
**MOBILEMAN**

IST-2001-38113

Mobile Metropolitan Ad hoc Networks

# Periodic Progress Report N°:1

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# 1. EXECUTIVE SUMMARY

The project, through the analysis and research of major Mobile Ad hoc NETwork (MANET) characteristics, is aimed to developing a metropolitan area, self-organizing, and totally wireless network that gives name to the project: *Mobile Metropolitan Ad hoc Network* (MobileMAN).

It is worth pointing out that even though it exists a very large literature on MANETs (the related literature counts more than 2000 papers), ad hoc networking is not yet a consolidated field. MANET (Mobile Ad Hoc NETworks) IETF task force since 1997 is working to develop Internet routing for multi-hop ad hoc wireless networks. Four major candidates routing protocols (AODV and DSR, OLSR and TBRPF) have been identified but there is lack of convergence. There has been good progress in studying the protocols' behavior (almost exclusively by simulation), but the absence of performance data in non-trivial network configurations continues to be a major problem. More than 10 years of research has been carried out but this area is far from being consolidated. Three areas where ad hoc research lacks "realism" can be identified: i) *Integration* (lack of), ii) *Implementations/Testbeds* (lack of), and iii) *Experimentation* (lack of). Indeed the focus of MANET research has been mostly on revising routing Internet drafts. In addition, main other areas have been analyzed (and new areas are continuously added). However, most works focus on either a single layer/issue (MAC, Routing, TCP, middleware, etc.), or analyze the interaction among few layers (e.g., TCP and MAC, TCP and routing, energy and topology control). There is a lack of an overall view of MANET architecture and protocols.

The ad hoc protocols (and Internet drafts) production cycle is mainly driven by simulation. The approach is: "implementations can come later, simulations tell the truth".

Few attempts exist in the literature to validate/calibrate simulative studies with measurements. In addition, not all aspects of a real ad hoc network are represented in simulative models (e.g., most simulators assume the same transmission range for *unicast* and *broadcast* frames). Given this status of the art in the MANET research, the MobileMAN project novelty is to contribute to address the lack of Integration, Experimentation and Implementations/Testbeds. Specifically, the project aims to the development and validation of solutions for the relevant technical issues of self-

organizing networks (routing and medium access control protocols, power management, security, and location), and the implementation of integrated solutions. Our aim is to concentrate on novel and unsolved issues, while we are ready to exploit valuable concepts/solutions already proposed in the literature. For this reason a careful state-of-the-art analysis has been performed during the project first year. Real testbeds are (and will be) used in MobileMAN either to validate the developed solutions whenever possible or, (at least), to calibrate/validate the simulation models to be used for architecture and protocols design. Finally, whenever possible, hardware/software implementation of the MobileMAN solutions will be developed and integrated in a testbed.

In addition, to contribute to the MANET technical evolution, the project will also provide an economic and social analysis of this new networking paradigm. Specifically, we are investigating the users' perception of ad hoc networking potentials and limits. Measuring the users' satisfaction about the ad hoc networking paradigm does this. The economic analysis is working to answer the following questions: how economic issues impact MANET, and which novel business processes may emerge from the ad hoc paradigm?

During the project first year, we mainly worked to the development, validation, and testing of the architecture, and related protocols, for configuring and managing a MobileMAN. We also started to build the basement for the validation of the self-organizing paradigm from the social standpoint. The creation of an environment for promoting new business activities and processes (economic standpoint) is expected to enter later in the project's activities. According with the view of MANET IETF WG, we started with a legacy layered-architecture. During the first year activities, we identified the limitations of this approach (that makes difficult to fix some ad hoc networks performance problems), and we investigated to what extent the pure layered approach needs to be modified. Two directions, both with pros and cons, are currently emerging in the literature: i) extension of the layered architecture by adding layer triggers; and ii) a full cross layering design that may violate the layers independence principle. MobileMAN identified a solution to this problem by introducing cross-layer interactions among protocols still guaranteeing the independence in protocols design and hence the advantages of a modular architecture. Specifically, MobileMAN approach tries to balance performance optimization with protocols' stack adaptability. The kernel of the

MobileMAN cross-layer architecture is a shared memory that is a repository of all the network status information collected by the network protocols. All protocols can access this memory to write the collected information, and to read information produced/collected from the other protocols. This approach allows for a full compatibility with standards, as it does not touch the core functions of each layer. It is robust to upgrading, and protocols belonging to different layers can be added/removed from the protocol stack without modifying the operations at the other layers. During the second year of the project, according to Annex 1, we will continue along the construction of a MANET following the IETF approach to be used for experimental tests (internal and with users). In addition, we will further investigate the goodness and feasibility of an architecture based on a cross-layered approach. As a consequence of this, we decided to activate the task T2.9 *Domain model refinement and risk reduction*. The objective of task T2.9 is the refinement of the domain model to take into account the impact of cross layering on the MobileMAN architecture and protocols.

Even though the dissemination and exploitation workpackage was planned to start in the second year of the project, MobileMAN results already started to be disseminated in different international forum. In fact, the innovative approach of MobileMAN to architectural analysis and design produced original and relevant results, and thus accepted for publication in several conferences and journals.

# 2. WORK PROGRESS OVERVIEW

This project investigates the potentialities of the Mobile Ad hoc NETworks (MANET's) paradigm. Specifically, the project aims to define and develop a metropolitan area, self-organizing, and totally wireless network that we call *Mobile Metropolitan Ad hoc Network* (MobileMAN). The main technical outputs of this proposal can be summarized as follows. i) Development, validation, implementation and testing of the architecture, and related protocols, for configuring and managing a MobileMAN. ii) Physical implementation of this architecture for lowers layers (i.e., wireless technologies). iii) Integration of applications on top of our self-organized network. iv) Validation of the self-organizing paradigm from the social and economic standpoint.

## 2.1 Specifics Objectives for the Reporting Period

The objectives reported below constitute the criteria for evaluating the success of the first year of the project.

*MobileMAN architecture definition*

- Definition of the complete MobileMAN architecture with the communication flows among different activities and the integration of vertical issues as co-operation and energy awareness.

*New applications and services*

- Identification of existing applications (or classes of applications) that can become a customer advantage, when run on top of MobileMAN, compared to traditional technologies. Define the services that we need to provide for efficiently supporting some of these (classes of) applications.

*Middleware*

- Comparative analysis of existing middleware solutions for mobile environment (Xmiddle, Jxta, Lime, etc.). The aim of this comparison is the identification of the best solution(s) for the MobileMAN environment.
- Definition of new solutions for P2P information delivery. This will be done by selecting some of the resilient mechanisms that have emerged in the p2p community (such as CAN, Chord, Pastry, etc.), and then introducing location information and scope information so that content is initially placed and requests are routed to copies that have proximity on a number of QoS axes.

*Co-operation Model*

- Design of models and mechanisms that encourage users to behave as "good citizens".

*Networking services*

- Design of location and packet forwarding schemes suitable for MobileMAN.
- Comparison of routing protocols for ad hoc networks utilizing simulation studies, and, whenever possible, measurements on real testbeds.
- Development and testing of a few hops ad hoc network implementing a minimal set of functionalities (routing, forwarding, and location).

*Wireless Technologies*

- Analysis of the limits of the existing solutions (based on IEEE 802.11) for constructing multi hop ad hoc networks. The analysis is performed by simulation and measurements.
- Design of an enhanced MAC protocol for ad hoc networks. The new MAC protocol must be compatible with the IEEE 802.11 and provide a better channel utilization.
- Comparative analysis of existing chipsets to identify the best solution for implementing the MobileMAN enhanced NIC.

*Socio-economic Model*

- Develop a methodology for evaluating social, anthropological, and economic potential of MobileMAN.

## 2.2 Overview of the Progress during the Reporting Period

During the first year, as planned, all workpackages, but WP4 (Integration, Evaluation and Social Analysis) and WP5 (Dissemination and Exploitation) started. They produced results according to the defined milestones (M1 – Month 6, and M5 Month 10).[1] In particular, five deliverables were produced in the project first year; see the Deliverables' Table below. In addition we produced a "*Project Presentation*" that summarizes the project scope, methods, and expected results. All of them are made publicly available at the web site of the project (http://cnd.iit.cnr.it/mobileMAN). MobileMAN results already started to be disseminated in different international forum. In fact, the innovative

approach of MobileMAN to architectural analysis and design produced original and relevant results, and thus accepted for publication in several conferences and journals.

[1] The details of each WP activities, and the temporal diagram of each activity are reported in the Annex 1 "Work Description".

## DELIVERABLES TABLE

**Project Number:** IST-2001-38113

**Project Acronym:** MOBILEMAN

**Title:** Mobile Metropolitan Ad hoc Networks

| Del. No. | Revision | Title | Type[1] | Classification[2] | Due Date | Issue Date |
|---|---|---|---|---|---|---|
| **D1** | | Project web-site set up | **S** | Pub | December 2002 | December 2002 |
| **D2** | | Project Plans | **R** | Pub | December 2002 | 21 January 2003 |
| **D3** | | Dissemination and Use Plan | **R** | Pub | March 2003 | March 2003 |
| **D4** | | MobileMAN intermediate evaluation report | **R** | Pub | October 2003 | 7 October 2003 |
| **D5** | | MobileMAN architecture, protocols, and services first report | **R** | Pub | October 2003 | 7 October 2003 |

**1** *R: Report; D: Demonstrator; S: Software; W: Workshop; O: Other – Specify in footnote*

**2** *Int.: Internal circulation within project (and Commission Project Officer + reviewers if requested)*
*Rest.: Restricted circulation list (specify in footnote) and Commission SO + reviewers only*
*IST: Circulation within IST Programme participants*
*FP5: Circulation within Framework Programme participants*
*Pub.: Public document*

### 2.2.1 Deliverables Short Description

D1 *Project web-site set up*

To support communications among project partners and to publicize the project activities a project web site was set up: http://cnd.iit.cnr.it/mobileMAN.

D2 *Project Plans*

The aim of this deliverable is to document the first phase of the MOBILEMAN project: *Phase 1 Infrastructure Creation.* The objective of this phase is to ensure that the goals for the different project partners are aligned with the project goals. Specifically, this deliverable presents the detailed project plans, and establishes the *baseline for assessing project success*. In addition, it defines the external, methods and tools (e.g. ideas, mechanisms, approaches, and HW/SW platforms) that will be used for the MOBILEMAN project.

D3 *Dissemination and Use Plan*

This deliverable presents the two distinct ways, namely dissemination and exploitation, identified by the project partners to ensure that the project benefits are realized. The consortium approach is to use dissemination to create awareness around the solutions provided by MOBILEMAN, and to define and execute an exploitation plan. In D3 we discuss in detail the MOBILEMAN strategies for dissemination and exploitation.

D4 *MobileMAN intermediate evaluation report*

The aim of this deliverable is to evaluate the activities performed during the first year of the MOBILEMAN project. During this period, the partners successfully fulfilled to the major promised project goals. This deliverable presents the achieved project goals for the first year. Furthermore, it introduces the evaluation criteria for the second year, as enhancement of the project goals (as defined in the deliverable D2 "*Project Plans*") and the first year experience. Related to that, it shows how the project dynamically adapts itself to new and external ideas and findings, in order to continue to produce relevant and

innovative results. Thus, this document introduces the changes to the original design and plans that the consortium decided to adopt for the MOBILEMAN project in order to continue to drive the research in this field and reach innovative and valid results.

D5 *MobileMAN architecture, protocols, and services*

The aim of this deliverable is to provide the overview of the architecture, protocols and services designed for the MobileMAN paradigm as emerging at the end of the first year of the project. First, we present the complete architecture with the communication flows among different functions, and then we discuss protocols belonging to the MobileMAN protocols' stack. Protocols are presented by following a bottom up approach from wireless technologies up to the application and economic issues. In addition, protocols' presentations are grouped to reflect the working groups that are operating inside the MobileMAN project.

As far as the architecture, we decided to enhance the reference model of MobileMAN in order to integrate in a careful way, in our architecture, the novel view of cross layering, while maintaining layer independence when opportune. A cross-layering approach is emerging as the most suitable attempt to optimize the architecture and protocols for systems with high dependences among layers, as wireless ones. In MobileMAN, some specific information, gathered at different layers of the network stack, is shared in a common local memory structure, and used to adapt the behavior of the node depending on the particular circumstance (e.g., traffic type, channel perturbations, network status, node selfishness and/or maliciousness, among the others) the node operates in. This is likely to be the first attempt, in the research community, that such type of reference architecture is adopted. However, the MobileMAN reference architecture tries to achieve the advantages of an advanced cross layer design (i.e., joint optimization of protocols belonging to different layers) still satisfying the layer separation principle, i.e., protocols belonging to different layers can be added/removed from the protocol stack without modifying the protocols operating at the other layers. This implies that a high attention needs to be given to the choice of the shared information, and to balance between cross-layering and layer separation will be matter of careful research. The reminder of the deliverable presents (for

all the layers of the MobileMAN protocol stack) an exhaustive overview of relevant issues, and the directions for solving them. In detail, for each section dedicated to a particular layer, a detailed state of the art is presented focusing on the particular requirements needed to satisfy both the ad hoc networking, and the MobileMAN objectives. Where suitable, an analysis of existing approaches that solve the issues specific to each layer is presented. Investigating on whether the techniques available in the literature were suitable for the MobileMAN purposes was one of the fundamental directions to follow in the design of the system architecture in order to be able to focus on specific and unsolved issues. Depending on the progress status of each part of the network stack, the design and the implementation details of original components is provided, when available. Moreover, if a final solution or partial results only, were available, a detailed description of each research direction is presented.

This deliverable represents a precious reference point for a collaborative development of the MobileMAN testbed, a source of information for a cross layering design in which the issues, objectives, and solutions proposed for each specific layer are available and exploitable by protocols belonging to different levels.

## 2.3 Evaluation of Work Accomplished during the Reporting Period

The project work plan has been fulfilled and a great majority of the project objectives (see Section 2.1) have been achieved. Specifically, MobileMAN partners achieved the following objectives:

*MobileMAN architecture definition*

- Definition of the complete MobileMAN architecture with the communication flows among different activities and the integration of vertical issues as co-operation and energy awareness.

*New applications and services*

- Identification of existing applications (or classes of applications) that can become a customer advantage, when run on top of MobileMAN, compared to traditional technologies. Define the services that we need to provide for efficiently supporting some of these (classes of) applications.

*Middleware*

- Comparative analysis of existing middleware solutions for mobile environment (Xmiddle, Jxta, Lime, etc.). The aim of this comparison is the identification of the best solution(s) for the MobileMAN environment.
- Definition of new solutions for P2P information delivery based on resilient mechanisms that have emerged in the p2p community (Pastry), and then introducing location information and scope information so that requests are routed to copies that have proximity on a number of QoS axes.

*Co-operation Model*

- Design of a model that allows studying the cooperation in MANETs.
- Design of a mechanisms that encourage users to behave as "good citizens".

*Networking services*

- Design of a location schemes suitable for MobileMAN.
- Study of a packet forwarding schemes suitable for MobileMAN.
- Comparison of routing protocols for ad hoc networks utilizing measurements on real testbeds.
- Development and testing of a few hops ad hoc network implementing a minimal set of functionalities (routing, forwarding, and location).

*Wireless Technologies*

- Analysis of the limits of the existing solutions (based on IEEE 802.11) for constructing multi hop ad hoc networks. The analysis is performed by simulation and measurements;
- Design of an enhanced MAC protocol for ad hoc networks. The new MAC protocol is compatible with the IEEE 802.11 and provides a better channel utilization.
- Comparative analysis of existing chipsets to identify the best solution for implementing the MobileMAN enhanced NIC.

*Socio-economic Model*

- Development of a methodology for evaluating social, anthropological, and economic potential of MobileMAN.

In addition, the consortium has performed additional work with respect to the one described in the Annex 1:

- to study and evaluate an innovative cross-layered architecture. Specifically, during the first year we have proposed a system architecture that introduces cross-layer optimization and, at the same time, permits the use of legacy protocols without changes. As we consider this proposal of high value for the project we decided to extend the activities originally planned in Annex 1 to investigate the impact of cross layering on MANET.
- to increase the role of measurement studies, with respect to simulation, in the system performance evaluation. Measurements studies have been extensively applied, rather than using only simulative analyses (as originally planned), to: i. 802.11 experimental evaluations (not originally planned), and ii. performance analysis of routing protocols.

As a consequence of these additional activities, the consortium increased the first year total effort (see Section 2.4.3)

## 2.4 Activities

According to the different perspectives of the MANET-paradigm investigation, the project activities, as explained in Deliverable D2, were naturally subdivided into three main areas (technical, social, and economic). The Figure 1 below points out the relationships existing between these areas, and the participants to each project area.

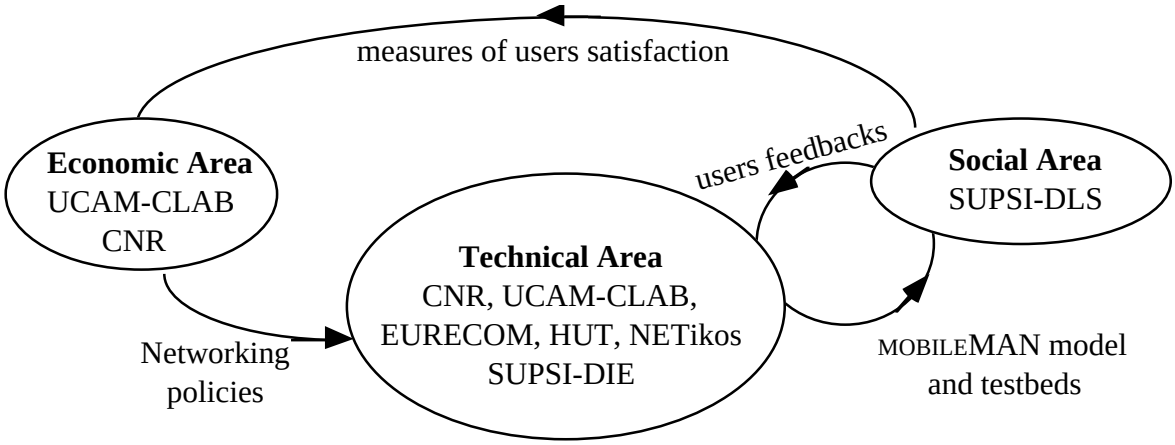


**Figure 1:** Relationships among the project activities

The economic and social activities were mainly under the responsibility of a single partner: Cambridge and SUPSI-DLS, respectively. On the other hand, almost all partners contributed to the activities of the Technical Area.

To better coordinate the work and to highlight synergies and roles of the partners the Technical Area activities have been subdivided into three Working Groups (WGs), see has Figure 2:

WG 1: Applications and Middleware (CNR, Cambridge, HUT, Netikos)

WG 2: Networking (CNR, Eurecom, HUT)

WG 3: Wireless Technologies (CNR, SUPSI-DIE)

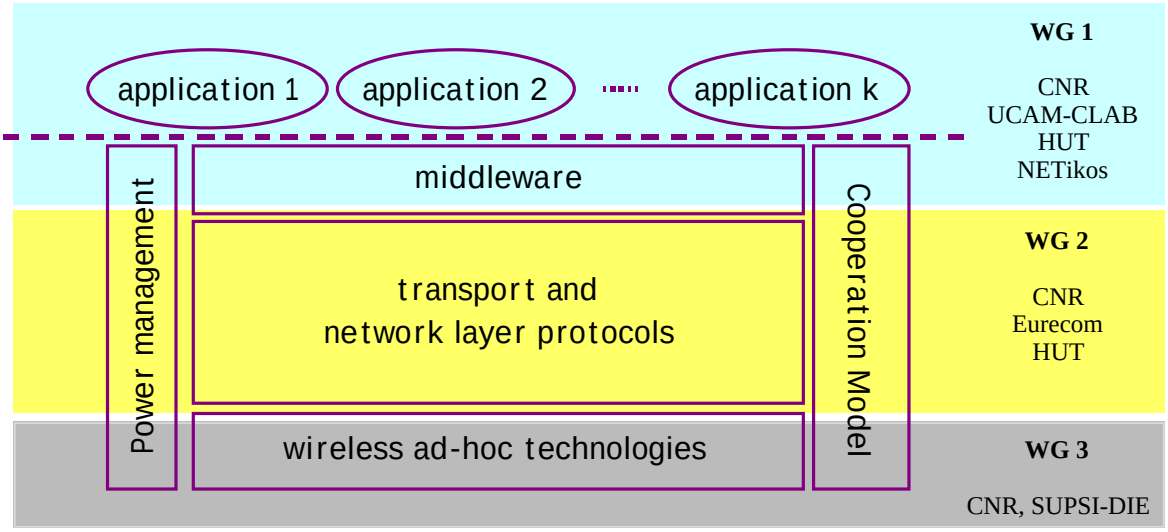


**Figure 2.** Reference Architecture

The different partners' roles are well reflected by the activities performed during the first year (as detailed below), and by their contribution to the different sections of Deliverable D5 that contains a detailed presentation of the technical activities performed during the first year of the project.

Figure 3 summarizes the activities, listed by work-packages and tasks, to be performed during the project first year. WP0 and WP1 are aimed, respectively, to manage the project and to establishing a common baseline for the project activities to be accomplished during its lifetime. In addition, in the framework of WP1 we performed, at the end of the first year, the self-assessment task to evaluate the work accomplished during the first year as reported in Deliverable D4.

In the framework of WP0 we set up the communication infrastructure of the project. This included the design and implementation of the Project we site (WP0, deliverable D1), setting up a project mailing list, and preparing a project presentation report.

The following activities constituted the main contribution of WP1 to the project:

- Definition of a detailed project's plan that contains the *baseline for assessing project success* in terms of project execution and final result effectiveness (WP1, deliverable D2)
- Definition of a detailed project Dissemination and Exploitation plan (WP1, deliverable D3)
- The first year activities ended with the *T1.5- Self-assessment procedure and risks mitigation* to verify the alignment with the project goals, control the quality of what has been produced, and identify and manage the project risks. This task produced Deliverable D4 as its output.

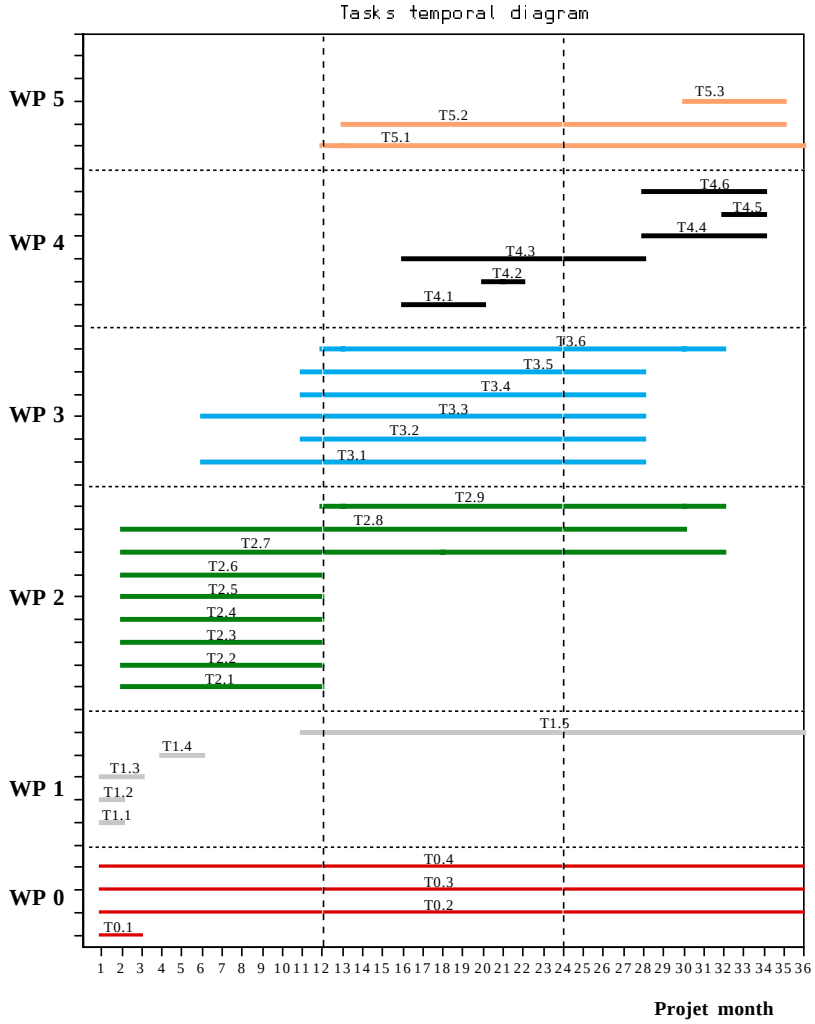


**Figure 3.** First Year Workpackages and Tasks

The first year technical activities were performed mainly in the framework of WP2. In addition, in the second part of the year, we started some tasks of WP3.

### 2.4.1 WP 2 Activities

The aim of WP 2 is to define the MobileMAN architecture and protocols. In addition, the WP provides models and methods for investigating the socio and economic value of the ad hoc networking paradigm.

*T2.1 New applications and service*

We identified a set of applications in the framework of co-operative tools for content/document sharing. Selected applications are based on a P2P architecture that points out the co-operative nature of Mobile ad Hoc networks. The client-server paradigm is moved to a server-less model because is difficult to obtain a client-server communication in an environment where the network splits in continuation.

*T2.2 MobileMAN architecture definition*

We defined the complete MobileMAN architecture according to the layered approach as defined by MANET IETF WG. In addition we also defined an innovative architecture that fully exploits the cross-layering concept with communication flows among all protocol layers thus providing full context awareness (WP2, deliverable D5). A cross-layering approach is emerging as the most suitable attempt to optimize the architecture and protocols for systems with high dependences among layers, as wireless ones. In MobileMAN, some specific information, gathered at different layers of the network stack, is shared in a common local memory structure, and used to adapt the behavior of the node depending on the particular circumstance (e.g., traffic type, channel perturbations, network status, node selfishness and/or maliciousness, among the others) the node operates in. This is likely to be the first attempt, in the research community, that such type of reference architecture is adopted.

*T2.3 Bursty-responsive MAC*

We investigated via measurements on a real testbed the problems existing in using 802.11 in ad hoc environments and the motivations for a new MAC protocol and a new card

(WP2, deliverable D5).

The activities performed in this task include an extensive performance analysis based on measurements to evaluate the 802.11b technology in ad hoc networks. This analysis pointed out the problems of the 802.11 back off algorithm in ad hoc networks. In addition using these results we defined an 802.11 channel model. According to this model, the physical carrier sensing range is very large (compared to the transmission range) and, in average, it contains most of the stations around a transmitting one. Therefore a back off tuning algorithm must be effective inside the physical carrier sensing range, and it must use a very simple feedback from the channel. Stations inside the physical carrier sensing range may be not able to measure the idle and collision lengths. To cope with this problem, we developed an algorithm to enhance the 802.11 back off algorithm that utilizes a very simple estimate of the channel conditions, which can be measured by all stations inside the physical carrier sensing range of the transmitting one. Specifically, our mechanism, named Asymptotically Optimal Backoff (AOB), dynamically adapts the backoff window size to the current network contention level, and guarantees that an IEEE 802.11 WLAN asymptotically achieves its optimal channel utilization. The AOB mechanism measures the network contention level by using two simple estimates: the slot utilization, and the average size of transmitted frames. These estimates are simple and can be obtained by exploiting information that is already available in the standard protocol. AOB can be used to extend the standard 802.11 access mechanism without requiring any additional hardware.

*T2.4 Definition of networking services*

We started with a careful review of state of the art in MANET routing and we performed some simulative analyses of some routing protocols emerging in the IETF MANET working group (WP2, deliverable D5). In the framework of the proposed cross-layering architecture we are currently working to define a novel routing approach based on link-state algorithms where the topology information are propagated with a frequency that decreases with the distance (WP2, deliverable D5). This routing approach is also the basis for the reliable forwarding mechanism we have designed and (partially) evaluated. This mechanism exploits multi-path information provided by link-state routing to select paths

taking into consideration several aspects, such as: nodes cooperation, congested links at MAC layer (cross layering with MAC), BER, congested nodes, etc (WP2, deliverable D5).

We also analyzed the problems in using the legacy TCP protocol in ad hoc environment and we started the design of a simplified transport protocol for our cross layering architecture. The simulative evaluation of this novel protocol is currently ongoing (WP2, deliverable D5).

Finally, for large scale MANET we have designed a Location protocol based on the hot spots concept. This approach is currently under simulative evaluation (WP2, deliverable D5).

*T2.5 Security and Co-operation Model and Mechanisms*

MobileMAN key aspects are the nodes co-operation and the security, in order to provide a collaborative and safe environment to the application layer. The self-organising environment introduces new security issues that are not addressed by the basic security services provided for dedicated networks: nodes misbehaviour can take the form of a denial of collaboration to the network operation both due to malicious and/or selfish intentions. Security mechanisms that solely enforce the correctness or integrity of network operations would thus not be sufficient in MANET. To this end, after a security analysis of the MobileMAN environment (including the robustness to malicious attacks), we defined a cooperation enforcement mechanism “CORE” that encourages users to behave as “good citizens”. This innovative mechanism enforces node co-operation based on a collaborative monitoring technique that can be integrated with any network function. The performance of this mechanism has been extensively evaluated by simulation and analysis. Specifically, we developed a simulative model of CORE for the Scalable-Networks QualNet simulation environment. In addition, we provided a formal assessment of the properties of the CORE mechanism using game theory. The analytical model obtained through a game theoretical analysis of the selfishness problem in ad hoc networks was translated into a numerical model developed for the MATLAB suite. A numerical framework has been necessary in order to speed up the validation process of the CORE mechanism. The results obtained through the numerical methodology provide a reference to appropriately set the CORE parameters in the QualNet simulation environment.

*T2.6 P2P information delivery*

With reference to middleware layer, we surveyed existing middleware solutions for mobile and ad hoc environment pointing out pros and cons of existing approaches. The result of this analysis is that Pastry is a promising technology for the ad hoc environment. We are currently working to extend/modify Pastry to efficiently integrate it in MobileMAN cross-layering architecture (WP2, deliverable D5).

*T2.7 Socio-economic modelling*

The aim of this task is to create a conceptual and empirical interface between the 'system developers' and the potential 'system users'. Our approach is based on the assumption that there is a significant socio-cultural distance between user communities and ICT designers that may impede to anticipate users' needs and concerns. To reduce this separation, we adopted an action research approach known as 'participatory design'. This methodology was developed in Scandinavia in the late seventies and is currently used in academic, public, and private research institutes (e.g. MIT, UCLA, Microsoft, Intel, Xerox) as a strategy to anticipate and keep into account users' needs and concerns in ICT product development. A prerequisite to the adoption of this methodology is the development of 'user friendly' information and communication material. To this end, we are currently working on the development of such material that will be presented to various categories of stakeholders by means of focus groups to be held during the project second year. In addition, we are further working on the development of information material oriented to end-users to be integrated in the project's website. The website will thus be divided in a sub-site for 'experts and a sub-sites for interested potential end-users. As the objective of this activity is not merely to facilitate an information flow from 'experts' to potential customers, but also to obtain a public feedback that may be kept into account in design development, this sub-site will be interactive. Through this activity we aim at facilitating communication between society and information technology designers.

T2.8 *Economic driven modelling*

We focused on providing economic incentives for cooperation with mobile ad hoc networks. Due to the autonomous nature of nodes with such a network and the scarcity of resources such as energy, cooperation between nodes can be promoted by using some

credit system. In addition, such a credit system may open up a wide range of opportunities for development of unique applications such as gaming.

We have modelled the operation of a mobile ad hoc network at the fluid level, where users are interested in communicating with other nodes within the network, yet determine their routes and rates through the use of pricing information. Each user monitors the usage of its bandwidth and energy resources, and adjusts prices associated with each resource accordingly. These prices are then combined into a single price when a route uses that particular node. The performance and stability of such a system have been demonstrated through simulations.

The model that we have developed used a simple model of the contention for capacity that occurs within a network. In reality, interference can severely limit the performance of a network, and we have been investigating ways of including interference within our model. One approach is to model the effect of interfering flows of traffic onto a bit-energy-to-noise-density ratio, which then allows us to determine the probability of successfully receiving traffic at the downstream node. However, there is the modelling difficulty that prices cannot adequately capture the impact that packets transmitted from a node will have on its neighbours. Another promising technique that has recently been published is the concept of using "clique-associated" shadow prices. We are investigating these and other ways of addressing the issue of interference.

Other economic issues associated with deploying mobile metropolitan ad hoc networks will also be reviewed and addressed.

### 2.4.2 WP3 Activities

The WP3 activities during the first year concentrated on T3.1 *Bursty-responsive MAC* and T3.3 *Routing and forwarding*.

*T3.1 Bursty-responsive MAC*

The work in the first 12 months of the project was mainly focused on the (hardware) architectural aspects. An appropriate development system (hardware and software) has been chosen; this will allow the development of a modified 802.11 NIC during the next project phase. More in details, the following work has been done:

- Study of both the 802.11/802.11a/802.11b standard and the proposed modified MAC algorithm (i.e., the modified MAC algorithm developed in T2.3). This work did allow to spot the critical parts in a MAC algorithms and consequently to choose the right hardware/software combination for the future development.
- Analysis of the available solutions for 802.11 cards. Silicon manufactures and integrators have been investigated. This study has allowed pre-selecting the technology for the final solution. The Intersil Prism-I chipset has been chosen; although not one of the most powerful on the (today) market, it has the advantage of being extremely modular and easy to use: MAC, BB and RF chips are distinct and their interface is clear and well documented.
- Choice of the tools (hardware/software development system). For the BB/RF part, a product by the company Elektrobit AG has been selected. For the MAC part, a very powerful Texas Instruments floating point DSP (TMS6701) has been chosen; an off-the-shelf OEM module from company Orsys has been selected. The TMS6701 processor may appear at first sight a bit over-dimensioned, but having a very powerful processor will certainly be of enormous advantage in the future project phases (quick software development using C language). Several variants of the modified MAC may be programmed and checked without having to worry about the computing resources. The software tools are based on TI Code Composer Studio.
- Design of the MAC software architecture. This work is just at the beginning and will constitute the bulk of the work for the next 12 months.

T3.3 *Routing and forwarding*

The work in the first 12 months has been mainly concentrated on the implementation and analysis of routing/forwarding protocols emerging in the MANET framework. The intent was to analyze their limitations and provide an extensible platform for developing new routing and networking solutions. So far the developed framework includes the AODV, OSLR routing protocols. The framework contains a "common module" and individual "routing modules". The "routing modules" are independent modules that implement the selected routing protocols (AODV, OSLR, etc). These modules can be activated and deactivated at runtime in order to accommodate the routing mechanism to the node resources or network conditions. The "common module" constitutes the core of the Ad

Hoc framework and it is kept permanently in the Ad Hoc node. The "common module" stores all the routing information collected in the same node from multiple routing protocols that may be running simultaneously, and interacts with the lower layers (Kernel routing table).

### 2.4.3 Effort used and Planned for the Reporting Period

Figure 4 shows the planned and the real effort (planned plus additional effort) for the first year of the project. As pointed out by the figure there have been two major deviations from original planning of Annex 1: CNR (8 extra person months) and HUT (17 extra person months). This extra effort as explained before was necessary to cover two new areas of the project that emerged during the first year of high value for the project:

- to study and evaluate an innovative cross-layered architecture;
- to increase the role of measurement studies, with respect to simulation, in the system performance evaluation.

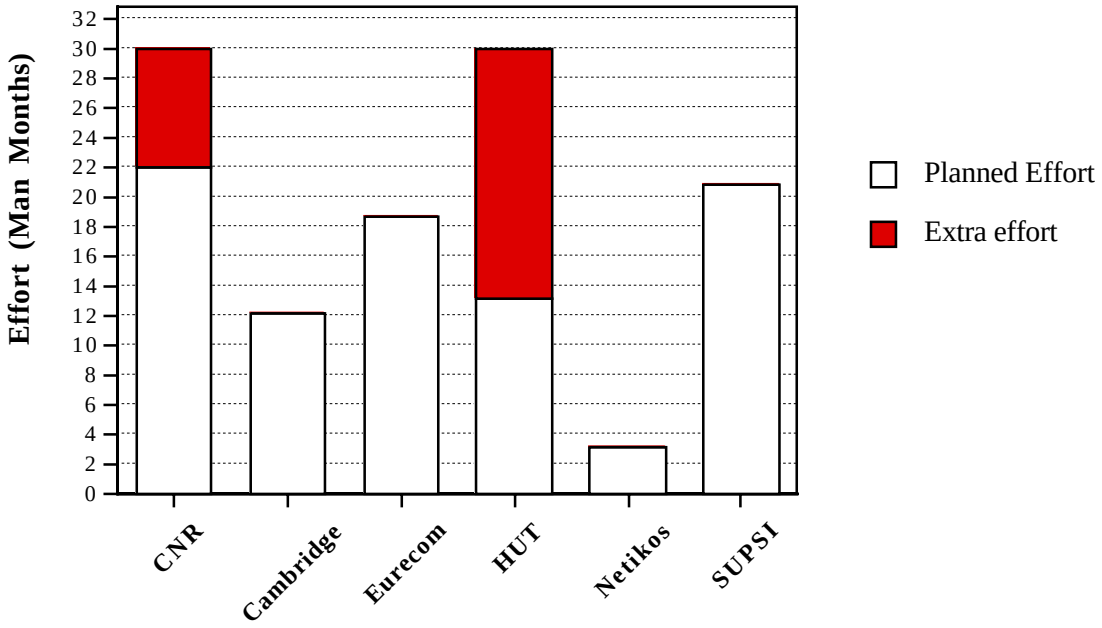


**Figure 4.** Planned and Real Effort for the reporting period

The first activity was in charge of CNR, while the second activity was performed by CNR as far as measurement studies of Wi-Fi networks, and by HUT for routing protocols measurement studies. The latter activity requested a big effort for the developing the software required to set up the experimental environment. However, most of the extra effort was done exploiting resources that do not introduce additional costs for the project

(master and PhD students, etc.). Therefore, we have been able to perform all the tasks with minor impacts on the project budget.

**Table 1.** Effort for the reporting period per WPs/Tasks (person months)

| | CNR | | Cambridge | | Eurecom | | HUT | | Netikos | | SUPSI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WP/Task | Est | Act | Est | Act | Est | Act | Est | Act | Est | Act | Est | Act |
| WP0 | 3.5 | 3.5 | 0.5 | 0.5 | 0.8 | 0.8 | 0.5 | 0.5 | 0.2 | 0.2 | 1.2 | 1.2 |
| WP1 | 1.5 | 1.5 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0.5 | 0.2 | 0.2 | 1.5 | 1.5 |
| WP2* | 1 | 1 | | | 4 | 4 | | | | | | |
| Task 2.1 | | | 0.5 | 0.5 | | | | | 2.5 | 2.5 | 0.5 | 0.5 |
| Task 2.2 | 1 | 4 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.2 | 0.2 | 0.5 | 0.5 |
| Task 2.3 | 7 | 15 | | | | | | | | | 3 | 3 |
| Task 2.4 | 5 | 2.5 | | | 1 | 1 | 1 | 1.5 | | | | |
| Task 2.5 | | | | | 9.3 | 9.3 | | | | | | |
| Task 2.6 | 1 | 1 | 4.5 | 4.5 | | | | | | | | |
| Task 2.7 | | | | | | | | | | | 3.4 | 3.4 |
| Task 2.8 | | | 4.5 | 4.5 | | | | | | | | |
| WP 3 * | 1 | 1 | | | | | | | | | | |
| Task 3.1 | | | | | | | | | | | 10.7 | 10.7 |
| Task 3.2 | 0.5 | | | | | | | 2 | | | | |
| Task 3.3 | 0.5 | 0.5 | | | | | 10.7 | 25 | | | | |
| Task 3.4 | | | | | 2 | 2 | | | | | | |
| Task 3.5 | | | 1 | 1 | | | | | | | | |
| TOTAL | 22 | 30 | 12.1 | 12.1 | 18.6 | 18.6 | 13.2 | 30 | 3.1 | 3.1 | 20.8 | 20.8 |

Table 1 reporting the total efforts spent by each partner in the first year activities points out that the deviation from the planned effort occurred to study and evaluate an innovative cross-layered architecture (Task 2.2), and to increase the role of measurement studies, with

* WP coordination and deliverables management.

respect to simulation, in the system performance evaluation (i.e., Task 2.3 and Task 3.2 for measurements at MAC and routing level, respectively).

## 2.5 World-wide state-of-the-art Update

The IETF MANET WG proposes a view of mobile ad hoc networks as an evolution of the Internet. This mainly implies an IP-centric view of the network, and the use of a layered architecture. This paradigm has greatly simplified network design and led to the robust scalable protocols in the Internet. The use of the IP protocol has two main advantages: it simplifies MANET interconnection to the Internet, and guarantees the independence from wireless technologies. However, current results show that the layered approach is not equally valid in terms of performance.

Relaxing the Internet layered architecture, by removing strict layer boundaries, is therefore an open issue in the mobile ad hoc networks evolution. However, the layered approach was, and is, one of the key elements of the world-wide diffusion of the Internet. The question is to what extent the pure layered approach needs to be modified.

At one end, we have solutions based on *layer triggers* that are still compatible with the principle of separation among layers. A full cross-layering design represents the other extreme.

Layer triggers are pre-defined signals to notify some events to the higher layers, e.g., failure in data delivery, thus increasing the cooperation among layers. Layer triggers have been extensively used both in the wired and wireless Internet. For example, in wired Internet, the Explicit Congestion Notification (ECN) mechanism is used by intermediate routers to notify congestion conditions to the TCP layer, while Corson[2] proposed to add L2 triggers, between the link and IP layer, to efficiently detect (at IP layer) changes in the wireless links' status.

A full cross-layer design is a more extreme solution that tries to exploit, in the protocols design, layers' interdependencies to optimize the overall network performance. In this case, control information is continuously flowing top down and bottom up through the protocols' stack and a protocol behavior adapts both to higher and lower protocols' status. For example, the physical layer can adapt rate, power, and coding to meet the requirements

[2] http://www.ietf.org/internet-drafts/draft-corson-triggered-00.txt

of the application given current channel and network conditions. The MAC layer can adapt based on underlying link and interference conditions as well as delay constraints and bit priorities. Adaptive routing protocols can be developed based on current link, network, and traffic conditions. Finally, the application layer can utilize a notion of soft QoS that adapts to the underlying network conditions to deliver the highest possible application quality.

Currently, a debate is ongoing among ad-hoc-network researchers on cross-layered vs. legacy-layered architectures. While it is well recognized that cross layering can provide significant performance benefits, it is also pointed out that a layered design has been one of the key element of the success and proliferation of Internet. Supporters of the layered architectures point out:

i. this design approach guarantees controlled interactions among layers, and hence designers of protocols at a particular layer do not need to worry about the rest of the stack. On the other hand, a cross layer design can produce unintended interactions among layers (e.g., adaptation loops) resulting in performance degradation;

ii. an "unbridled" cross layer design can produce a spaghetti-like code that is impossible to maintain in an efficient way as every modification needs to be propagated to the all protocols.

We believe that layer triggers are not the only solution for overcoming all MANET performance problems, and that a "careful" cross layer design must be adopted. The MobileMAN approach is to introduce inside the layered architecture the possibility of protocols belonging to different layers to cooperate by sharing network-status information still maintaining layers' separation for protocols design. This is a very innovative approach for a working solution. At the best of our knowledge, no reference architecture has been defined to exploit a full[3] cross-layer design of a MANET protocol stack. For this reason, in the framework of the MOBILEMAN project we have defined a reference architecture for MANET able to exploit the advantages of a balanced cross-layer design. We decided to enhance the reference model of MobileMAN in order to integrate in a careful way, in our architecture, the novel view of cross layering, while maintaining layer independence when opportune. A cross-layering approach is emerging as the most suitable attempt to optimize

[3] With the term "full" we refer to the fact that the cross-layered design applies to all layers.

the architecture and protocols for systems with high dependences among layers, as wireless ones. In MobileMAN, some specific information, gathered at different layers of the network stack, is shared in a common local memory structure, and used to adapt the behavior of the node depending on the particular circumstance (e.g., traffic type, channel perturbations, network status, node selfishness and/or maliciousness, among the others) the node operates in. This is likely to be the first attempt, in the research community, that such type of reference architecture is adopted. However, the MobileMAN reference architecture tries to achieve the advantages of an advanced cross layer design (i.e., joint optimization of protocols belonging to different layers) still satisfying the layer separation principle, i.e., protocols belonging to different layers can be added/removed from the protocol stack without modifying the protocols operating at the other layers. This implies that a high attention will be given to the choice of the shared information, and the balance between cross-layering and layer separation will be matter of careful research.

## 2.6 Planned Work for the Next Reporting Period

No major modifications have been made with respect to the plans (see Deliverable D2). Indeed, we extended the scope of the project by adding the new concept of "cross layering" in the MobileMAN architecture and protocols. Thus, with the goals defined in D2 in mind, we defined the criteria for evaluating the success of the second year of the project. The goals defined in D2 are:

- The software implementation of the solutions defined and studied during the first year, except the MobileMAN enhanced NIC.
- The integration of the developed solutions in a fully functioning testbed.
- Preliminary measures of the users' satisfaction of the ad hoc networking paradigm. These measures will be mainly done by *empirical research based on forms to be filled*. In addition, some measurements with a small group of users (on a simplified testbed) will be also performed.
- To investigate market-based mechanisms for exploiting the self-organized paradigm. This will take into account both the users' satisfaction and the

advantages provided by the MobileMAN environment to some class of applications.

In Deliverable D4 we reported the detailed criteria for evaluating the success of the second year of the project.

## 2.7 Assessment of Project Results and Achievements

SCIENTIFIC AND TECHNOLOGICAL ACHIEVEMENTS OF THE PROJECT. The project has proposed a system architecture that introduces cross-layer optimization and, at the same time, permits the use of legacy protocols without changes. The design and implementation of a cross-layer architecture and protocols for ad hoc networks is novel and very relevant for future research in the area. In addition, measurements, simulation and analysis have been used to characterize the ad hoc networks environment and to design the MobileMAN protocols.

IMPACT ON SCIENCE AND TECHNOLOGY: SCIENTIFIC PUBLICATIONS AND PARTICIPATION TO CONFERENCES/SYMPOSIUM/WORKSHOPS OR OTHER DISSEMINATION EVENTS. Even though the dissemination and exploitation workpackage was planned to start in the second year of the project, in this first year partners attended 11 international conferences and workshops and we produced 34 technical documents (Journal papers, Conferences presentations, books, books chapters, theses, etc.). Additionally, some of them participate in relevant Journal Editorial Boards and Conference Committees. A detailed presentation of these activities can be found in Section 5.

Besides, we realized the project web site and they keep it up-to-date.

TRAINING. The technological challenges of the MobileMAN project attracted several good students and this contributes to increase the number of European specialists in mobile and wireless technologies. ISTAG has identified this area as one of the key technologies where Europe needs to build knowledge and research skills. Currently, within the consortium, there are 7 PhD students working on MobileMAN issues. Furthermore, a large number of Master-level students completed (and others are currently working to complete) their

theses in the framework of the project. Specifically, during the first year the following PhD and Master theses have been completed in the framework of the MobileMAN project:

CNR

- Raffaele Bruno, "Algorithms and Protocols for Efficient Resource Utilization on Wireless Local And Personal Area Networks", PhD thesis in Information Engineering, University of Pisa.
- Paolo Longo, "Impact of Carrier Sensing and Fresnel Zone on 802.11 wireless Ad Hoc Networks", Laurea Thesis, University of Pisa, 2003.
- Tommaso Pampana, "Performance Analysis of 802.11b MAC protocol in multi-hop Ad Networks with Internet Traffic", Laurea Thesis, University of Pisa, 2003.

CAMBRIDGE

- T.J.P. Drummond, "The Operation and Performance of Wireless Wide Area Networks:
- Considerations for 802.11b Metropolitan Access Networks", University of Cambridge 4th Year Engineering Project, 2003.

HUT

- Lei Xiao, "Design and Implementation of an Ad Hoc Routing Framework", Master Thesis, Helsinki University of Technology, 2003.
- Juan Gutierrez, "Design and Implementation of OSLR in Ad Hoc Framework", Master Thesis, Helsinki University of Technology, 2003.

SUPSI

- Claudia Brazzola, "Communication between Expert and Non-expert in Technological Contexts: Application to the MobileMAN Case", Master Thesis, University of Italian Switzerland, 2003.

IMPACT ON INNOVATION AND MICRO-ECONOMY. The area of ad hoc networking is of long-term nature. Furthermore, the project is still at an early stage for evaluating the potential for commercial exploitation beyond the already known expectations at the beginning of the project.

# 3. PROJECT MANAGEMENT AND CO-ORDINATION

The activities of the first year of the project were planned and monitored by continuous communications among partners responsible, and in the Executive Board meetings. We had three Executive Board meetings during the three plenary workshops. During these workshops, plans for progressing work packages were agreed with particular attention being given to deliverables in the first year. In addition, work has started ahead of schedule in the other work packages in accordance to project plans.

The project's coordination infrastructure has been established. Communication is primarily by project mailing list supported by an internal and public web server http://cnd.iit.cnr.it/mobileMAN.

## 3.1 Project Management Details

The MobileMAN project officially started on 1st October 2002.

The activities of the first year of the project can be subdivided into two main phases corresponding to months 1-6, and months 7-12, respectively.

The primary aim during the first six months of the project was to bring together all project members, and launch work on the work packages. Two projects meeting were organized to coordinate these activities. The first brought together all the partners at the 1st Project Closed Workshop held at CNR (Pisa, Italy), November 4-6 2002. The second meeting was at Eurecom (Sophie-Antipolis, France), 6-7 March 2003.

The 1st plenary workshop allowed all project members to become familiar with the overall workplan of the project and to interact directly with existing and potential collaborators. This has been enhanced by the 2nd plenary workshop, which was held in Eurecom (Sophie-Antipolis, France), 6-7 March 2003. During the 2nd workshop the members provided input on further developed work that had been carried out between November

and March. During this meeting the partners verified the correct project start up and the partners alignment for methods and tools (milestone M1).

The second half of the first year of the project was mainly devoted to WP2 activities, i.e., design of MobileMAN architecture and protocols. This phase ended at month 12 with a self-assessment phase to compare and contrast the project results with the project success criteria defined in WP1. The results of this self-assessment phase are presented in Deliverable D4.

A third project meeting was held in Cambridge (UK), July 2-4 2003. This meeting included i) a meeting with people working on the UK-funded EQUATOR project, ii) a meeting with MobileMAN IAB members, and iii) an internal meeting among MobileMAN partners to check the status of the project activities and to manage the project.

i. The meeting with EQUATOR project provided valuable inputs mainly about the participatory design approach, and hence it was extremely useful for activities to be performed by SUPSI-DLS.

ii. The Cambridge meeting was the first meeting with IAB. We decided to have this at 9$^{th}$ month to present to IAB preliminary results about MobileMAN, and to have IAB feedbacks in time to prepare the first draft of Deliverable D5 “MobileMAN architecture, protocols and services preliminary report” by the end of July (Milestone M5). All industries involved in the IAB were represented at the meeting. Specifically, Michael Bahr (Siemens), Jeff Farr and Ben Strulo (BTexact Technologies), Jeff Owen (ST Microelectronics), and Pertti Suomela (Nokia) participated to the meeting. During the meeting with IAB were reviewed the MobileMAN more advanced research activities: cross-layer architecture, solutions for a new card, routing, security and cooperation, middleware, and economic incentives to cooperation. The discussion with the IAB focused mainly on the novel concept of cross layering architecture. This concept was generally well accepted by IAB members that pointed out the importance of our choice to maintain layers separation to guarantee a modular protocols’ design avoiding

*spaghetti* design in protocols development. Pertti Suomela recommended that should be possible to use existing Internet protocol (e.g., TCP/IP) without modifications inside the cross layer architecture. Other interesting inputs come from IAB with reference to cooperation models and mechanisms. Specifically, Ben Strulo suggested considering other types of selfishness (someone who wants to cooperate only with its friends, and someone who wants to cooperate based on the traffic it generates), and to extend the game theory model to have, in the non-cooperative game, reputation introduced in the utility function. Finally, BTexact people suggested to consider the MOCA distributed certification authority approach for building up a security infrastructure.

iii. In the internal meeting the partners presented and discussed the ongoing research activities on applications, users' location and social studies. Plans were defined to produce Deliverable D5.

During the second half of the project, an interim project meeting (technical) has been held at Lugano on May 21 2003 between CNR and SUPSI. This meeting was entirely devoted to discuss technical issues related to the development of the enhanced MAC card.

According to Milestone M5, the first draft of Deliverable D5 was produced by end July.

We also produced a Report "Project Presentation" that provides an extended summary of the project and is available from: http://cnd.iit.cnr.it/mobileMAN.

## 3.2 Cooperation with other projects

The project partners are cooperating with other national and EU-funded projects, whose results could be valuable for MobileMAN.

**CNR**

Virtual Immersive Communications (VICOM) is a three years Italian project (Nov. 2002 – Nov. 2005) funded by the Italian Ministry for Research (MIUR). This project is aimed to

investigate communications technologies, including ad hoc networks, for supporting ambient intelligence.

**Eurecom**

WITNESS: WIreless Trust for mobile business, (IST-2001-32275).

CNRS / ACI SPlaSH: Sécurisation des ProtocoLes dans les réseAux mobileS ad Hoc.

**HUT**

Networking laboratory is in direct contact with EU projects:

WIreless DEployable Network System, Proposal acronym: WIDENS, and national projects: AHRAS: http://www.netlab.hut.fi/tutkimus/ahras/

NAPS: http://www.netlab.hut.fi/tutkimus/naps/

MobileMAN cooperation with the following projects is currently under discussion

**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.

MobileMAN partners met EQUATOR people during the Cambridge meeting on July 2-4, 2003.

***MMAPPS****: Market Management of Peer to Peer Services*. The MMAPPS project started on March 1st, 2002 with funding from the EU Fifth RTD Framework Programme.

The MMAPPS project is researching how to use techniques from economics and social science to tackle some of the fundamental difficulties in creating well-founded, and therefore sustainable, P2P applications. The project's central approach is to extend techniques such as market management so that cooperation between peers can be encouraged without damaging the community-oriented structure of P2P architectures.

MMAPPS results could constitute a good input for the MobileMAN research on ad hoc network economic issues.

In the Cambridge meeting we decided that University of Cambridge should contact *MMAPPS* people to verify possible cooperation about economic/pricing issues.

# 4. COST BREAKDOWN

The costs (in Euro) incurred for the reporting period are summarized in the next table. As it appears from the table the costs are aligned with expected costs. The total costs for durable and consumable for the first year have been lower than expected also because the partners deferred the purchase of some durable equipments and software to next years in which development activities are concentrated. For CNR we had a 10% increase of the personnel costs that was due i) to the increase in the activities performed as explained in Section 2.4.3, and ii) to the increase, in 2003, of the personnel hourly cost.

# Costs in euro for reporting period 01/10/2002 – 30/09/2003

| | CNR | | UCAM-CLAB | | Eurecom | | HUT | | NETIKOS | | SUPSI | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Period | | Period | | Period | | Period | | Period | | Period | | Period | |
| **Cost category** | Est. | Act | Est. | Act | Est. | Act | Est. | Act | Est. | Act | Est. | Act | Est. | Act |
| **Direct costs** | | | | | | | | | | | | | | |
| 1. Personnel | 103.301 | 117.475,78 | 48.315 | 21.522,15 | 60.181 | 64.371,22 | 42.120 | 26.968,82 | 14.092 | 17.561,08 | 142.262 | 140.357 | 410.271 | 388256 |
| 2. Durable equipment | 25.450 | 17.697,53 | 3.400 | 2.292,04 | 9.700 | 889,52 | | 889,73 | 9.000 | 1.488,89 | 25.000 | 15.212 | 72.550 | 38470 |
| 3. Subcontracting | | | | | | | | | | | | | | |
| 4. Travel and subsistence | 11.800 | 10.472,49 | 1.870 | 3.108,90 | 8.500 | 4.852,65 | 5.200 | 3.172,88 | 6.000 | 1.426,28 | 5.500 | 6.064 | 38.870 | 29097 |
| 5. Consumables | 9.258 | | 1.700 | 1.195,70 | 2.500 | | 3.000 | | 1.000 | | 2.500 | | 19.958 | 1196 |
| 6. Computing | | | | | | | | | | | | | | |
| 7. Protection of knowledge | | | | | | | | | | | | | | |
| 8. Other specific costs | 1.000 | 1.371,16 | | | 1.500 | | | | | | | | 2.500 | 1371 |
| **Subtotal** | 150.809 | 147.016,96 | 55.285 | 28.118,79 | 82.381 | 70.113,49 | 50.320 | 31.031,43 | 30.092 | 20.476,25 | 175.262 | 161.633 | 544.149 | 458390 |
| **Indirect costs** | | | | | | | | | | | | | | |
| 9. Overheads | 82.641 | 93.980,62 | 11.057 | 5.624 | 76.440 | 72.750 | 4.655 | 6.206 | 11.274 | 14.049 | 35.052 | 28.071 | 221.119 | 220.681 |
| **Total** | **233.450** | **240.998** | **66.342** | **33.743** | **158.821** | **142.863** | **54.975** | **37.238** | **41.366** | **34.525** | **210.314** | **189.704** | **765.268** | **679.071** |

Period: Est.: estimated costs in contract for period Act.: actual costs in period
Total: Est.: estimated cumulative costs to date in contract Act.: cumulative actual costs to date

# 5. PROMOTION, INFORMATION AND DISSEMINATION

## 5.1 Conferences and Workshops

MobileMAN project members attended the following conferences during the first year of the project:

1. ACM MobiCom Atlanta 23-28 September 2002 (*) Participants: Cambridge (S. Ostring), CNR (M. Conti).
2. UBICOMP 2002: *Workshop on Security in Ubiquitous Computing*, Goeteborg Sweden, September 29, 2002. (*) Participants: Eurecom
3. EUROPEAN SCIENCE FOUNDATION (PESC): *Exploratory Workshop – Is Mobile Ad hoc Networking Part of the Future of Mobile Networking in Europe?*, Monterosso al mare, La Spezia, Italy, 10-12 October 2002. Participants: Cambridge (S. Ostring), CNR (M. Conti, E. Gregori, G. Maselli, G. Turi), Eurecom (P. Michiardi, R. Molva), HUT (R. Kantola), SUPSI (S. Giordano).
4. IEEE/ACM – WiOpt 2003: *Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks*, INRIA Sophia-Antipolis, France, March 3-5, 2003. Participants: Cambridge (J. Crowcroft, S. Ostring), CNR (M. Conti, E. Gregori), Eurecom (P. Michiardi, R. Molva), SUPSI (S. Giordano).
5. CNRS/STIC – MadNet 2003: *Workshop on Mobile Ad Hoc Networking and Computing*, Institut Eurecom, Sophia-Antipolis, France, March 6, 2003. Participants: Eurecom (P. Michiardi, R. Molva).
6. IEEE Workshop on Mobile and Wireless Networks (MWN 2003) in conjunction with IEEE ICDCS 2003, 19 May, 2003. Participants: CNR (E. Borgia)
7. *First International Conference, Trust Management iTrust 2003*, Heraklion, Crete, Greece, May 28-30, 2003. Proceedings P. Nixon, S. Terzis (Eds.). Participants: Eurecom.
8. NeXtworking'03 *The First COST(EU)-NSF(USA)* Workshop on EXCHANGES & TRENDS IN NETWORKING, 23-25 June 2003, Chania, Greece. Participants: CNR (M. Conti) and Cambridge (J. Crowcroft).

(*) These meetings occurred few days before the official start of the project but provided very relevant inputs to the project.

9. ACM SIGCOMM 2003, Karsluhe Germany August 25-29, 2003, Participants: Cambridge (M. Lim).
10. PWC 2003: The Eight International IFIP-TC6 Conference on "Personal Wireless Communications", Venice, Italy, 23-25 September 2003. Participants: CNR (M. Conti, E. Gregori, G. Maselli, G. Turi), Eurecom (R. Molva), and SUPSI (A. Puiatti, S. Giordano).
11. HET-NETs'03: the First Int. Conf. Performance Modelling and Evaluation of Heterogeneous Networks, Ilkley, West Yorkshire, U.K., 21-23 July, 2003. Participants: CNR (G. Turi).

## 5.2 Publications

1. S. Basagni, M. Conti, S. Giordano, I. Stojmenovic, *Mobile Ad hoc networking*, IEEE Press and John Wiley and Sons, Inc., New York, 2004.
2. 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.
3. 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.
4. Luciano Bononi, Marco Conti, Enrico Gregori, "Runtime Optimization of IEEE 802.11 Wireless LANs Performance", *IEEE Transactions on Parallel and Distributed Systems*, Vol. 14, N. 12, December 2003.
5. G. Anastasi, M. Conti, E. Gregori, "IEEE 802.11 Ad Hoc Networks: Protocols, Performance and Open Issues", *Mobile Ad hoc networking*, S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Editors), IEEE Press and John Wiley and Sons, Inc., New York, (March 2004)
6. A. Anastasi , E. Borgia, M. Conti, E. Gregari, "IEEE 802.11 Ad Hoc Networks: Performance Measurements", *Cluster Computing Journal, Special issue on Ad Hoc Networks* (to appear).
7. 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.

8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. 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,
14. http://www.comsoc.org/pubs/gcn/gcn0503.html.
15. A. Campbell, M. Conti, S. Giordano (Editors) Special Issue on "Mobile Ad Hoc Network", *ACM/Kluwer MONET* Vol. 8, No. 5 (Oct. 2003).
16. P. Michiardi, R. Molva, Chapter on *"Recent Security Solutions for Mobile Ad hoc Networks"*IEEE Press / Wiley Ed. Book on *Mobile Ad hoc Networking*. (to appear).
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21. 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.

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25. 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.

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

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28. S. Giordano, A. Urpi, "Self-Organized and Cooperative Ad Hoc Networking", in *Mobile Ad Hoc Networking*, S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Editors), IEEE Press and John Wiley and Sons, Inc., New York, 2004.
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31. J. Costa-Requena, R. Kantola, N. Beijar ," Replication of Routing Tables for Mobility Management in Ad Hoc Networks", ACM Wireless Networks (WINET), 2003.
32. Jon Crowcroft, Richard Gibbens, Frank Kelly & Sven Östring *"Modelling Incentives for Collaboration in Mobile Ad Hoc Networks"* Submitted for review for Performance Evaluation, May 2003.
33. P. Michiardi, R. Molva, *"A Game Theoretical Approach to Evaluate Cooperation Enforcement Mechanisms in Mobile Ad Hoc Networks"*, Submitted to Performance Evaluation Journal, May 2003.
34. 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.

## 5.3 Journal Editorial Boards and Conference Committees

### 5.3.1 Journal Board

- M. Conti is on the editorial board of the *Ad Hoc Networks Journal*.
- J. Crowcroft is on the editorial board of the following journals: *Computer Networks, IEEE Networks, Internet Protocol, Grid Computing, Cluster Computing, and Mobile Applications and Networks*.
- S. Giordano is on the editorial board of *IEEE Communications Magazine.*
- E. Gregori is on the editorial boards of *Computer Networks Journal and Cluster Computing Journal*.

### 5.3.2 Conference Committees

- ESF/PESC Exploratory Workshop: Is Mobile Ad Hoc Networking Part of the Future of Mobile Networking in Europe?", Monterosso Italy 10-12 October 2002.

  Role: M. Conti and S. Giordano were the workshop organizers and coordinators.

- PWC 2003: The Eight International IFIP-TC6 Conference on "Personal Wireless Communications", Venice, Italy, 23-25 September 2003.

  Role: E. Gregori was the general chair, M. Conti the technical program chair, S. Giordano the special tracks co-chair and J. Crowcroft member of the Steering Committee.

- ACM/IEEE workshop "Modeling and Optimization in Mobile, Wireless and Ad Hoc Networks" INRIA Sophia-Antipolis, France, 3-5 March 2003.

  Role: J. Crowcroft was the general chair. S. Ostring and S. Giordano were Publicity co-chairs.

- ACM SIGCOMM 2003, Karsluhe Germany August 25-29, 2003.

  Role: J. Crowcroft was the program committee chair.

### 5.3.3 Conference Technical Program Committees

- M. Conti, S. Giordano, S. Ostring: ACM/IEEE workshop "Modeling and Optimization in Mobile, Wireless and Ad Hoc Networks" INRIA Sophia-Antipolis, France, 3-5 March 2003.

- M. Conti: IEEE Conference on Pervasive Computing and Communication (PerCom2003) Fort Worth Texas, during March 23-26, 2003. http://www.percom.org.

- M. Conti: IEEE workshop on Wireless Networks and Mobile Computing in conjunction with the 23rd International Conference on Distributed Computing Systems (ICDCS 2003, http://www.cse.msu.edu/icdcs/) May 19-22, 2003 in Providence, Rhode Island, USA.

- M. Conti: IEEE Workshop on Mobile and Wireless Networks (MWN 2003) in conjunction with the 23rd International Conference on Distributed Computing Systems (ICDCS 2003, http://www.cse.msu.edu/icdcs/) May 19-22, 2003 in Providence, Rhode Island, USA. (M. Conti)

- M. Conti: IEEE Symposium on Personal Communications Services and Wireless LANs, May 11-15, 2003 Anchorage, Alaska, USA In conjunction with IEEE 2003 International Conference on Communications (ICC 2003) May 11-15, 2003, Anchorage, Alaska, USA, http://www.icc2003.com

- M. Conti and J. Crowcroft: The first NSF – COST Workshop on Networking, Chania, Greece, June 23-25, 2003
  http://www.di.uoa.gr/~istavrak/costnsf/Welcome.html

- M. Conti: HET-NETs'03: the First Int. Conf. Performance Modelling and Evaluation of Heterogeneous Networks, Ilkley, West Yorkshire, U.K., 21-23 July, 2003.

- M. Conti: The First ACM International Workshop on Wireless Mobile Applications and Services on WLAN Hotspots (WMASH'03), ACM Mobicom 2003 workshop. San Diego, California, in September 2003.

- M. Conti: The 6th ACM International Workshop on Modeling, Analysis and Simulation of Wireless and Mobile Systems (ACM MSWiM), ACM Mobicom 2003 workshop. San Diego, California, in September 2003.

- R. Buno, R. Molva, R. Kantola: PWC 2003: The Eight International IFIP-TC6 Conference on “Personal Wireless Communications”, Venice, Italy, 23-25 September 2003.