2006
Estimated Person Months: 5
Number of pages: 47
Classification: Internal circulation within project

Contributing Partners: Consiglio Nazionale delle Ricerche (Italy), University of Cambridge (UK), Institut Eurecom (France), Helsinki University (Finland), NETikos (Italy), Scuola Universitaria Professionale della Svizzera Italiana (Switzerland)

Authors: Marco Conti, (CNR); Jon Crowcroft, Andrea Passarella (Cambridge); Pietro Michiardi, Refik Molva (Eurecom); Jose Costa Requena (HUT); Piergiorgio Cremonese, Veronica Vanni (Netikos); Ivan Defilippis, Wilma Minoggio (SUPSI)

Abstract: This deliverable presents the ways identifies by MobileMAN partners to promote, present and potentially exploit the MobileMAN results. Given the project goals the promotion and development of the project results as a whole has been (and will be) mainly performed through the indirect way of dissemination. In addition, to present and discussing the dissemination channels, the deliverable describes the exploitation plans of the results for the consortium as a whole, or for group of participants; it expresses as much as possible in concrete terms, the strategic impact of the project in terms of improvement of competitiveness or creation of market opportunities for the participants.

Project funded by the European Community under the "Information Society Technologies" Programme (1998-2002)

Summary

The purpose of this document is to summarize the main results of the MobileMAN project and document the strategies MobileMAN partners have implemented (and will continue to implement after the project end) to exploit the project results. Specifically, this document is addressing the schemes for the dissemination of know-how and knowledge gained during the project, ways to promote the utilization of the our system and ultimately to plan and identify possible routes for the full exploitation of MobileMAN results, be it for future commercial or new research activities.

Given both the consortium nature and composition (mainly research and academic institutions) and the project goals, the promotion and development of the project results has been mainly performed through the indirect way of dissemination, and as feedback of the social analysis. However, the successful fulfillment of the project goals produced a set of results that constitute a solid basis for economical exploitation. Therefore, this document also defines a sustainable exploitation strategy to be implemented after the project ends with regard both the creation of start-ups and novel business processes. This document plays a strong attention to partners' interest, role and benefits in the exploitation.

To make this document self-contained, before presenting our dissemination and exploitation strategies, we present the motivations and aims of the MobileMAN project and summarize the achieved results that constitute the basic elements of our exploitation strategy.

Table of Contents

1. INTRODUCTION

This project started from the observation that (at beginning of 2000s) while Europe, through research and industrial efforts has established world-renowned leadership in infrastructure-based mobile communications, the European research on self-organizing network was almost missing. At that time, USA was driving research in this area, mainly in the context of defense-related projects. On the other hand, in Europe, research was mainly performed by research groups operating at the national level (e.g., Terminode project in Switzerland, the Fleetnet project in Germany and the APE testbed in Sweden). This produced a knowledge gap between Europe and USA, with a potential negative impact on the role of European industry, being self-organizing ad hoc networks an important part of next generation mobile and wireless systems. The primary aim of the MobileMAN project was therefore to constitute a kernel of European research on self-organizing networks to help maintaining and re-enforcing the European leadership in the mobile market. Specifically, MOBILEMAN aimed to explore the technical, social, and market effectiveness of the ad hoc networking paradigm at the European level by overcoming the barriers that could negatively affect the significance of results obtained at the national level; thus producing a common European approach toward self-organized networks to balance the USA leadership in this area. To achieve this, we set up a consortium consisting of partners whose role and competence can fill the complete chain of scientific and technological skills required to realize a metropolitan area, self-organizing, and totally wireless network named *Mobile Metropolitan Ad hoc Network* (MobileMAN). Specifically, we identified two main **objectives**:

- **technical solutions**: invent and demonstrate solutions that make the self-organization paradigm effective by developing architecture and protocols for self-organized networks.

- **business and social impact**: to exploit the self-organization paradigm for supporting innovative applications (in terms of novelty of the services context onto which the applications are integrated and novelty of the way they are offered to the users), which will improve the life quality of people and open new business opportunities.

To achieve these main objectives the project identified a set of relevant results (both from a technical and socio-economic perspective) to be achieved. Specifically, the main expected **technical outputs** of the project are:

- Development, validation, implementation and testing of the architecture, and related protocols, for configuring and managing self-organized wireless networks. This includes: routing and forwarding protocols, location services, transport protocols, p2p middleware platforms, security and cooperation.

- Physical implementation of this architecture for lowers layers (i.e., wireless technologies) by improving the existing IEEE 802.11 wireless technologies for dealing in bursty access environments as self-organized networks.

- Integration and validation of popular services, (such as SMS and chatting) on top of our self-organized network, as well as the extensions of these services into new realms, such as multimedia messaging, spontaneous electronic collaboration and wireless interactive games.

- The validation of the self-organized paradigm from the technological standpoint, (i.e., its technical feasibility) by the development of a fully functional MobileMAN where users can communicate and run applications with no cost for communication itself. The challenges of building a totally self-organized, highly dynamic and completely decentralized network are addressed by a layered networking architecture (Bursty-responsive MAC, Social-operated Networking, secure networks services, P2P middleware) integrated with applications to assess its validity.

The main business and social outputs of the project were summarized as follows:

- The validation of the self-organized paradigm from the social point of view.

- An evaluation of the effectiveness of the mobile ad hoc paradigm for promoting new business activities and processes, and its market access.

It is worth noting that, being mobile ad hoc networking an open research area, during the project activities new challenges were identified. Among these, it is worth remembering a novel organization of a MobileMAN architecture by exploiting the cross-layer principle. The potentialities of this new approach emerged during the project first year and, to explore them, new objectives were added to the project to show, through proof-of-concept prototypes and via simulation, the benefits of the cross layer approach. More precisely

- to develop a testbed for experimenting the benefits of a cross-layer architecture; and

- to develop a simulation framework to study the cross-layer architecture on a larger scale with respect to the experimental testbed.

2. PROJECT RESULTS

As explained in the previous section, the MOBILEMAN project aimed at creating an European perspective on self-organizing networking to contrast the USA leadership in this field by developing novel methods, tools, algorithms, and protocols supporting the construction and provisioning of self-organizing systems and applications. Alongside this, there methods specifically tailored for evaluating the economic and social impact of this technology. Hereafter, by reviewing the main results produced by the project, we will show that all these objectives have been achieved.

2.1. Stimulating the Growth of the European Research Community

First of all, the MobileMAN partners created a kernel for the European research in the field that stimulated with several initiatives the growth of an European community in this field. Indeed, the first step of the project was the organization of the ESF/PESC Exploratory Workshop "*Is Mobile Ad hoc Networking part of the future of mobile networking in Europe*?" held in Monterosso al Mare, La Spezia (Italy), 10-12 October 2002 – jointly organized by CNR and SUPSI. This workshop provided the following important contributions to the European research in the field:

i) an analysis of the state-of-art in the European research in this field;
ii) an analysis of the European projects and activities related to MANETs;
iii) an analysis of the role of the MANET paradigm on the future mobile ad hoc networking in Europe;
iv) the creation of a network among European researchers in the field that by exploiting this, in the successive years have been able to create a strong European approach to self-organizing networks.

This role of MobileMAN project was maintained throughout all the three years of the project through the organization of scientific events that were able to put the European researchers together to compare and contrast their approaches. Among these events it is worth remembering:

- The 8th International IFIP-TC6 Conference on *Personal Wireless Communications*, (PWC 2003) Venice, Italy, 23-25 September 2003.
- WiOpt 2003: *Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks*, INRIA Sophia-Antipolis, France, March 3-5, 2003.
- WiOpt 2004: *Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks*, Cambridge, UK, 24-26 March 2004.
- The 6th IEEE Symposium on a *World of Wireless Mobile and Multimedia Networks* (WoWMoM 2005), Taormina, Italy 14-16 June 2005.
- First IEEE WoWMoM workshop on *Autonomic Communications and Computing* (ACC 2005), Taormina, Italy, June 13, 2005.
- First IEEE WoWMoM Workshop on *Trust, Security and Privacy for Ubiquitous Computing* (TSPUC2005), Taormina, Italy, June 13, 2005.

As MobileMAN partners had a coordination role in the organization of these events, this opened opportunities to European research community, such as: i) inclusion of several European researchers in the program committees and ii) control on the agenda of these

events -- including the selection of keynote speakers, selection of panel arguments and speakers, identification of topics for special sections, etc.

The First IEEE Workshop on *Multi-hop Ad hoc Networks: from theory to reality* (REALMAN 2005) has a special role in this strategy. Indeed this workshop had a twofold role in the MobileMAN activities. We organized it as a part of our dissemination strategy to present our results in an international context; in addition this was an opportunity to establish in an international context an European approach in mobile ad hoc networking research: complementing theoretical research and simulation (as commonly used in USA research) by real experiences (e.g., measurements on real prototypes which provide both a direct evaluation of ad hoc networks and, at the same time, precious information for a realistic tuning of simulative models). REALMAN 2005 panelists -- representatives of (some of) most active research groups in Europe – confirmed this direction. Indeed, combining theoretical research on ad hoc networking with experiences/measurements obtained by implementing ad hoc networks prototypes is emerging as a distinct feature of the European research in the field as opposed to USA approach that almost exclusively based on simulation "implementations can come later, simulations tell the truth". The leadership of this European perspective in mobile ad hoc networks research is witnessed by the second edition of the REALMAN workshop, that will be the satellite workshop of ACM MobiHoc, i.e., the most prestigious event for worldwide ad hoc networking researchers.

Other MobileMAN initiatives further contributed to stimulate the growth of a European community. Among these, it is worth remembering the organization of journal special issue, such as:

- *Ad Hoc Networks Journal* Special issue on "Ad Hoc Networking for Pervasive Systems", (Elsevier). Volume 3, Number 2, March 2005;
- *IEEE Communication Magazine* Special issue on "Ad hoc and Sensor Networks", March 2005 and May 2005;
- *Wireless Ad Hoc and Sensor Networks: An International Journal*, Old City Publishing, Special section on "REALMAN 2005";

where contributions presenting experimental results were particularly welcome, and contributions by European researchers were solicited and encouraged.

All these actions highly contributed to provide a high visibility to the research carried out by European researchers with a special emphasis on the results produced by the MobileMAN project. During the 3-year of MobileMAN project the role of European researchers in the worldwide scientific community in this field considerably increased as shown by the leadership of main scientific events, the participation to journal editorial boards and the organization of journal special issues. A clear indication of this role is the scientific responsibility, during 2006, of two main events in this field. More precisely, IIT-CNR will have the scientific and organization responsibility of the main conference on pervasive systems, the 4th IEEE International Conference on Pervasive Computing and Communications (PerCom 2006), and the MobileMAN project coordinator is the Program Co-Chair of the 7th ACM Symposium on Mobile Ad Hoc Networking and Computing, MobiHoc 2006.

2.2. Technical Results

Contributing to increasing the visibility of the European research in the field would be not possible without carrying out high-quality research able to produce significant contributions to the scientific literature. Specifically, after a careful analysis of the state of the art, the project activities concentrated on three areas where significant contributions were still needed: i) *Integration*, ii) *Implementations/Testbeds*, and iii) *Experimentation*. Indeed, MobileMAN researchers produced relevant results in:

i) Design, validation and implementation of architecture and protocols for mobile ad hoc networks.
ii) Integration of our results in prototypes used for extensive experimentations.

2.2.1. Design validation and implementation of architecture and protocols for mobile ad hoc networks

In this section we summarize the main results of the project related to the design and validation of the architecture and protocols (from the medium-access-control to the application layer). After analyzing the novelty of our approach in designing the architecture of mobile ad hoc networks, we present the main results in protocols design. The presentation follows a bottom up approach: from wireless technologies up to applications.

MOBILEMAN ARCHITECTURE

One of the main project results has been the introduction of the cross-layer principle in mobile-ad-hoc-network organization still maintaining a layered organization of the network architecture and the compliance with TCP/IP protocol stack. More precisely, the MobileMAN cross-layer architecture is based on a layered organization, which can be enhanced with cross layering interactions if information gathered at different layers of the network stack is shared in a common local memory structure (Network Status, referred to as *NeSt*). Specifically,

- the *NeSt*, which is the key of the cross-layer architecture, has been completely defined by specifying the NeSt interaction models, and its exported interfaces.
- We designed the software architecture of a NeSt prototype supporting cross-layer interactions between a proactive routing protocol and the middleware platform, CrossROAD, which has been developed during the project.
- Starting from the software architecture, we implemented a proof-of-concept prototype of our cross-layer architecture.
- An experimental phase provided a proof of the benefits of this new approach in MANET design.
- A special attention was devoted to study the performance of our cross-layer architecture. To this end we extended the Network Simulator NS-2 (v. 2.27) with a

cross-layer interface (XL-interface) that standardizes vertical interactions among protocols according to the MobileMAN cross-layer architecture.

WIRELESS NETWORKS

- Analysis of the limits of the existing solutions based on IEEE 802.11 for constructing multi-hop ad hoc networks. The analysis has been performed by simulation and measurements.
- Definition of a channel model for CSMA-based wireless networks to be used for protocols design and to tune simulation models. The model is suitable for both 802.11 networks and Mote-based sensor networks.
- Design of an enhanced MAC protocol (AOB) for ad hoc networks. The new MAC protocol is compatible with the IEEE 802.11 and provides a better channel utilization.
- Extension of the AOB mechanism, with a credit-based mechanism, to effectively operate in a heterogeneous environment where enhanced and legacy cards co-exist.
  - The credit mechanism provides a formal basis to the activities of TG 802.11n that is working toward higher throughput for 802.11 networks. Indeed, AOB extended with the credit mechanism provides an optimized and efficient solution to the multiple transmissions approach currently under study in TGn.
  - It provides an efficient solution to fix 802.11 unfairness in multi-hop scenarios.
- Hardware implementation of the enhanced MAC card implementing both the AOB mechanism and its credit-based extension.
- Experimental validation of the AOB mechanism on a 4-node testbed.
- Implementation in the NS-2 tool of the simulation model of the enhanced MAC card.
- Validation of the AOB mechanism via simulation on large-scale networks.

NETWORKING PROTOCOLS

- Design and evaluation of a packet-forwarding scheme (REEF) for the reliable data forwarding in mobile ad hoc networks.
- NS-2 implementation of the REEF model.
- Design and implementation of the Ad Hoc routing framework software package for nodes (PDA or Laptop) running the Linux Operating System. The Ad Hoc routing framework supports different ad hoc routing protocols: proactive (OLSR), reactive (AODV) and also some hybrid solutions.

- Design and implementation of a Service Discovery Module (SDM). SDM provides the basic functionalities to implement (in an efficient way by exploiting cross layering) at the middleware layer the discovery of any service.

- Design of an architecture that allows constructing a *hybrid network environment* to interconnect (islands of) multi-hop ad hoc networks to the Internet.

- Implementation of the *Ad Hoc Proxy ARP daemon* (*AHPAd*) that enables the interconnection of MobileMAN ad-hoc islands to the Internet.

- Design and evaluation of a transport protocol for ad hoc networks (TPA)

- NS-2 implementation of the TPA.

- Prototype implementation of TPA

CO-OPERATION MODELS AND MECHANISMS

- Design of a model that allows studying the cooperation in mobile ad hoc networks.

- Design of the *Cooperation enforcement mechanism* (CORE) that encourages users to behave as "good citizens".

- Validation of the CORE mechanism. By exploiting a non-cooperative game model we showed the effectiveness of the CORE mechanisms with respect to other policies proposed in the literature.

- Implementation of CORE for the Linux operating system. CORE has been implemented as a Linux daemon. CORE software architecture includes three building blocks: a) a MAC layer sniffer that monitors the packets; b) a reputation function; c) a punishment mechanism.

- Experimental validation of CORE on a small-scale testbed.

- Large-scale validation of CORE by simulation. CORE has been implemented as an add-on component for the Glomosim network simulation suite.

MIDDLEWARE

- Development of NS-2 simulation models for p2p structured (Pastry) and un-structured (Gnutella) platforms;

- Simulation study of Pastry and Gnutella platforms in multi hop ad hoc networks;

- Integration of a free implementation of Pastry (FreePastry) in the MobileMAN architecture.

- A new middleware (CrossRoad) for ad hoc networks was designed and developed. It optimizes the Pastry platform by exploiting cross layer interactions with the network layer.

- A cross-layer optimization of Gnutella (XL-Gnutella) was designed and implemented in the NS-2 framework.

- Simulation comparison of Gnutella and XL-Gnutella showed that XL-Gnutella outperforms Gnutella in mobile ad hoc networks.

NEW APPLICATIONS AND SERVICES

We developed and integrated in the MobileMAN software architecture co-operative tools for document/content sharing based on a P2P architecture (Whiteboard and UDDI); and a VoIp application, which exploits the legacy TCP/IP protocol stack. Specifically, the following software modules have been developed:

- A Whiteboard application (implemented in Java) to create a virtual group (a community) for a limited amount of time in order to exchange dynamically generated content (e.g., drawings and text). The whiteboard application is a p2p multicast application which exploit the services offered by any structured overlay network implementing the commonAPI interface.

- *UDDI for manets (UDDI4m)*: a service discovery and location protocol for MANETs called *UDDI for manets (UDDI4m)*. This protocol exploits the traditional UDDI protocol with the introduction of a level that allows fitting into ad hoc environment.

- The VoIP application included in the Ad Hoc framework contains two main modules; signaling module and data transport module. The signaling module implements the SIP signaling protocol and utilizes IP addresses for finding the peer nodes to initiate the VoIP session; it uses UDP as the transport protocol. The data transport module implements a RTP client for exchanging the voice packets. A public-source GSM codec is used for encoding audio samples.

2.2.2. Design validation and implementation of architecture and protocols for mobile ad hoc networks

By exploiting the software we developed, and integrating it with existing software modules, we obtained three (software) architectures to be used for testing MobileMAN ideas. Specifically, we have:

1) a legacy TCP/IP architecture on which we run VoIP applications;
2) a legacy p2p architecture on which we run both Whiteboard and UDDI4m applications
3) a p2p cross-layer architecture on which we run both Whiteboard and UDDI4m applications

By exploiting these architectures, we implemented small- and medium-scale ad hoc networks on which we performed extensive experimental evaluations, that contributed to remove a set of simplifying assumptions commonly used in simulative studies that caused a lack of credibility in most of the results so far obtained. Specifically, it is worth remembering:

- the testing of 802.11 multi-hop ad hoc networks;
- the comparison of proactive (OLSR) and reactive (AODV) routing protocols on realistic testbeds;
- the measurement-based analysis of FreePastry and CrossROAD performance when running on mobile ad hoc networks;
- the experimentation of a medium size (up to 23 nodes with paths made up of up top 8 hops) ad hoc network implementing the architectures 1 and 2. Currently, this is one of the largest ad hoc testbeds implemented in worldwide research projects.

2.3. Socio-economic Results

2.3.1. Social Evaluation

We applied the participatory design approach to involve potential end-users in evaluating how they perceive the MobileMAN technology and how to integrate it into their life. Several categories of users were involved in the social evaluation, e.g., students, professionals, businessmen, elderly.

The main result of social evaluation is apparently a negative one. Indeed, due to the perceived abstract nature of ad hoc networks, users have huge difficulties in seeing the aspects that are specific features of ad hoc networks. For this reason, even though several different communities of users were involved in the social analysis (among others, university students, businessman and elderly), and different methodologies and tools have been applied (from web-based tools like wiki and blogs, up to questionnaires and interviews), the social studies were not able to identify novel scenarios for MobileMAN usage. This negative result, it is not completely negative for our project. Indeed this indicates that the pragmatic approach of the MobileMAN project, which focuses the research on developing and implementing prototypes in realistic scenarios (small scale networks with legacy applications), is the correct one to lowering the barriers for the users' access to ad hoc networking. On the other hand research based only on simulation studies of very large node scenarios (up to 1000 nodes) with CBR traffic (as it is done by most of the research in the field) does not provide any contribution to create the conditions for motivating the users to find this technology useful.

2.3.2. Economic and Market Access

The area of ad hoc networking is of long-term nature. However, our results show good potentialities from the innovation and economic standpoint. Specifically,

- The algorithm designed and evaluated for the enhanced 802.11 card is very promising from an economic standpoint, too. The widespread usage of the 802.11 technologies and its economic value in the wireless market open to our solution (which is compatible with existing standards) extremely interesting business.

- We have identified new applications that can leverage the ad hoc technology to provide valuable services to the user. The city cab scenario (i.e., the use of 802.11 ad hoc networks to replace the currently used taxi radio dispatch systems) is the most promising one. We have found that, in this scenario, an ad hoc networking system is viable both economically and technically.

- Mesh networks constitute a short-term direction to turn mobile ad hoc networks in a commodity by providing a flexible and "low cost" extension of wired infrastructure networks.

- The usage of VoIP on top of ad hoc networks has interesting industrial potentialities. Nokia showed the interest to launch a project on this topic.

3. DISSEMINATION

Dissemination is the previous activity to exploitation, and could be considered as the market strategy to create awareness around MOBILEMAN by making the results of this project visible to a wide audience. Efficient dissemination is a fundamental activity in any research process, since the success of these dissemination activities contributes decisively to the short and long term success of a research project – as measured by knowledge usage by external entities and degree of adoption in the industry.

Several different dissemination channels have been used to achieve this: (i) dissemination via web, newspapers, interviews, presentations; (ii) publishing and presenting results within the scientific community; (iii) organizing high-quality and focused scientific events for dissemination of project results; (iv) presenting/testing the MOBILEMAN solutions with/to users' communities; (v) dissemination of MOBILEMAN solutions to the industry and to the society; (vi) training of students.

3.1. Public Deliverables

Project deliverables constitute the primary way to disseminate the project results. All project Deliverables are available as public material on the project web site: http://cnd.iit.cnr.it/mobileMAN

3.2. Web and other dissemination channels

The project web site constitutes a key communication and dissemination mechanism both for consortium members and non-members. It contains general project information as well as information about project results, news, consortium members, etc. In addition, during the project, we activated specialized web sites devoted either to interact with potential users or to distribute the software we developed. Specifically,

- The "Social studies" web site http://mobileman.projects.supsi.ch designed and maintained by SUPSI-DSAS devoted to facilitate the interaction with users. The website has an interactive section which enabled users to collaborate with us in creative scenarios building activities.
- The Software web site http://keskus.hut.fi/tutkimus/MobileMan/, maintained by HUT, was implemented with the aim to make available the updated versions of the HUT developed software. This web site has two parts: a public and private ones. Currently, all the software is still in the private area and available on demand. It will move in the public area at the end of the project.
- A blog http://mobilemanstorytelling.blogspot.com/ to perform a social evaluation study on ad hoc networking potentialities. Specifically, the blog has been used for interacting with a group of potential end-users that are technology skilled and aware of what a MobileMAN is. The blog was implemented as a part of the thesis jointly supervised by CNR and University of Siena (Social Communications department).

3.2.1. Newspapers and Radio Interviews

This dissemination channel was used to make citizens aware of what mobile ad hoc technologies are and the potential benefits for the society of MobileMAN results. For this reason we exploited this dissemination channel towards the end of the project. Among these activities, it is worth remembering:

- Claudia Brazzola, Ivan Defilippis, and Silvia Giordano; *MobileMAN: da utente a nodo di rete*; radio interview in the serie *Usi e Ricerche*; **RTSI–Radiotelevisione svizzera di lingua italiana**; broadcasted February 28, 2004, 17^{20}–17^{35}. http://www.rtsi.ch/prog/Rete2/welcome.cfm?mpg=5876

- Silvia Giordano; *Quali prospettive per il futuro? Reti Wireless e tecnologie pervasive*; **Lugano Communication Forum**; Lugano, Switzerland; April 8, 2004.

- Marco Conti, *MobileMAN per una vita senza rete* **Almanacco della Scienza** Rivista on line del Consiglio Nazionale delle Ricerche, N.8, April 2005, http://150.146.47.106/rivistaonline/documenti/storiadicopertina/06_8_2005.htm

- Marco Conti, *Ecco il cellulare gratuito. Crea la rete da solo e può avere mille usi*, **La Nazione** (Italian national newspaper)– Firenze 23 May, 2005 (page 16) - not available on line

- Marco Conti, *"Mobileman" la rete senza fili e infrastrutture,* **Il Tempo** (Italian national newspaper)– Roma 9 August 2005 "Mobileman» la rete senza fili e infrastrutture" http://www.iltempo.it/approfondimenti/index.aspx?id=746320&editionId=5&SectionId=4

- Silvia Giordano, *Quando la rete fa a meno di Internet,* **La Repubblica – Affari e Finanza** (Italian national newspaper) – 7 November 2005 http://www.repubblica.it/2005/j/sezioni/scienza_e_tecnologia/wifi/senzaintern/senzaintern.html

3.2.2. MobileMAN presentations

CNR and SUPSI organized joint presentations of MobileMAN in IST sponsored events:

- M. Conti, S. Giordano, G. Maselli, G. Turi, "Mobile Metropolitan Ad hoc Networks: The Cross-layer Architecture" Poster presentation at the *Workshop on Multi-hop and Ah-Hoc Networking (MHAH 03)*, Brussels, Dec. 2003. http://www.ist-romantik.org/mhah-workshop/

- Patrizia Andronico, Claudia Brazzola and Jennifer Duyne "Social Dimensions of MobileMAN. Opportunities and Constraints in Adopting Participatory Approaches in ICT Projects" poster at the 13th IST Mobile and Wireless Communication Summit in Lyon (France) in May 2004.

In addition, MobileMAN partner presented the project activities in national/EU events at which they participated:

CNR

- M. Conti "Cross Layering in MANETs' Design", (Extended abstract) NeXtworking'03 *The First COST(EU)-NSF(USA)* Workshop on EXCHANGES & TRENDS IN NETWORKING, 23-25 June 2003, Chania, Greece.

- Patrizia Andronico, "MobileMAN project", Presentation at ACM Conference on Human Factors in Computing (CHI 2004) Workshop on *Lost in Ambient Intelligence*? http://parlevink.cs.utwente.nl/chi2004-conference/chi04-abstracts.html

- CNR organized several presentations of MobileMAN technologies to Computer Engineering students at the University of Pisa. The aim of these lectures was to present the MobileMAN experimental activities in order to identify students to be involved in the project activities (Master and Laurea theses).
    - on May 13 2004 a two-hour presentation in the framework of the course *Applications for Mobile Computers* for the last-year students in Computer Engineering (5-year degree) (Engineering Faculty).
    - on April 22, 2005 Marco Conti one-hour lecture on MobileMAN in the framework of the course *Operating Systems and Networks* for the last-year bachelor students in Computer Engineering (3-year degree).

HUT

- Workshop for Nokia Networks representatives to show the usage of VoIP on top of Ad Hoc networks. Their intent is to launch a project on this topic.

- Two meetings with the "new innovation integration" center located in the Helsinki University of Technology campus to present MobileMAN project and announce it for interested start ups.

Cambridge

- Andrea Passarella, "Understanding the Real Behavior of Mote and 802.11 Ad hoc Networks: an Experimental Approach", Intel Research, Cambridge, UK, 27 April 2005

- Andrea Passarella, "MobileMAN Project: building Campus-Wide MANETs through Cross-Layering", 4th Cost 290 Management Committee Meeting, Wuerzburg, Germany, 16 October 2005

- Andrea Passarella, "Ad hoc and Sensor Network Design: it's All about Cross-Layering", University of Parma, Italy, 7 November 2005

- Jon Crowcroft, "Wireless Architecture", Max Planck Institute. for Software Systems, 22 September 2005

3.3. Publications

MobileMAN partners published extensively in the main scientific events in the field (over 75 publications). This has a double value. The acceptance for presentation of the

MobileMAN results in the main scientific events is a validation of the quality of what we produced; in addition this is a vehicle for the dissemination of our results to the worldwide scientific community.

3.3.1. Books

B.1. M. Conti, S. Giordano, E. Gregori, S. Olariu (Eds.), "Personal Wireless Communications", Proceedings 8th International IFIP-TC6 Conference, Venice, Italy, 23-25 September 2003, Lecture Notes in Computer Science LNCS 2775

B.2. S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Editors), Mobile Ad hoc networking, IEEE Press and John Wiley and Sons, Inc., New York, 2004. ISBN 0-471-373133. http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471373133.html

B.3. R. Battiti, M. Conti, R. Lo Cigno, (Eds.), "Wireless On-Demand Network Systems" Proceedings of the First IFIP TC6 Working Conference, WONS 2004, Madonna di Campiglio, Italy, January 21-23, 2004, Lecture Notes in Computer Science Vol. 2928.

B.4. T. Basar, M. Conti, (Eds) Proceedings Second IEEE Workshop on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt '04), Cambridge, UK, 24-26 March, 2004.

B.5. Pierangela Samarati, Dieter Gollmann, Refik Molva: Computer Security - ESORICS 2004, 9th European Symposium on Research Computer Security, Sophia Antipolis, France, September 13-15, 2004, Proceedings Springer 2004.

B.6. Marco Conti, Dipankar Raychaudhuri, Proceedings of the 6th IEEE Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM 2005), Taormina, Italy 5-8 April 2005.

B.7. Marco Conti, Ali Hurson Proceedings of the Third IEEE Conference on Pervasive Computing and Communications (PerCom) 2005 - Workshops, Kauai, Hawaii, March 8-12, 2005.

B.8. S. Giordano, I. Stojmenovic, C. Tschudin, Proceedings of the Second Wireless On demand Network Systems and Services (WONS) conference, IEEE Press, January 2005

B.9. Marco Conti, Jon Crowcroft, Andrea Passarella, Proceedings of the 1st IEEE ICPS Workshop on Multi-hop Ad hoc Networks: from theory to reality (REALMAN 2005), July 14, 2005, Santorini, Greece. http://www.cl.cam.ac.uk/realman

B.10. Marco Conti, Jon Crowcroft and Andrea Passarella, "Mobile Ad Hoc Networks: from Theory to Reality", published by Nova Science Publishers (USA), 2006.

B.11. Marco Conti "Mobile Multi-hop Ad hoc Networks (MobileMAN)", Springer 2006.

3.3.2. Books Chapters

BC.1. M. Conti, "Body, Personal, and Local Wireless Ad Hoc Networks", Chapter 1 in *Handbook of Ad Hoc Networks* (M. Ilyas Editor), CRC Press, New York, 2003.

BC.2. Silvia Giordano and Ivan Stojmenovic; *"Position-Based Ad Hoc Routing in Ad Hoc Networks*"; in "Ad Hoc Wireless Networks", Mohammad Ilyas Editor; CRC Press, 2003

BC.3. G. Anastasi, M. Conti, E. Gregori, "IEEE 802.11 Ad Hoc Networks: Protocols, Performance and Open Issues", Chapter 3 in Mobile Ad hoc networking, S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Editors), IEEE Press and John Wiley 2004.

BC.4. P. Michiardi, R. Molva, "Ad hoc Networks Security" Chapter 12 in Mobile Ad hoc networking, S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Editors), IEEE Press and John Wiley 2004.

BC.5. S. Giordano, A. Urpi, "Self-Organized and Cooperative Ad Hoc Networking", Chapter 13 in Mobile Ad hoc networking, S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Editors), IEEE Press and John Wiley 2004.

BC.6. Frank Stajano and Jon Crowcroft, "The Butt of the Iceberg: Hidden Security Problems of Ubiquitous Systems", in Basten et al., eds., Ambient Intelligence: Impact on Embedded System Design, Kluwer.

BC.7. M. Conti, "Wireless Communications and Pervasive Technologies", Chapter 4 of Environments: Technologies, Protocols and Applications, Diane Cook and Sajal K. Das (Editors), John Wiley and Sons, 2004, ISBN 0-471-54448-5. pp. 63-99.

BC.8. E. Baccarelli, M. Biagi, R. Bruno, M. Conti, E. Gregori, "Broadband Wireless Access Networks: a Roadmap on Emerging Trends and Standards", Chapter 14 in Broadband Services to Businesses Communities: Business models and technologies. C. Szabo, I. Chlamtac, A. Gumaste (Editors), John Wiley and Sons, Inc., New York, March 2005.

BC.9. M. Conti, J. Crowcroft, G. Maselli, T. Turi, "A Modular Cross-layer Architecture for Ad Hoc Networks" Chapter 1 in *Handbook on Theoretical and Algorithmic Aspects of Sensor, Ad Hoc Wireless, and Peer-to-Peer Networks,* Jie Wu (Editor), Auerbach Publications (Taylor & Francis Group), Boca Raton (FL), 2005, pp. 5-16.

BC.10. G. Anastasi, M. Conti, A. Passarella, in "Power Management in Mobile and Pervasive Computing Systems", Chapter 24 in *Algorithms and Protocols for Wireless and Mobile Networks*, Azzedine Boukerche (Editor), CRC-Hall Publisher, October 2005.

BC.11. M. Conti, F. Delmastro, T. Turi, "Peer-to-peer Computing in Mobile Ad Hoc Networks", in *Mobile Middleware,* Antonio Corradi and Paolo Bellavista (Editors), CRC press (To appear)

BC.12. Raffaele Bruno, Claude Chaudet, Marco Conti and Enrico Gregori, "Fair MAC Protocols for 802:11-based Multi-Hop Ad hoc Networks: Challenges and Solutions" in *Performance Analysis of Mobile Ad Hoc Networks*, Chita Das, Yi Pan Chansu Yu (Editors) Nova Science Publishers Inc. (to appear)

BC.13. P. Michiardi, R. Molva, "Ad hoc network security"Chapter in Book: Handbook of information security IEEE Press, Wiley & Sons (to appear)

BC.14. M. Conti, "Principles and Applications of Ad Hoc and Sensor Networks", in The Hanbook of Computer Networks, Volume II, Hossein Bidgoli (Editor), John Wiley & Sons inc. 2006

3.3.3. Journals

J.1. I. Chlamtac, M. Conti, J. Liu, "Mobile Ad hoc Networking: Imperatives and Challenges", *Ad Hoc Networks Journal*, Vol.1 N.1 January-February-March, 2003.

J.2. Marco Conti, Silvia Giordano, "ESF/PESC Exploratory Workshop: Is Mobile Ad Hoc Networking Part of the Future of Mobile Networking in Europe?" *IEEE Global Communications Newsletters*, May 2003, http://www.comsoc.org/pubs/gcn/gcn0503.html.

J.3. Luciano Bononi, Marco Conti, Enrico Gregori, "Runtime Optimization of IEEE 802.11 Wireless LANs Performance", *IEEE Transactions on Parallel and Distributed Systems*, Vol. 15, N. 1, January 2004, pp. 66-80.

J.4. P. Michiardi, R. Molva, *"Ad hoc Network Security"*, ST Microelectronics Journal of System Research.

J.5. Jon Crowcroft, Richard Gibbens, Frank Kelly, Sven Östring *"Modelling Incentives for Collaboration in Mobile Ad Hoc Networks"* Performance Evaluation, 57 (2004) 427-439.

J.6. Jose Costa-Requena, Nicklas Beijar, Raimo Kantola: Replication of Routing Tables for Mobility Management in Ad Hoc Networks. Wireless Networks 10(4): 367-375 (2004)

J.7. M. Conti, G. Maselli, G. Turi, S. Giordano, "Cross Layering in Mobile Ad Hoc Network Design", *IEEE Computer*, February 2004, pp. 48-51.

J.8. Eleonora Borgia, Marco Conti, Franca Delmastro, Luciana Pelusi "Lessons from an Ad hoc Network Test-bed: middleware and routing issues", *Wireless Ad Hoc and Sensor Networks: An International Journal*, Old City Publishing, Vol. 1, N. 1, 2005.

J.9. Pietro Michiardi, Refik Molva, "Analysis of Cooperation Strategies in Mobile Ad hoc Networks with Imperfect Monitoring" to appear in *Ad Hoc Networks Journal*, special issue on "Ad Hoc Networking for Pervasive Systems", M. Conti, E. Gregori (Editors). Volume 3, Number 2, March 2005.

J.10. R. Bruno, M. Conti, E. Gregori, "Mesh Networks: Commodity Multi-hop Ad Hoc Networks", *IEEE Communications Magazine*, March 2005, pp.123-131.

J.11. A. Anastasi , E. Borgia, M. Conti, E. Gregori, A. Passarella, "Understanding the Real Behavior of Mote and 802.11 Ad Hoc Networks: An Experimental Approach", *Pervasive and Mobile Computing* Journal, Vol 1, N. 2, June 2005.

J.12. A. Anastasi , E. Borgia, M. Conti, E. Gregori, "IEEE 802.11 Ad Hoc Networks: Performance Measurements", *Cluster Computing Journal, Special issue on Ad Hoc Networks,* Volume 8, 2005, Pages: 135-145.

J.13. M. Conti, E. Gregori, and G. Maselli, "Reliable and Efficient Forwarding in Ad Hoc Networks", *Ad Hoc Networks* Journal, (to appear).

J.14. M. Conti, E. Gregori, and G. Maselli, "Self-Interest in Mobile Ad Hoc Networks: issues and solutions", To appear in the *International Journal on Wireless and Mobile Computing* (Inderscience), Special issue on *Wireless Ad Hoc Networking*, D. Simplot and I. Stojmenovic (Editors).

J.15. M. Conti, G. Maselli, G. Turi, "A flexible cross-layer interface for ad hoc networks: Architectural and Implementation issues", *Ad Hoc & Sensor Wireless Networks: An International Journal* (Old City Publishing), (to appear).

3.3.4. Conference Proceedings

C.1. Jon Crowcroft, Richard Gibbens, Frank Kelly & Sven Östring *"Modelling Incentives for Collaboration in Mobile Ad Hoc Networks"* WiOpt'03, Nice, March 2003.

C.2. A. Urpi, M.A. Bonuccelli and S. Giordano; *"Modelling Cooperation in Mobile Ad Hoc Networks: a Formal Description of Selfishness"*; WiOpt 2003, March 3-5, 2003, Sophia-Antipolis, France.

C.3. P. Michiardi, R. Molva, *"A Game Theoretical Approach to Evaluate Cooperation Enforcement Mechanisms in Mobile Ad Hoc Networks"*, WiOpt 2003: Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks, INRIA Sophia-Antipolis, France, March 3-5, 2003.

C.4. G. Anastasi, E. Borgia, M. Conti, E. Gregori, "IEEE 802.11 Ad Hoc Networks: Performance Measurements", Proc. Workshop on Mobile and Wireless Networks (MWN 2003) in conjunction with ICDCS 2003, 19 May, 2003.

C.5. Marco Conti, Enrico Gregori, Giovanni Turi, "Design and analysis of a context-aware location service for ad hoc networks" Proc. First International Working Conference on Performance Modelling and Evaluation of Hetrogeneous Networks (HET-NETs '03), 21-23 July 2003, Ilkley, West Yorkshire, U.K.

C.6. Marco Conti, Enrico Gregori, Gaia Maselli, "Towards Reliable Forwarding for Ad Hoc Networks", Proc. Eight International IFIP-TC6 Conference, Venice, Italy, 23-25 September 2003, Lecture Notes in Computer Science LNCS 2775.

C.7. Giovanni Turi, "Locating Nodes in Metropolitan Ad Hoc Networks", Proc. Eight International IFIP-TC6 Conference, Venice, Italy, 23-25 September 2003, Lecture Notes in Computer Science LNCS 2775.

C.8. Marco Conti, Silvia Giordano, Gaia Maselli, Giovanni Turi, "MobileMAN: Mobile Metropolitan Ad hoc Networks", Proc. Eight International IFIP-TC6 Conference, Venice, Italy, 23-25 September 2003, Lecture Notes in Computer Science LNCS 2775, pp. 173-178.

C.9. G. Anastasi, A. Passarella "Towards a Novel Transport Protocol for Ad Hoc Networks" Proc. Eight International IFIP-TC6 Conference, Venice, Italy, 23-25 September 2003, Lecture Notes in Computer Science LNCS 2775, pp. 795-800.

C.10. Ralph Bernasconi, Ivan Defilippis, Silvia Giordano and Alessandro Puiatti*; "An enhanced MAC architecture for multi-hop wireless networks"*; PWC2003, September 23-25, 2003, Venice, Italy.

C.11. R. Molva, P. Michiardi, *"Ad hoc Network Security"*, Proceedings of PWC 2003, Venice, Italy, September 23-25, 2003.

C.12. A. Anastasi , E. Borgia, M. Conti, E. Gregori, "Wi-Fi in ad hoc mode: a measurement study", Proceedings of the Second IEEE Annual Conference on Pervasive Computing and Communications (PerCom 2004), March 14-17, 2004 pp. 145- 154.

C.13. M. Conti, E. Gregori, and G. Turi, "Towards scalable P2P computing for mobile ad hoc networks", Proc. workshop on Mobile Peer-to-Peer computing (MP2P'04), IEEE PerCom 2004 Workshops proceedings, pp. 109- 113.

C.14. M. Conti, E. Gregori, and G. Maselli, “Cooperation Issues in Mobile Ad Hoc Networks”, International Workshop on Wireless Ad Hoc Networking (WWAN), Proceedings of IEEE ICDCS Workshops, Tokyo, Japan, March 2004.

C.15. M. Conti, E. Gregori, and G. Maselli, “Performability in Ad hoc Networks”, Proceedings of the 59th IEEE Vehicular Technology Conference, Milan, Italy, May 2004.

C.16. R. Bruno, M. Conti, E. Gregori, “Distributed Contention Control in Heterogeneous 802.11b WLANs”, (to appear) Proc. The Second Conference on Wireless On-demand Network Systems and Services (WONS 2005), Saint Moritz (Switzerland) January 19-21, 2005.

C.17. Eitan Altman, Arzad A. Kherani, Pietro Michiardi, Refik Molva, "Non cooperative forwarding in Ad hoc Networks”, Proc. 15th IEEE PIMRC Symposium, Barcelona, Spain, 5-8 September, 2004.

C.18. P.Cremonese, V.Vanni *“UDDI4m: UDDI in Mobile Ad Hoc Network”,* Proc. Second Conference on Wireless On-demand Network Systems and Services (WONS 2005), Saint Moritz (Switzerland) January 19-21, 2005.

C.19. Silvia Giordano, Davide Lenzarini, Salvatore Vanini, Alessandro Puiatti, *“WiSwitch: Seamless Handover between Multi-Provider Networks”,* Proc. Second Conference on Wireless On-demand Network Systems and Services (WONS 2005), Saint Moritz (Switzerland) January 19-21, 2005.

C.20. Jose Costa-Requena, Raimo Kantola and Jorge Nuevo Fonseca, "Strategies for the Formation of a Service Distribution Backbone in Ad Hoc Networks", Proc. International Conference on Communications, Internet and Information Technology (CIIT 2004), November 22 to November 24, 2004, in St. Thomas, Virgin Islands, USA.

C.21. J. Costa-Requena, J. Gutiérrez, R. Kantola, J. Creado, N. Beijar "Network architecture for scalable Ad Hoc Networks", Proc. International Conference on Telecommunications ICT2004, Agust 01-06, 2004 - Fortaleza - Ceará – Brazil, http://www.ict2004.com.br/index.shtml

C.22. Elgan Huang, Jon Crowcroft, Ian Wassell, “Rethinking incentives for mobile ad hoc networks “, Proceedings of the ACM SIGCOMM workshop on Practice and theory of incentives in networked systems 2004, Portland, Oregon, USA September 03 - 03, 2004, Pages: 191 – 196.

C.23. S. Giordano, D. Lenzarini, A. Puiatti and S. Vanini, "WiSwitch: Seamless Handover between Multi-Provider Networks", Proceedings of WONS 05, ST. Moritz, Switzerland, January 2005.

C.24. S. Giordano, D. Lenzarini, M. Schiavoni and S. Vanini, "Virtual Web Channel: Flow Aggregation for Enhanced Ubiquitous Web Access", Proceedings of IEEE WirelessCom 2005, Maui, Hawaii , Junuary 2005.

C.25. M. Conti, E. Gregori, G. Turi, “A Cross Layer Optimization of Gnutella for Mobile Ad hoc Networks”, Proc. ACM MobiHoc Symposium, Urbana-Champain, May 2005, pp.343-354.

C.26. E. Huang, W. Hu, J. Crowcroft, I. Wassell, “Towards Commercial MobileAd Hoc Network Applications: A radio Dispatch System” Proc. ACM MobiHoc Symposium, Urbana-Champain, May 2005, pp. 355-365.

C.27. G. Anastasi, E. Ancillotti, M. Conti, and A. Passarella, "TPA: A Transport Protocol for Ad hoc Networks", Proc. 10th IEEE Symposium on Computers and Communications, June 2005.

C.28. M. Conti, G. Maselli, and G. Turi, "Design and evaluation of a flexible cross-layer interface for ad hoc networks", Proceedings Fourth Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net 2005), June 2005 (21-24) Ile de Porquerolles (France).

C.29. Ralf Bernasconi, Raffaele Bruno, Ivan Defilippis, Silvia Giordano, and Alessandro Puiatti, "Experiments with an enhanced MAC architecture for multi-hop wireless networks", Proc. 1st IEEE ICPS Workshop on Multi-hop Ad hoc Networks: from theory to reality (REALMAN 2005), July 14, 2005, Santorini, Greece

C.30. Franca Delmastro and Andrea Passarella, "An Experimental Study of P2P Group-Communication Applications in Real-World MANETs", Proc. 1st IEEE ICPS Workshop on Multi-hop Ad hoc Networks: from theory to reality (REALMAN 2005), July 14, 2005, Santorini, Greece.

C.31. . Costa-Requena, M. Ayyash, J. Creado, J. Hakkinen, R. Kantola and N. Beijar "VoIP Testbed in Ad Hoc Networks", IEEE ICPS REALMAN workshop, July 05

C.32. E. Borgia, M. Conti, F. Delmastro, E. Gregori, "Experimental comparison of routing and middleware solutions for mobile ad hoc networks: legacy vs cross-layer approach", ACM SIGCOMM Workshop on Experimental Approaches to Wireless Network Design and Analysis (E-WIND) August 22, 2005 - Philadelphia, PA.

C.33. M. Conti, E. Gregori, G. Maselli "Improving the performability of data transfer in mobile ad hoc networks", Proc. Second IEEE International Conference on Sensor and Ad Hoc Communications and Networks (SECON), Santa Clara, CA, September 2005.

C.34. Raffaele Bruno, Claude Chaudet, M. Conti, E. Gregori, "A Novel Fair Medium Access Control for 802.11-based Multi-Hop Ad hoc Networks, Proc. 14th IEEE Workshop on Local and Metropolitan Area Networks, Chania, Greece, September, 2005.

C.35. Altman, Eitan; Kherani, Arzad; Michiardi, Pietro; Molva, Refik, "Non cooperative forwarding in ad hoc networks", Proc. IFIP Networking 2005

C.36. Altman, Eitan; Borkar, Vivek; Kherani, Arzad; Michiardi, Pietro; Molva, Refik "Some game-theoretic problems in wireless ad hoc networks" Proc. EURO-NGI 2005.

C.37. J. Costa-Requena, R. Kantola and N. Beijar "Ad Hoc Networks Scalability", ICAS'05 and ICNS'05", October 05.

C.38. S. Giordano, M. Kulig, D. Lenzarini, A. Puiatti, F. Schwitter and S. Vanini "WiOptiMo: Optimised Seamless Handover", IEEE IWS2005 / WPMC'05 Proceedings, Aalborg, Denmark, September 2005.

C.39. Emilio Ancillotti, Raffaele Bruno, M. Conti, E. Gregori, Antonio Pinizzotto "A Layer-2 Architecture for Interconnecting Multi-hop Hybrid Ad Hoc Networks to the Internet", Proc. Third Annual Conference on Wireless On demand Network Systems and Services (IEEE Computer Society Press)

3.4. Organizing high-quality scientific events

3.4.1. Focused Events

- ESF/PESC Exploratory Workshop: Is Mobile Ad Hoc Networking Part of the Future of Mobile Networking in Europe?", Monterosso Italy 10-12 October 2002. URL: http://www.iit.cnr.it/esf2002/ **Workshop Coordinators:** Marco Conti and Silvia Giordano.

  A detailed presentation of this workshop is reported in Deliverable D2

- IEEE ICPS Workshop on Multi-hop Ad hoc Networks: from theory to reality (REALMAN 2005), July 14, 2005, Santorini, Greece
  URL: http://www.cl.cam.ac.uk/realman **Workshop Organizers:** Marco Conti, Jon Crowcroft and Andrea Passarella.

  A detailed presentation of this workshop is reported in Deliverable D15

3.4.2. Conferences Organization

- Enrico Gregori have been the **General Chair** and Marco Conti has been **Program Chair** of PWC 2003: The 8th International IFIP-TC6 Conference on "Personal Wireless Communications", Venice, Italy, 23-25 September 2003. URL: http://www.iit.cnr.it/pwc2003

- Marco Conti has been **Program Co-Chair** (with Renato Lo Cigno, University of Trento, Italy) - First IFIP TC6 Working Conference on Wireless On-demand Network Systems (WONS 2004), Madonna di Campiglio (Italy) January 21-23, 2004 URL: http://www.dit.unitn.it/wons/

- Marco Conti has been **Program Co-Chair** (with T. Basar, University of Illinois) - Second IEEE Workshop on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt '04), Cambridge, UK, 24-26 March, 2004.
- URL: http://www.cl.cam.ac.uk/Research/SRG/wiopt04/

- Marco Conti is the **Vice-Program Chair** - 1st IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS) Fort Lauderdale, Florida, October 25-27, 2004. URL: http://www.ececs.uc.edu/~cdmc/mass

- Marco Conti has been the **Workshop Coordinator** (with A. Misra, IBM Research, USA) -- First International Workshop on Broadband Wireless Multimedia:

Algorithms, Architectures and Applications (BroadWIM) October 29, 2004 San Jose, California, USA. URL: http://www.broadwim.org

- Refik Molva has been the **General Chair** 9th European Symposium On Research in Computer Security (ESORICS 2004), Sophia Antipolis, French Riviera, France - September 13-15, 2004.

- Refik Molva has been the **General Chair** 7th International Symposium on Recent Advances in Intrusion Detection (RAID 2004), Sophia Antipolis, French Riviera, France - September 15-17, 2004.

- Silvia Giordano has been the **General Chair** of the Second Conference on Wireless On-demand Network Systems and Services (WONS 2005), Saint Moritz (Switzerland) January 19-21, 2005. http://www.wonss.org/

- Marco Conti has been **Workshops Co-Chair** (with A. Hurson, University of Pensilvania, USA) -- Third IEEE Conference on Pervasive Computing and Communications (PerCom) 2005, Kauai, Hawaii, March 8-12, 2005.
- URL: http://www.percom.org.

- Marco Conti has been **Track Chair** (with G. Anastasi University of Pisa, Italy, and M. Kumar, University of Texas, USA) - Special track on *Energy Management in Mobile and Pervasive Computing Systems* at the 38th Annual Hawaii International Conference on System Sciences, 2005.

- **Program Co-Chair** (with D. Raychaudhuri, Rutgers University, USA) - The 6th IEEE Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM 2005), Taormina, Italy June 2005.
  http://cnd.iit.cnr.it/wowmom2005

- Silvia Giordano has been **Workshop Co-Organizer** of the - 1st IEEE WoWMoM Workshop on Autonomic Communications and Computing (ACC 2005), http://www.autonomic-communication.org/acc/index.html

- Silvia Giordano has been **Workshop Co-Organizer** of the - 1st IEEE PerCom Workshop on Sensor Networks and Systems for Pervasive Computing (PerSeNS 2005), http://www.ing.unipi.it/persens2005/

- Refik Molva has been **Workshop Co-Organizer** of the - 1st IEEE WoWMoM Workshop on Trust, Security and Privacy for Ubiquitous Computing (TSPUC2005) http://www.iit.cnr.it/TSPUC2005

- Jon Crowcroft has been **Program Co-chair** of Fourth Workshop on Hot Topics in Networks (HotNets-IV), November 14-15, 2005 College Park, MD USA http://www.acm.org/sigs/sigcomm/HotNets-IV

- Jon Crowcroft has been **General Co-chair** of the 1st Conference on Wireless Internet (WICON 2005), Budapest, Hungary, 10-15 July 2005

- Refik Molva has been **Program Co-Chair** of the 2nd European Workshop on Security and Privacy in Ad hoc and Sensor Networks (*ESAS 2005*), July 13-14, 2005, Visegrad, Hungary, http://www.crysys.hu/ESAS2005/cfp.html

3.4.3. Journal Special issues

- Special issue on "Mobile Ad-Hoc Networking", *ACM/Kluwer Mobile Networks and Applications (MONET) Journal,* Vol. 8, No. 5, Oct. 2003 (**Co-guest Editors**: M. Conti, A.T. Campbell and S. Giordano).

- Special Issue on "Networking Technologies, Services and Protocols", *Cluster Computing Journal* (Springer). Volume 8, Issue 1, January 2005. (**Co-guest Editors**: M. Conti and E. Gregori).

- Special issue on "Ad Hoc Networking for Pervasive Systems", *Ad Hoc Networks Journal* (Elsevier). Volume 3, Number 2, March 2005, (**Co-guest Editors**: M. Conti and E. Gregori).

- Special issue on "Ad hoc and Sensor Networks", IEEE Communication Magazine, March 2005, (**Co-guest Editors**: S. Giordano).

- Special issue on "Ad hoc and Sensor Networks", IEEE Communication Magazine, July 2005, (**Co-guest Editors**: S. Giordano).

- Special issue on "WiOpt 2004", *ACM/Kluwer Mobile Networks and Applications (MONET) Journal*. Publication scheduled for Vol. 11, No. 3 (June 2006). (**Co-guest Editor**: M. Conti).

- Special issue on "Multimedia over Broadband Wireless Networks", IEEE Network. Publication planned March 2006 (**Co-guest Editor**: M. Conti). URL: http://www.comsoc.org/pubs/net/ntwrk/cfpnetwork2006.htm

- Special issue "Internet Wireless Access: 802.11 and Beyond", *ACM/Springer Mobile Networks and Applications (MONET) Journal*. (**Co-guest Editor**: M. Conti).

- Special issue on "Broadband Wireless Multimedia: Algorithms, Architectures and Applications", *ACM/Kluwer Wireless Networks (WINET) Journal*. Publication planned in 2006 (**Co-guest Editor**: M. Conti).

- Special section on "REALMAN 2005", *Ad Hoc & Sensor Wireless Networks: An International Journal*. Publication planned in 2006 (**Co-guest Editors**: M. Conti, Jon Crowcroft and Andrea Passarella).

- Special issue on "Wireless Mesh Neworks", *Ad Hoc Networks* (Elsevier) Journal, Publication planned in 2006 (**Co-guest Editor**: M. Conti).

3.4.4. Panel, Tutorials and Invited Speeches

- Pietro Michiardi has been **Tutorial Speaker**, *"Ad hoc Networks Security*, SEE – SIC, March 11th 2004 - ENST – Paris

- Pietro Michiardi has been **Tutorial Speaker**, *"Ad hoc Networks Security*", at the Conference on Security and Network Architectures - July 2004 - La Londe

- Marco Conti has been **Invited Speaker** "WiFi Performance Modeling and Optimization", at 16th ITC specialist seminar "Performance Evaluation of Wireless and Mobile Systems", Antwerp, Belgium, August 31 - September 02, 2004.

- Marco Conti has been **Panel organizer and chair** "*Is Mobile Ad Hoc Technology Ready for the Wireless Networking World*?" at the 1st IEEE Conference on Mobile Ad hoc and Sensor Systems (MASS) 2004. Panelists: Ian F. Akyldiz (Georgia Institute of Technology, USA) Ed Callaway (Motorola Labs, USA) Mario Gerla (UCLA, USA) and Vann Hasty (MeshNetworks, USA).

- Jon Crowcroft has been **Panel organizer and chair** "How to make MANETs scale and provide coverage *for real*" at the 1st IEEE REALMAN 2005 Workshop Panelists: Matthias Grossglauser (*EPFL*), Edward Knightly (*RICE University*), Martin Mauve *(Duesseldorf University),* Joerg Ott *(Helsinki University of Technology*), Christian Tschudin (*Basel University*).

3.5. Collaboration

The project established collaboration links (mainly exchange of information) with other projects both at EU and national level.

EU projects

During the project activities the partners have meetings and ideas' exchanges with several EU project working on ad hoc networking and related fields including FP5 IST projects: 6HOP (Protocols for Heterogeneous Multi-Hop Wireless IPv6 Networks), ROMANTIK (ResOurce Managment and AdvaNced Transceiver algorIthms for multihop networks), UCAN (Ultra-wideband Concepts for Ad-hoc Networks), BROADWAY (The way to broadband access at 60Ghz); and the FP6 IST PALCOM project http://www.palcom.dk/.

Among these projects, more in-depth collaborations were established with:

- M M A P P S*: Market Management of Peer to Peer Services*. http://www.mmapps.info/index.html The MMAPPS project started on March 1st, 2002 with funding from the EU Fifth RTD Framework Programme.

- *WIreless DEployable Network System, Proposal acronym: WIDENS,* http://www.widens.org/ The project is supported by the European Commission under the IST Framework Programme 6. The overall objective of the WIDENS project is to design, prototype and validate a high data-rate, rapidly deployable and scalable wireless ad-hoc communication system for future public safety, emergency and disaster applications.

- Network of Excellence *Emerging Network Technologies* (E-NeXT) http://www.ist-e-next.net/

In addition it is worth pointing out that the MobileMAN results constitute the inputs for three projects starting in 2006 under the IST – FET proactive call "Situated and Autonomic Communications" http://www.cordis.lu/ist/fet/comms-sy.htm:

- HAGGLE http://www.haggleproject.org/
- BIONETS http://www.create-net.org/create-net/bio-nets/
- CASCADAS http://netmob.unitn.it/cascadas/index.html

National Projects

EQUATOR. This is a six-year Interdisciplinary Research Collaboration (IRC) supported by The Engineering and Physical Sciences Research Council (EPSRC) of the UK Government. Equator challenges address fundamental research issues arising from the mixing of the physical and digital. Three different forms of challenge are important to Equator: Devices, Adaptive Infrastructures, and Understanding Interaction.

CNRS / *ACI* SPlaSH *project*: *Sécurisation des ProtocoLes dans les réseAux mobileS ad Hoc*. (French National Funding). Participants: EURECOM (Refik Molva, Pietro Michiardi, Claudio Lavecchia) INRIA (Pars Mutaf) and University of California Irvine (Claude Castelluccia)

Virtual Immersive Communications (VICOM) a Italian project (November 2002 – April 2006) funded by the Italian Ministry for Research (MIUR). This project is aimed at investigating communications technologies, including ad hoc networks, for supporting ambient intelligence.

Project AHRAS (http://www.netlab.hut.fi/tutkimus/ahras/)

concentrates on the routing and other traffic related issues in wireless ad hoc networks. The project started in 2001 and it is funded by the Finnish Defence Forces Technical Research Centre.

Project NAPS (Networking and Architecture for Proactive Systems) is a 3 year project (2003-2005) funded by the Academy of Finland. It is part of the research programme on Proactive Computing (PROACT). http://www.netlab.hut.fi/tutkimus/naps/

3.6. Presenting/testing the MOBILEMAN solutions with/to users' communities

SUPSI-DSAS promoted several initiatives to present/test MobileMAN solutions to community of users (see Deliverable D17 for details):

a) a collective **creative scenario and application building** activity, through an interactive wiki website; this study involved HUT university students.

b) a study on the **use of mobile phones** and the relationship that users have with this device; the study involved different categories of users (university student, psychologist, employee, logopedist, architect, etc.). The study was divided in two parts. In the first part the users have to collect on a diary all activities and interactions with their mobile phone over a period of one week. The second part of the study consisted of a questionnaire to be filled in.

c) a study on the use of **public hotspots** and the concept of "mobile connection" based on an online questionnaire. IBM employees were selected by their job function (consultants were ideal because they are frequent travelers)

d) a study on **elderly and their relationship with new communication technology** to test whether MobileMAN could bring benefits to these people. Specifically during this study we:

- interview key people dealing with elderly;
- interview with a group of users of tele-care wristband, who live at home and mostly alone;
- interview with some elderly who used QualiLife products.

CNR promoted several initiatives to present/test MobileMAN solutions both from a technical and social standpoint to university students. Specifically,

a. CNR involved a group of 20 university students in an extensive experimentation of MobileMAN solutions (five days experimentation during June-July 2005). Specifically we selected Bachelor's and Master's degree candidates in Computer Engineering of University of Pisa. See deliverable D16 for details.

b. A subset of the 20-student group also participated to the social evaluation of the MobileMAN paradigm, see http://mobilemanstorytelling.blogspot.com/

3.7. Dissemination of MOBILEMAN solutions to the industry and to the society

Dissemination to the society was mainly performed by Newspapers and Radio interviews, see Section 3.2.1.

Dissemination to the industry was performed by the presentations for the Industrial Advisory Board, focused workshops, and each partner direct contacts.

3.8. Training of students

Students' training was a relevant activity for MobileMAN. This activity involved Master, and PhD students.

PhD students: Emilio Ancillotti, Eleonora Borgia, Raffaele Bruno, Franca Delmastro, Gaia Maselli, and Giovanni Turi (CNR), Pietro Michiardi (Eurecom), Meng How Lim (Cambridge).

Specifically, the following PhD theses have been completed working on MobileMAN:

- Raffaele Bruno, "*Algorithms and Protocols for Efficient Resource Utilization on Wireless Local And Personal Area Networks*", (advisor: E. Gregori), University of Pisa, April 2003.
- Pietro Michiardi "*Cooperation enforcement and network security mechanisms for mobile ad hoc networks*" (advisor: R. Molva), Institut Eurecom, September 2004.
- Gaia Maselli "*Performability in mobile ad hoc networks*", (advisor: M. Conti), University of Pisa, June 2005.
- Meng How Lim, "Landmark Guided Routing" (advisor: Jon Crowcroft), University of Cambridge, October 2005.

Master students: Nicola Scalabrino, Ivan Velasco, Giuseppe Valente, Carlo Spagoni, Paolo Longo, Tommaso Pampana (CNR), Lei Xiao, Juan Gutierrez, Javier Garcia Sanchez, Olmo Leon Cadahia (HUT), Claudia Brazzola (SUPSI), Marcel Dischinger (Cambridge)

In addition it is worth remembering the 20 university students that were involved in the MobileMAN experimental activities:

Bachelor's degree candidates:

Gaetano Anastasi, Giovanni Bianchi, Roberto Corradi, Marco D'Alò, Danilo Levantesi, Fabrizio Lovino, Damiano Macchi, Matteo Mattei, Luca Melette, Luca Niccolini, Mario Olivari, Stefano Pallicca

Master's degree candidates:

Annalisa Bizzarrini, Chiara Boldrini, Edoardo Canepa, Mario Di Francesco, Salvatore Gerace, Ilaria Giannetti, Iacopo Iacopini, Giacomo Santerini

4. EXPLOITATION PLANS FOR THE PROJECT AS A WHOLE

Given both the consortium nature and composition and the project goals, the economic promotion and development of the project results has been (and will be) mainly performed through the indirect way of dissemination. Indeed dissemination of the project results is the main route for exploitation of the project as a whole that is considered by the consortium as an opportunity to bring one step furthers the related research activities. One of the main channel that we have planned for the exploitation of the project as a whole is the book "*Mobile Multi-hop Ad hoc Networks* (MobileMAN)", Marco Conti (Editor) Springer 2006. Indeed this book will summarize to the worldwide scientific community the main results obtained by the project.

In the project exploitation plan it is worth including the contributions to the European information society:

- MOBILEMAN stimulated the growth of a European research community in this field; this will help to create expertise and knowledge in the field to support the European industry.

- MOBILEMAN addressed research issues that in the ISTAG time-framework are scheduled for 2007, and beyond. Therefore, the results of MOBILEMAN represent a basis for the future EU R&D activities on Ambient Intelligence and Pervasive Communications.

- MOBILEMAN stimulated the participation for all in the knowledge-based society; this has been done by involving several categories in the MobileMAN social analyses and identifying the reasons that limit social inclusion.

- Training of students in a relevant ICT area (i.e., wireless and mobile communications and networking), which is fundamental for the evolution of the European (information) society.

- Support for civilian and environmental crises management. This is important considering Europe's increasing role providing aid during conflicts and natural disasters.

- Employment and consumer benefits. Accelerating reforms in the wireless market is essential for higher growth and employment and increased consumer benefits. MOBILEMAN investigated how to realize a *secondary wireless market* (with respect to the cellular market) based on the ad hoc paradigm. While for infrastructure-based networking, wireless operators are best placed to assume the role of kingmaker in the infrastructure-less approach this position is challenged, as new developments do not require involvement from major infrastructure players. This significantly reduces the

cost-barriers for creating new services and open the telecommunication market by fostering competition in the local accesses to Internet.

5. PARTNER'S EXPLOITATION PLANS

The exploitation plans will obviously vary between the different types of organizations within the consortium. Indeed, each partner has already expressed the interest to use internally some of the project results. Internal exploitation of the results will be initiated on the short term, to benefit directly from the running project dynamics. External exploitation for creating market opportunities is long-term and contingent upon emerging business opportunities in the different fields of application.

In this section, each project partner explains own exploitable results obtained during the activities of the MobileMAN project, and its plans for exploiting own results. Moreover, each partner illustrates any technical and economic market consideration; any obstacles identified which might prove to be barriers to commercialization; the further additional research and development work and any commercial contacts already taken and any comments received.

5.1. CNR

The main outcomes of MobileMAN project that CNR plans to exploit are:

Know-how

- Know-how related to implementing and experimenting multi-hop ad hoc networks.
- Several PhD and Master students have been trained. Now they have an in-depth knowledge of configuring 802.11 technologies for setting up ad hoc networks and implementing over these networks a full protocol stack to support both p2p and client-server applications in multi-hop ad hoc environment. This expertise will be available either for future CNR research and development activities or for the organizations (both academy and industry) that will hire them.

Methodologies

- We developed a methodology for designing multi-hop networks using cross-layer optimization still maintaining the layered organization of the network architecture.

Software and Tools

- A full protocol stack for multi-hop ad hoc networks for both legacy and cross-layer architecture.
- An architecture and the related software to transparently interconnect ad hoc islands to the Internet
- NS-2 simulation environment for supporting the design and testing of cross-layer architecture and protocols.

- The cross-layer plugin (XL-plugin) for OLSR service-discovery support.
- The software implementing the Hazy Sighted Link State (HSLS) routing protocols with cross-layer support.
- The software implementing the CrossROAD p2p platform.
- A proof-of-concept implementation of the Transport Protocol for Ad hoc networks (TPA).

Prototypes and Experimental results

- A testbed for legacy mobile ad hoc network.
- A proof-of-concept prototype of a cross-layer MANET architecture.
- Experimental results about the behavior of 802.11 ad hoc networks.
- Experimental results about the OLSR and AODV performance.
- Experimental results of p2p platforms performance on multi-hop ad hoc network (both legacy and cross-layer architectures).

Three main channels have been identified for the exploitations of these results. These channels correspond to different ways an ad hoc networks can be implemented, hybrid networks (mesh networks), pure multi-hop ad hoc networks, and opportunistic or delay tolerant networks; these channels also correspond (in our view) to different time scales for commercial exploitation of ad hoc networks technologies.

Mesh networks constitute the short-term direction to turn mobile ad hoc networks in a commodity by providing a flexible and "low cost" extension of wired infrastructure networks. CNR exploitation plans include the commercial exploitation of mesh networks to provide, in an efficient way, broadband and ubiquitous access to the Internet. The software modules developed in the project, and the know-how about implementing, configuring and testing multi-hop ad hoc networks, constitute the bases for this exploitation plan. As an academic partner, direct commercial exploitation of the MobileMAN results is rather difficult; however, to go beyond the classical academic ways to exploit project outcomes we are currently working to set up a joint association with the University of Pisa, named ANTARES, which will operate as a not-profit organization aimed at developing mesh networks solutions jointly with local government institutions. If successful, this will be a step towards setting up a start-up aimed to provide a commercial exploitation of mesh networks. In parallel with this, we plan to use our research results as the basis for new research projects aimed to refine and apply our solutions to construct mesh networks with Quality of Service (QoS) support:

- A bilateral project between IIT-CNR and FORTH-ICS (Greece) "Routing Protocols in Wireless Mesh Networks based on Cross-Layer Design". On December 6th 2005, the Italian-Greek cooperation for 2006-2008 has been signed and our project was included in the cooperation agreement.

- A bilateral project between IIT-CNR and IITP Institute of Russian Academy of Science (Russia) "Wireless Multi-Hop Mesh Networks with QoS support". On August 2005, the project was selected among those eligible for funding. A negotiation is currently ongoing between Italian and Russian governments to define the funding procedures.
- A joint project between IIT-CNR and University of Pisa "QWiMAN – Progetto di rete wireless mesh con garanzie di Qualità del Servizio" that we submitted to a local funding agency ("Fondazione Cassa di Risparmio di Pisa"). The project proposal is currently under evaluation.

Pure multi-hop ad hoc networks seem not yet ready for economic exploitation except for specialized environments. We already identified the public safety field as one of the most important and promising direction for exploitation of pure multi-hop networks. To this end, CNR has established collaborations with people working in the public safety and interested to apply ad hoc networking techniques in this field. Specifically, at EU level we established collaboration with Adrian Boukalov former chairman of the Technical Specification Group – Systems (TSG SYS) of the MESA (Mobility for Emergency and Safety Applications) project http://www.projectmesa.org. and workpackage leader of the IST project WIreless DEployable Network System, (WIDENS) aimed to design, prototype and validate a high data-rate, rapidly deployable and scalable wireless ad-hoc communication system for future public safety, emergency and disaster applications. At national level, IIT-CNR cooperates as networking expert in a team of industries and academic institutions that, in the framework of the three-year Italian national plan for research (2005-2008), lunched a project proposal aimed at applying ad hoc networking technologies for developing communications systems for natural disasters scenarios.

Opportunistic networking is the long-term direction for exploitation of ad hoc networking technologies. Further research is still needed before opportunistic networks have a market value. For this reason, our plans for exploiting the project results in this direction are related to use them as inputs for research projects. During 2005, research collaborations have been established that produced the successful participation to two project proposals under the IST – FET proactive call "Situated and Autonomic Communications": HAGGLE (http://www.haggleproject.org/) and BIONETS (http://www.create-net.org/create-net/bio-nets/). HAGGLE and BIONETS constitute the primary ways to exploit the MobileMAN results for advancing the knowledge on opportunistic networks.

As side effects of the MobileMAN results, we contributed to create worldwide communities of researchers focusing on mobile ad hoc networking, and we developed tools for facilitating their interactions and exchanging of ideas and results in this field. These tools include new scientific events like the REALMAN workshops series (see also Section 5.2.2), a special issue for EURASIP Journal on Wireless Communications and Networking (WCN) on *MobileMAN (Mobile Multi-hop Ad hoc Networks): from theory to reality*, and two books:

- "*Mobile Ad Hoc Networks: from Theory to Reality*", edited by Marco Conti, Jon Crowcroft and Andrea Passarella, and published by Nova Science Publishers (USA) in 2006. This book is closely related with REALMAN workshops series. Indeed, the aim of the book is to providing an overview of experimental research activities related to ad hoc networking. The book, in addition to several chapters devoted to the presentation of MobileMAN results, will contain chapters from main EU and USA researchers.

- "*Mobile Multi-hop Ad hoc Networks (MobileMAN)*" edited by Marco Conti and published by Springer in 2006. The aim of this book is to provide an in depth analysis of mobile ad hoc networks and to present MobileMAN architecture and protocols as an integrated solution for mobile ad hoc networks design.

5.2. University of Cambridge

In the framework of the MobileMAN Project the University of Cambridge achieved a number of results. They range from software prototypes, to feasibility analyses for exploiting ad hoc technologies in the market, to start-up of successful international conferences and workshops. In previous deliverables we have provided detailed descriptions for all of them. In this document we envision possible exploitation of the results both in industrial environments, and in the research community.
In the following of this section we will focus on two representative results, i.e. i) a taxi radio dispatch system based on ad hoc networks, and ii) the start-up and evolution of the "International Workshop on Multi-hop Ad hoc Networks: from Theory to Reality" – *REALMAN*.

5.2.1. Ad hoc technology for taxi radio dispatch systems

Current radio dispatch systems for taxi companies rely on licensed and proprietary solutions. This is a strong barrier for new companies to enter into the market. Furthermore, adopting licensed and proprietary solutions results in significant recurring costs for running and maintaining the system.
Based on these remarks, we have analysed the feasibility of implementing an open radio dispatch system entirely based on the 802.11 ad hoc technology. In this scenario, each taxi is equipped with an 802.11 device, and is able to communicate directly with other taxies within radio range. Multi-hop routing is used to allow communication between taxies further away. We have deeply analysed this scenario from both the economical and the technical standpoint. The detailed analysis has been presented in Deliverable D15. Hereafter, we briefly recall the main results, and identify possible exploitation opportunities.
From a technical point of view, the main findings are as follows:

- All in all, a radio dispatch system based on 802.11 networks is able to serve the purposes of taxi companies. Outage times (i.e., time intervals during which a taxi is not reachable) are on average in the order of few tens of seconds, and maximum outage times are in the order of few minutes.

- Highly crowded and congested environment may increase outage times, but not dramatically.

- Outage times are reduced significantly when the number of taxies is increased, or the time to setup connections is reduced.

Alongside technical feasibility, the analysis has provided the following financial and economical insights:

- Such a system has the potential to bring value to all players involved, increasing the revenue per taxi, decreasing the cost and time to fulfill jobs and improving profitability per customer as well as customer satisfaction. The system would also be fast to deploy and scalable in size.

- The benefit of increasing the number of taxies calls for different small/medium companies to share the same radio dispatch system. This can further reduce the

entry barriers for new operators. Furthermore, it is easily achievable from a technical standpoint, thanks to the open platform that is adopted.

The adoption of such a system presents also some risks. We briefly present them, together with possible countermeasures to reduce their potential impact:

- Current taxi companies would face a switching cost for adopting the new system. However, possible increase in the spectrum license costs may provide the necessary impetus to switch.

- Research is also being performed to link conventional wireless LAN systems with seamless handoffs. The primary advantages that ad hoc networks have over these other forms of communication are low cost and ease of deployment. Should the alternatives advance sufficiently in performance or decrease substantially in price, they could render ad hoc systems inadequate in comparison for commercial uses.

- Security issues may raise concerns. Encryption is required for sharing the same network among different companies, as well as to enable credit-card transactions. Cooperation enforcement is required to avoid selfish and malicious behaviors.

- Due to outage times, backup systems based, for example, on cellular networks might be required. In the future, research efforts on opportunistic networks could provide lower cost solutions to cope with this problem.

Based on the feasibility analysis, we can envision several exploitation opportunities and future research directions, either in a research or industrial perspective.

- Coping with outage times is an interesting and challenging task. Opportunistic networking and QoS-driven routing-protocol suites (described in Deliverable D15) are promising directions to explore. It is reasonable to foresee that they will be able to provide ways to support both real-time and best-effort applications in scenarios such as the taxi dispatch system. The University of Cambridge is actively involved in these fields, mainly through the Haggle Project, funded by the European Community under the Information Society Technologies (IST) Programme, Future and Emerging Technologies (FET).

- Both the software and the underlying radio technology must allow for significant growth in the number of nodes. One way to mitigate possible problems would be to use adaptive/cognitive radios. The University of Cambridge is actively involved in this field, and collaborates with the UK government, BT and MIT.

- The results achieved by our analysis will be leveraged by UK and International Projects on Intelligent Transportation Systems currently in their start-up phase. Specifically, the University of Cambridge is involved in the TIME Project (EPSR grant, Oct. 2005 – Sept. 2010, http://www.cl.cam.ac.uk/Research/SRG/opera/projects/index.html#time), and in the initiatives of the Cambridge-MIT Institute in this area (http://www.cambridge-mit.org/industry/transport).

- The analysis shows that 802.11 based radio dispatch systems are actually feasible. Furthermore, it also shows that other applications with similar patterns and requirements can be successfully based on this open technology. This can have direct exploitations in the start-up of new companies providing such kind of applications.

- Another possible exploitation is represented by starting companies acting as consultant for the deployment of such systems.

- In a longer time frame, 802.11-based radio dispatch systems could become *open networks*, used to wirelessly extend Internet coverage. Clearly, this represents an outstanding opportunity, both from a technical and economical standpoint.

5.2.2. The International Workshop on Multi-hop Ad hoc Networks: from Theory to Reality – *REALMAN*

A major commitment of MobileMAN partners has been to take an *experimental* approach to validate the proposed solutions. Apart from (supposedly) being the ground of any applied science, such an approach is of paramount importance in the field of wireless networking. However, due to the high costs both in terms of resources and in terms of manpower, much of the research on this field has been carried out just through analytical and simulation models. Unfortunately, it is very difficult to model wireless communications precisely enough, and this can highly reduce the results significance.
In the last few years these observations have steadily gained popularity among researchers. Building on top of this, the Computer Laboratory of the University of Cambridge and the IIT Institute of the CNR have organised the first edition of the REALMAN workshop, that has been held in Santorini (Greece), on July 14th, 2005.The aim of the workshop was to raise the interest of the research community on experiment-based research on ad hoc networking, and thus to create a well-linked network between researchers working in this area. It is worth mentioning that all MobileMAN partners have enthusiastically contributed to this initiative.
The first edition of the Workshop has been very successful. It received about 40 submissions from several countries, and featured a high-quality technical program. It is worth noting that several real prototypes have been presented during the workshop sessions. Furthermore, a panel has been organised, in which EU and USA research leaders have discussed current limitations and future directions of multi-hop ad hoc technologies.
We can mention a number of ways in which the success of the REALMAN workshop is currently being exploited, and will be exploited in the future.

- We are currently organizing the second edition of the workshop. It will be co-located with the ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHOC 2006), which is the world reference event for researchers working on ad hoc networks. This further highlights the importance of the core topics of REALMAN, and shows that the research community highly welcomes this workshop.

- The co-location with MobiHOC will provide an outstanding opportunity for discussing future research directions, and to further extend the network of researchers established during the first REALMAN edition.

- Based on the success of the first edition, and on the visibility of MobiHOC, we can expect REALMAN to become one of the reference events in the field of ad hoc networking.

- The first REALMAN edition has created and strengthened links among researchers sharing similar views. This is already leading to joint research initiatives, such as submissions of Projects to the European Commission. We can thus expect this trend of collaborations to steadily increase.

5.3. Eurecom

Our team has been involved in the exploitation of the results achieved in MobileMAN following different directions. If neither standardization activities nor software development oriented to a business perspective has been undertaken due to the academic nature of our institution, we were able to gain visibility on the European scene on future developments of the key technologies explored during the project. Furthermore, the expertise acquired through our research and thanks to the interaction with other partners of the project allowed the creation of Doctoral Courses for graduate students in the area of mobile ad hoc networking. Lastly, the combination of our skills developed during the project and the growth of interest showed by the international research community in the topics addressed by the project allowed our group to actively participate to the creation of international conferences and workshops in the mobile ad hoc networking domain. In the following we detail our activities in exploiting the results of the project.

5.3.1. Participation to new EC call for projects

The MobileMAN project opened new paths for the exploitation of the techniques developed during the project in the field of distributed security and incentive mechanisms. The project enriched our team with a unique expertise that attracted the attention of new partners towards the definition of new IP-FET project proposals.
Our group is member of two freshly approved European projects (HAGGLE and CASCADAS) that further push the limits of MobileMAN to the domain of autonomic computing and communications.
In HAGGLE we focus on security protocols based on a combination of cryptography and networking techniques such as network coding. In CASCADAS our contribution will be on the design of mechanisms based on game theory to form coalitions of cooperating entities that contribute to service provision.
We plan to hire two PhD students and two Post-doc researchers to join our team.

5.3.2. Creation of doctoral courses

The expertise gained during the project has been used to create an advanced course in security for graduate students. In this course, future PhD student are offered the opportunity to study state-of-the-art as well as recent advances in research on security mechanisms and incentive schemes for self-organized and fully decentralized mobile networks.

5.3.3. Active participation to international conferences

During the project our team has been involved as program committee in several international conferences and workshops on security for mobile networks, ubiquitous computing and wireless networking. Further, we jointly organized international workshops on trust and security for ubiquitous computing.
Here follows a list of the main conferences and workshops we have been involved into:

- IEEE SECURECOM
- IEEE TSPUC
- IEEE PERCOMM
- IEEE PERSEC
- IFIP SEC

5.4. Helsinki University of Technology

5.4.1. Exploitation results

The exploitation results include:

- Ad hoc routing prototype including state of the art protocols such as AODV, OLSR and ZRP. The prototype includes routing modules implementing AODV, OLSR and ZRP. Those modules are integrated and tested in real Ad hoc nodes (i.e. PDA model HP 3850 and HP 3900).

- VoIP application prototype with QoS enhancements for Ad hoc networks. The VoIP application consists of a lightweight implementation of SIP and RTP together with a QoS module for optimizing the throughput toe the network conditions.

- Master Thesis completed:

  - "Design and Implementation of an Ad Hoc Routing Framework", May 2003,Lei Xiao
  - "Design and Implementation of an optimized Architecture for Service Discovery in Ad hoc networks", September 2004, Olmo Leon Cadahia.

- Course: Networking course to describe Ad hoc networking and get input from the students on their expectations in this technology.

- Distribution of free (open source) Software prototype: Hosting web page for accessing the prototypes delivered within the project. The web page is accessible with

username and password obtained upon request. Foreign universities are using the MobileMAN Software.

- Workshop: A workshop was arranged to show the prototypes to representatives from Nokia Networks. In the workshop the routing and VoIP application prototypes were tested with real Ad hoc nodes (i.e. PDAs).

- New Innovation Integration center: Two sessions have been held with the "New Innovation Integration" center to communicate the goals in MobileMAN project so start ups interested in the Ad hoc networking can access the MobileMAN results.

5.5. NETikos

In the Deliverable D3 is explained that the NETikos services would been focused on the vertical segments of m-business, Media and Entertainment, Telecommunications, Healthcare, Public Administration, Tourism, as well as solutions to e-procurement and vertical virtual marketplaces, exploiting direct channels, technology partnerships, and commercial agreements. So, the NETikos activities are been to locate the application areas of the Ad-Hoc Network and the attractive applications or services for the final user of this environment. Then, it has developed a content-sharing application (**WSL**, Web Services Location Application), for more technical and software details see Deliverables D13-D16. This section, briefly, explains the WSL functionalities, and shows, in more details, how NETikos intends exploiting the own result.

5.5.1. WSL functionalities and prototype

WSL Application allows at the users to find contents or services available in the network and to publish own contents and services (i.e. web services) providing to other users. This application, to define a way to publish and discover information about web services, uses the UDDI (Universal Description Discovery and Integration) standard, but fitting to ad hoc environment called *UDDI4m* (UDDI for Mobile). So, each information system can publish contents through the WSL application and it can use contents published from other publisher. In developing of the application, an example of user target is Campus where the user activities can be: cooperative working, document sharing, media sharing or entertainment (e.g. distributed gaming). An user wants to publish the service information about his new business and make it available to the whole ad hoc network, he should write to all the users in the ad hoc network to inform them about it, but this solution is censured because very difficult and time expensive, whereas with WSL Application, an user, trough an user-friendly interface, can share the information relative to his service, so that the service information can be distributed in the ad hoc network and automatically the users, of whole network, are informed. Besides, if a user wants to search a service of another node presented in the network, he should try to phone him to know how to access it, but this solution is difficult and time expensive, whereas with WSL Application the user, through an user-friendly interface, can retrieve the information on how to access to the service that he wants to use.

The WSL Application is an application that provides a *discovery service* based on the Web service architecture: each node, on the network, can deploy its services publishing them in the Business Registries (*UBR4m*) distributed among nodes present in the ad hoc network, and it can retrieve information related to the available service. This application is based on the UDDI standard but supports the mobile platform taking care of the ad hoc network features where the application cannot be client-server application but the data exchanges among nodes are peer-to-peer communications and it is critical to consider a single node that plays the role of centralized server due to the dynamic nature of that environment. The service repository (*UBR4m*) is distributed on the network supporting of the light terminal, devices with constrains resources that cannot to manage a database. Finally, the communication among nodes is based on the available middleware making it independent on the network topology. The use of a middleware is due to distribute, in the network, the contents related to the service provided from nodes and this involves a categorization of the services, server nodes classified for the service type and a publication or search of contents is forwarded to node handle to manage the request.
The software requirements, to run the WSL Application prototype, are a web server (i.e. Tomcat), Java Virtual Machine, Mysql database and a middleware (i.e. Pastry or CrossROAD); the application can be run on the light devices as PDA or mobile phone, in fact during the development of the application an investigation has been done on the used resources and the hardware requirements, for more details see Deliverable D16.

5.5.2. Exploitation of the WSL Application

The NETikos objective was to combine semantics and Ad hoc (peer-to-peer) networks in order to develop a secure and interoperable framework for exploiting Web services.
The MobileMAN platform is envisaged to be beneficial for various industries that are established on a large number of company-level service suppliers and service users that are distributed over an international business network.
The target focused from NETikos are environments where there aren't infrastructures but there is need to have a flexible, self-organized and dynamic network, for example: campus where could be attractive to be able to set up network at low cost without any infrastructure or Disaster Recovery, Building Site, etc…
Two distinct markets can be identified:

- The main target market of the SATINE platform consists of the individual national markets.

- Secondary markets are the international travel market, the GDS integrators and providers.

In general we can classify our material into the following groups.

- The scientific community group where we will present project techniques methodologies and results.
- The system developers group where we will present the various technical exploitable aspects of the *WSL application* services.

- The commercial group that will be introduced to the various commercial benefits *WSL application* services.
- The end users community that will be familiarized with how to use the *WSL application* services and what benefits it offers.

In particular, we believe that our *WSL application* prototype can be focused and provided to clients corporate that can be taken care to mobile wireless ad hoc architecture.

5.6. SUPSI

5.6.1. SUPSI DTI

The main result of the MobileMAN project for SUPSI-DTI is a development and rapid prototyping platform for wireless networks. The platform is modular: MAC, BB and RF parts may be replaced if necessary, and allows the rapid experimentation of hardware/firmware solutions. The platform is very flexible; the MAC module (which also implements the interface with the host CPU) is implemented on a powerful DSP microprocessor, easily programmable in C language. One of the main advantages of the chosen approach is the possibility to efficiently implement the extensions required for a cross-layering approach to the problem.

SUPSI-DTI exploitation of MobileMAN results is quite in line as discussed in deliverable D3:

- A laboratory for wireless and ad-hoc networks has been created, courses and labs are being given for both the basic and on-job (post-graduate) education department activities.
- Cooperation with IDSIA Institute has been reinforced; new research projects are in execution and in preparation.
- Cooperation with and support of local industries is pursued; a possible future applied research project with a Swiss company is in discussion, with the goal, among others, of bringing some of the MobileMAN technical results to the market.

As an academic partner, direct commercial exploitation of the MobileMAN results by SUPSI will be rather difficult; however, beside the classical university ways to exploit projects outcomes (publications, PhD's, contacts…), some commercial exploitation could be possible if the specific knowledge acquired during the project is required (e.g. in case of a specific product development).

Market for MANETS is still in its infancy, the most interesting field where one may see a rapid future growth is the domain of sensor networks. It is therefore very premature to make strong assertions of the commercial potential of the MobileMAN technical results (at least for the low-level firmware parts realized by SUPSI-DTI).

Obstacles to the commercialization of the SUPSI-DTI project results are mainly given by the difficulty to influence the standard bodies (e.g. the different IEEE 802.xx bodies), which are strongly dominated by large companies. As a consequence, SUPSI-DTI will try to commercially exploit the project results and acquired knowledge by mean of more

specific applied-research projects with the goal of producing more ad-hoc solutions, outside the conventional mass-market world of wireless networks.

Further and additional research activities related to MobileMAN are pursued at SUPSI-DTI:

- A new project granted by the Swiss National Science Foundation has started in October 2005 with title "New Priority Disciplines And Algorithms In Queuing Analysis" (SCOPES SNF IB7320-110720).
- A new EU-FP6 project (HAGGLE) with title "An innovative Paradigm for Autonomic Opportunistic Communication" has been approved by the European Commission and due to start in January 2006.
- A new project granted by the RETECA foundation has started in October 2005, with the goal of establishing a SDR (Software Defined Radio) modular platform for wireless networks. This new platform will extend the MobileMAN platform with new possibilities in the BB and RF modules.
- Many student projects (semester and Bachelor theses) have been done and are currently in execution at SUPSI in the field of ad-hoc and sensor networks.
- A joint research activity with University of Lugano is under definition.

No Intellectual Property issues have been addressed within the MobileMAN project; from one side, the project results have been largely published in conference and review papers, on the other hand, the strategic advantages reside more in the acquired know-how rather than in clearly identifiable Intellectual Property rights.

5.6.2. SUPSI DSAS

The main results for SUPSI DSAS within the MobileMAN project are to be found extensively in the already submitted deliverable D18. As a social study of the potential impacts of MANETs there is obviously no practical product, like there is for technical project partners.

In terms of outcomes from the social evaluation of MobileMAN, we have already explained by large the results of the studies conducted to perform such evaluation. To summarize, the main finding is that there are a number of variables that constitute an obstacle to the concrete and real success of a technology like the one intended in the MobileMAN project in the near future.

Within the project, one Master thesis was written at USI, which constituted the initial work done for the social evaluation.

Activities that can be related to MobileMAN, which have been initiated at DSAS are mainly focused on the topic of the new elderly and the challenges that come from their attitude and relations to new technology. What are the issues that technological innovation and a society that grows older bring when they encounter together?

Further research in the direction commenced with the MobileMAN project has been decided not to be undertaken at SUPSI DSAS, while concentrating the expertise on other areas of interest.